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Exercise Intensity in Elementary School Physical Education Classes

by

J. Dru Marshall

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF Master of Science

Department of Physical Education

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DEDICATION

To my parents, for showing me the way. . .

ABSTRACT

Four boys were randomly selected from one grade five class in Millgrove Elementary School. Heart rate data was collected every 30 seconds from an exersentry heart rate monitor in 3 of each of the gymnastics, dance, and games orientated physical education classes for each subject. The heart rates that were collected were categorized as follows: resting (≤ 100 bpm); mild (101-120); high mild (120-130); moderate (131-159); high moderate (150-159); and severe (≥ 160 bpm). The percentage of class time spent in each category was calculated for the total group and for each individual subject.

The group results indicated that the gymnastics and dance classes were similar in terms of the relatively low activity intensity that was exhibited by the subjects, while the games classes resulted in a slightly higher activity intensity. A high activity intensity was seldom maintained for a long period of time.

It was concluded that the classes studied were not of a sufficient intensity to cause a training effect; and that the less fit subjects appeared to be more highly stressed than the fit subjects studied.

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I. INTRODUCTION

Researchers for many years have been interested in promoting physical fitness in youth. Physical fitness is an important pre-requisite for optimum physical, mental, and social well-being (Hale and Bradshaw, 1978). The development of physical fitness is an objective that is unique to the physical education curriculum (Fabricius, 1964; Hale and Bradshaw, 1978). The benefits of physical activity are well known and physical education, in one form or another, is universally accepted as a necessary part of a child's education (Knuttgen and Steendahl, 1963).

In recent years the physical education of a child has taken on increased importance. As Bailey (1973) states:

> "Canadian children today are entering a post-industrial society characterized by sedentary living patterns, emotional stress, poor dietary habits and lack of physical activity. It is essential that our children leave school prepared to meet these facts of life as they exist today."(p. 425).

Many investigators have examined the value of different physical education programs that have varied in intensity, duration, and frequency. Many investigators have failed to show an effect of physical education on physical fitness (Taddonio, 1966; Cumming et al, 1969; Bar-Or and Zwiren, 1973), while other investigators have demonstrated that physical education is successful in improving physical fitness (Fabricius, 1964; Shephard et al, 1979; Knuttgen and Steendahl,1963). The inconsistency in the results of studies concerning the effectiveness of physical education can partly be explained by differences in content as well as frequency and duration of the physical education classes (Kemper and Verschuur, 1974). The characteristics of the subjects participating in the programs also have an effect on the results of the programs (Kemper and Verschuur, 1974; Shephard et al, 1979).

When investigating the development of physical fitness it is important to examine the parameters of intensity, duration, and frequency. Daily programs of physical education have demonstrated fitness benefits (Shephard et al, 1979; Quinney, 1982). During daily physical education programs, the duration of class time and the frequency of classes is usually known. However, the intensity of activities and the duration of activities occurring within the class time are seldom measured.

Intensity of work should be monitored and quantified to provide an accurate account for the study of training effects (Lussier and Buskirk, 1977). Minimum levels of stress have been recommended by many authors (Massicotte and Macnab, 1974; Crews and Roberts, 1976; Sharkey and Holleman, 1967; Karvonen et al, 1957), but evidence of the actual intensity of a physical education lesson is scarce (Hale and Bradshaw, 1978). If improved pupil fitness is a primary objective of an elementary school physical education curriculum (Fabricius, 1964, Millgrove School Proposal, 1977), then the intensity of a physical education lesson should be considered. As Cumming et al (1969) have stated .

. . "The mere increasing of the number of hours devoted to physical education classes or the provision of games periods in the school does not necessarily lead to improvements in laboratory measures of cardiorespiratory fitness" (p. 72). It is also possible that different types of physical education classes may provide more intensive activity than others and therefore may offer a possibility for greater improvement in physical fitness.

A. JUSTIFICATION

It has been established that the daily program of physical education studied has been successful in demonstrating fitness benefits (Quinney, 1982). Therefore, it was important to look at more specific questions concerning the program. The intensity of activities that are encountered during a physical education class would provide important information on the qualitative aspect of the program.

Evidence of the actual intensity of a physical education lesson is scarce (Hale and Bradshaw, 1978; Faulkner et al, 1963). If investigators are to examine the effect of training on children, it is important that they know some of the stresses the children are under during normal activities. The quantification of the intensity encountered during physical education lessons would therefore add to the knowledge base in the area of children's activities and fitness.

It is possible that the different activities which a child performs may have varying effects on the fitness level of the child. This study involved a comparison of physical education classes with a gymnastics, dance, or games orientation. It is important to know which type of activities provide a high level of intensity when planning a physical education program in which the primary objective is an improvement in physical fitness.

B. STATEMENT OF THE PROBLEM

The purpose of the present study was to determine the intensity of activities, as indicated by heart rate, encountered during physical education classes consisting of a gymnastics, dance, and games orientation. The main objectives of the study are as follows:

1. To determine the percentages of class time spent in each of the resting, mild, moderate, and severe heart rate categories during a gymnastics, dance, or games orientated class.
2. To determine the individual heart rate responses to the gymnastics, dance, and games units in physical education.
3. To determine the corresponding oxygen consumption (VO2) values at heart rates of 130 and 160 bpm for each subject.
4. To determine the percentage of maximal oxygen consumption (mVO2) that each of the oxygen consumption

values at heart rates of 130 and 160 bpm represented.

C. LIMITATIONS OF THE STUDY

1. The investigator used an exersentry (Respironics, Inc.) to monitor heart rate. The exersentry is a small, lightweight device that is strapped to the chest of an individual. It provides a digital display of heart rate. The obtrusiveness of the exersentry may have caused behavioural changes.
2. The heart rate was recorded every 30 seconds during a physical education class. The investigator recorded the heart rate herself if the child was near, or called for a heart rate if the child was in activity. This method of recording caused limitations such as interruption of activity and class, subject's knowledge of heart rate, and teacher's knowledge of heart rate. However, a period of accustomization to both the exersentry and the investigator kept the interruption of the activity and class to a minimum.
3. The subject was required to wear an exersentry and therefore knew he was being monitored. This may have caused him to be more active than usual. The accustomization procedure that occurred prior to the data collection is believed to have minimized the novelty effect of the monitors.
4. The class teacher was aware of the study and could sometimes hear the heart rates that were being recorded.

Although he had been asked to provide his students with activities that were usually encountered in his class, he could have provided more activity or activities that elicited higher heart rates than usual. However, after observing classes prior to the study and during the study, the investigator believed that the teacher was conducting his typical classes.

5. The investigator could only monitor two subjects during each class.
6. A small sample from an atypical school was chosen making it difficult to generalize to the population at large.

D. DELIMITATIONS OF THE STUDY

1. The sample was delimited to 4 randomly selected grade five boys from one class at Millgrove Elementary School in Spruce Grove, Alberta.
2. The study was further delimited in that data for nine classes was collected for each subject. Three classes of data were collected for each subject in each of the gymnastics, dance, and games orientated classes.

E. DEFINITIONS OF TERMS

DANCE ORIENTATED CLASS: a class which involved exploratory movements to music.

GAMES ORIENTATED CLASS: a class in which the approach was to develop skills for the major games, that is, volleyball, basketball, etc.

GYMNASTICS ORIENTATED CLASS: a class in which the focus was on movement pattern development and routine development. It included skill development in balancing, flight, twisting, turning, and combinations thereof.

HEART RATE ACTIVITY CATEGORIES: were defined as follows:

$\leq$100 bpm = resting (Marshall, 1981)
101-130 bpm = mild (Massicotte and Macnab, 1974)
120-130 bpm = high mild
131-159 bpm = moderate
150-159 bpm = high moderate
$\geq$160 bpm = severe (Gilliam et al, 1981)

HEART RATE PLATEAU: the longest period of time during a class that a heart rate was maintained above 130 bpm (based on findings of Massicotte and Macnab, 1974).

MAXIMAL HEART RATE: the highest heart rate (bpm) that was obtained during the bicycle ergometer test.

MAX VO2 or MAXIMAL AEROBIC POWER: the highest oxygen uptake (ml/kg-min) an individual can attain during physical work at sea level.

II. REVIEW OF LITERATURE

The review of literature will be subdivided as follows:

1. descriptive analytic research, which describes the importance of this type of investigation;
2. physical education and activities, which demonstrates the effects and importance of these programs on children;
3. physiological variables, which presents the literature relating to heart rate, heart rate versus oxygen consumption, and the development of max VO2 during childhood and adolescence; and
4. exercise intensity studies, where the concept of a minimal training threshold is reviewed.

A. DESCRIPTIVE ANALYTIC RESEARCH

The aim of descriptive analytic research is to objectively and accurately describe (not evaluate) behaviours or events that occur in the classroom (Costello, 1977). Although descriptive investigations are the least sophisticated research efforts, the facts gathered by such investigations may be essential before more sophisticated types of research can be carried out (Weber and Lamb, 1970; Moursund, 1973). Descriptions, case histories, and anecdotal material are usually interesting and are often useful in pointing the way toward more formal development of hypotheses to be investigated (Moursund, 1973).

Information about classroom behaviour can be used in a number of ways. As previously mentioned, descriptive information can serve as the basis for further investigations. Descriptive information can also be a valuable source of feedback for teachers and it can also provide feedback about an instructional program (Costello, 1977).

B. PHYSICAL EDUCATION AND ACTIVITIES

Physical Education

One of the primary objectives of the physical education curriculum in the elementary school is the improvement of physical fitness in boys and girls (Fabricius, 1964; Millgrove School Proposal, 1977). Investigators have examined the value of different physical education programs that have varied in intensity, duration, and frequency.

Many studies have failed to demonstrate an effect of physical education on the fitness of school children. Shephard et al (1979) have suggested some possible reasons for this failure when they state:

> ". . .Possible reasons include inadequacy of the programme, the commencement of training at too late an age, and the commencement of observations at too late an age. Some programmes have been quite light, adding no more than one weekly physical education period to the normal programme. Some, also, have continued for only a few weeks."(p.68)

The results of physical education programs are directly related to: 1) the qualitative and quantitative characteristics of the program itself; and 2) the characteristics of the subjects who participate in these programs (Kemper and Verschuur, 1974).

Taddonio (1966) compared the physical fitness, as determined by the AAHPER Youth Fitness Test, of two grade five classes: one which had no physical education curriculum, and one which had a curriculum of fifteen minute daily periods of calisthenics. The AAHPER Youth Fitness Test was administered before the experiment began and at it's termination four months later. The post experimental data comparison between the control group and experimental group, for both boys and girls, revealed no statistically significant differences on any of the test items. A comparison of the mean changes of test scores between the control and experimental groups revealed a statistically significant difference in favor of the experimental group in one item: the boys' 50 yard dash. Taddonio concluded that the examination of the post experimental data indicated that fifteen minute daily periods of calisthenics done at the intensity that they were done at in this study, although intensity was not quantified, had little or no effect upon the physical fitness of grade five boys and girls as measured by the AAHPER Youth Fitness Test.

Cumming, Goulding, and Baggley (1969) examined the PWC 170 and maximum oxygen consumption (max VO2) of grade ten and grade six Winnipeg boys from three different school systems over the course of a school year. Two private schools participated in this study: one which offered a full program of physical education, and the other which had no formal program of physical education, but where participation in snow-shoeing and canoe trips and farming occurred. The public school boys who participated in the study had less than ninety minutes of physical education every six days.

The investigators found no significant change in the mean PWC 170 per kilogram of body weight in any of the classes during the school year. Similarly, the mean max VO2 of the individual classes failed to show any alteration during the school year. The fitness levels of the individual students tended to remain constant, those with high values maintaining their fitness and those with low values failing to improve. Cumming, Goulding, and Baggley concluded that the PWC 170 and max VO2 of fairly fit boys was unlikely to change over a school year, no matter how many hours were allotted or facilities were available for physical education, without the institution of a training program specifically designed to improve endurance fitness. They suggested that for many of the younger boys, the stresses of most of their physical education classes were likely less than those of normal play activities.

Knuttgen and Steendahl (1963) studied the fitness of eighty Danish school boys (average age of 16 years and 7 months), who had physical education four times a week with approximately 35 minutes a session being devoted to physical activity. The boys were tested four times during the academic year with the AAHPER Youth Fitness Test and six times during the same year with a test of cardiovascular fitness employing a bicycle ergometer. The investigators found a marked general improvement in the fitness of the subjects during the course of the academic year, with the greatest gains in cardiovascular fitness occurring during the outdoor physical education programs of autumn and spring. Knuttgen and Steendahl attributed the gains in fitness directly to the physical education program and concluded that the Danish physical education program had definite positive effects on fitness.

Cooper et al (1975) investigated the feasibility of implementing an aerobics conditioning program for an entire school system. They studied 1215 high school males, (average age of 15.4 years), who participated in a 15 week training study. The experimental group (N=778) added 15 to 20 minutes of aerobic exercise five times a week to their daily program. The Cooper 12 minute run-walk test was administered to all subjects at the beginning of the study. The experimental group improved it's average performance in the Cooper run-walk test from 1.277 to 1.500 miles (17.5%), while the control group remained relatively consistent. Cooper and his collegues concluded that it was feasible to implement an aerobics conditioning program in an entire school system.

Frabicius (1964) compared the physical fitness development of grade four boys and girls who participated in a regular elementary school physical education curriculum with those who participated in a regular elementary school physical education curriculum which was supplemented with selected calisthenics. Physical fitness in this study was primarily concerned with muscular strength, muscular endurance, and circulorespiratory endurance and was measured by the Oregon Motor Fitness Test. Both the experimental and control groups received 30 minute physical education classes four times a week. In the experimental group, 3 minutes and 9 seconds were spent on added calisthenics in each class period. The results of this study demonstrated that both groups improved significantly in physical fitness in a six month period. The experimental group improved significantly more than the controls and this was attributed to the five or six calisthenics that were added to the normal physical education curriculum.

Bar-Or and Zwiren (1973) studied the effects of frequency of physical education classes over a nine week period. Three grade four classes, 30 children in each class, were given 2, 3, and 4 physical education lessons per week, respectively. Each class was further subdivided into an "endurance" group, which underwent strenuous interval training in each lesson, and a "regular" group, which carried out a program of calisthenics and movement games. The groups were matched for sex, max VO2, body density, and ethnic origin.

No significant differences were found in the max VO2 (ml/kg-min) in any classes from pre to post conditioning, nor when "endurance" and "regular" groups were compared. Significant pre to post conditioning changes were found in heart rate during submaximal treadmill walking: the boys in the "endurance" group had a greater drop in heart rate than the boys from the "regular" group and this phenomenon was greater in the class that had physical education 3 times per week than in the other two classes. The authors proposed that this latter finding, combined with the intensity of training during the physical education classes that was performed, suggested that the children who had physical education 4 times per week became more fatigued than the others, and this adversely affected their response to exercise.

A longitudinal study examining the growth of 546 French Canadian school children, aged 6 to 12 years, was done by Shephard et al (1979). Equal numbers of boys and girls were drawn from the town of Trois-Rivieres and a rural area, Pont Rouge. One half of the sample was given one 45 minute period of physical education per week, while the other half was given an hour of physical activity per day. All of the activity programmes were led by a physical education graduate. The program stressed the development of cardiorespiratory endurance and muscular strength, with maximum participation by all students throughout the class hour.

The results of the longitudinal study demonstrated that the added activity had no effect upon the height and weight of the children, but it produced significant gains in directly measured max VO2, PWC 170, muscular strength, and physical performance as measured by the CAHPER fitness test. The boys had significantly larger gains than the girls, while the urban children tended to score significantly better than the rural children. The main dividends of the activity did not appear until the child had reached his ninth and tenth years.

Diary records that each child kept throughout the course of the study demonstrated that the experimental children who did more activity during the school day compensated slightly for this by doing less activity at home. However, on the weekend they remained more active than the control subjects, demonstrating that the habits of physical activity acquired during the week continued to influence their behaviour when they were not required to attend school.

Shephard et al concluded that appreciable gains in fitness could result from a program that introduced 5 hours of vigorous physical activity into the classroom week of the elementary school.

In the previously mentioned studies the investigators refer to the intensity of work performed during the actual physical education lesson, but have seldom measured the intensity. Intensity of work should be monitored and quantified to provide an accurate account for the study of training effects (Lussier and Buskirk, 1977). Minimum levels of stress have been recommended by many authors (Massicotte and Macnab, 1974; Crews and Roberts, 1976; Sharkey and Holleman, 1967; Karvonen et al, 1957), but evidence of the actual intensity of a physical education lesson is scarce (Hale and Bradshaw, 1978). If, as stated earlier, improved pupil fitness is a primary objective of an elementary school physical education curriculum, then the intensity of a physical education lesson should be considered. As Cumming et al (1969) have stated, . . . "The mere increasing of the number of hours devoted to physical education classes or the provision of games periods in the school does not necessarily lead to improvements in laboratory measures of cardiorespiratory fitness"(p. 72).

Two studies were found in the literature in which the authors had quantified the intensity of physical education lessons. Hale and Bradshaw (1978) used heart rate as an index of intensity to describe the reactions of two groups of girls during physical education lessons. The first group of girls consisted of 10 randomly selected physical education students aged 19 to 20 years, while the second group consisted of seven school girls, aged 12 to 16 years, regarded by the school staff as enthusiastic participants in physical education lessons.

The heart rate was recorded by a Parkes telemeter for 24 practical sessions; seventeen for the physical education group, and seven for the school girls. The heart rates were recorded on a tape and subsequently replayed through a Washington pen-recorder; a minute by minute heart rate was obtained.

The activity sessions included: five gymnastics, six games, one dance, and five Union games for the physical education group, and one keep-fit, two athletics, two net-ball, and two badminton sessions for the school girls. The mean heart rates recorded for the physical education group were: 106.3 bpm for gymnastics, 121.6 bpm for games, and 124.6 bpm for Union games. The values for gymnastics and Union games were significantly different at the .05 level. The school girls had an average heart rate of 129.7 bpm during their activity sessions.

Out of 176 minutes of activity observed involving the school girls, the heart rate exceeded 140 bpm for 61 minutes. Hale and Bradshaw suggested that the physical education sessions monitored were not physiologically demanding enough to promote organic development to any marked degree.

Faulkner, Greey, and Hunsicker (1963) determined the effect of physical activity periods in a youth fitness school on the heart rates of young boys. They measured the heart rates of 42 boys, aged 7 to 12 years, who took part in a daily 35 minute activity period in each of swimming, gymnastics, and sports skills.

Heart rate was obtained by a portable Sanborn Visette Model 300. The child was removed from the class for less than 30 seconds per reading. Six heart rate readings were taken on each subject during each 35 minute period: one during the pre-period activity, and one every five minutes during instruction or practice. A subject's mean daily heart rate for the activity was obtained by averaging the 6 readings. Heart rate sampling in each of the three activities was repeated with the same subjects on three different days to determine the stability of the data.

The authors found that the composite mean heart rate of 148 bpm for sports skills was significantly greater than the 136 bpm found in gymnastics and the 139 bpm found in swimming.

The authors also found that the subject variance was significant in all 3 activities. The three main conclusions that Faulkner and his collegues drew from their study were: . . . "1)the mean heart rate of a random group of participants varies among different activities, 2)the mean heart rate varies in some activities from day to day, and 3)the mean peak heart rates of individual participants vary greatly while exposed to the same class structure."(p. 97).

Costello (1977) studied student behaviour in elementary school physical education classes. Although Costello did not quantify the intensity of activities during a physical education lesson, his study was interesting to examine because he classified the student behaviour during a physical education lesson. In his study, Costello used Laubach's (1975) BESTPED (behaviour of students in physical education classes) System to describe the student behaviour in physical education classes. In this system a natural unit of student behaviour is coded according to its function, mode, content, specific content, and duration.

Using the BESTPED System to describe the behaviour of 193 students, Costello found that 35.4% of class time was spent awaiting, 25.4% of class time was spent receiving information, which generally involved listening to the teacher, and 29.4% of the time was spent either practicing, game-playing, exercising, or exploring. Furthermore, 63.2% of the class time was spent in non-movement, while 27.5% of the time was spent in substantive movement, which reflects the actual participation in physical education activities. One of the most startling results was that 48.8% of the time was spent in non-substantive activity characterized by waiting in line, relocating, and listening to a teacher talk about non-physical education subject matter. This study provides us with some valuable information about the actual activity of a child during his physical education lesson.

In summary, the initial studies noted in this section demonstrate both positive and negative effects of school physical education on physical fitness. However, in the initial studies reported (Taddonio, 1966; Cumming et al, 1969; Knuttgen and Steendahl, 1963; Cooper et al, 1975; Frabicius, 1964; Bar-Or and Zwiren, 1973; Shephard et al,

1979) the actual intensity of a physical education class was not measured. From the results of the latter studies reported, where intensity was measured (Hale and Bradshaw, 1978; Faulkner et al, 1963; Costello, 1977) it would appear that the intensity of a physical education class is insufficient to cause a training adaptation.

Physical Activity

It was interesting to note some studies in which the investigators have examined the habitual physical activity of children. Habitual physical activity studies provide some insight into the daily activities of children and shed some light on the importance of elementary school physical education. As Shephard (1976) states . . . "In particular, we need to answer the challenge that existing physical education programs are insufficient to improve the physiological variables associated with fitness (Cumming et al, 1969), and fail to develop patterns of habitual activity that will persist into adult life."(p. 38).

Gilliam et al (1981) examined the heart rate patterns in children aged six to seven years during the summer using a continuous 12 hour holter monitoring system. Their sample included 22 boys and 18 girls who had volunteered for the study and obtained parental consent. No sex differences in height, weight, and age were present before the experiment began. A holter monitor was worn by each child from 8:00 a.m. to 8:00 p.m. once during June and July. The parents were requested to complete a diary of the child's daily activities on the monitoring day, including information on the environment.

The investigators grouped heart rate into 20 beat intervals, beginning at 80 bpm. Of the 12 hours monitored, the boys and girls had heart rates greater than 160 bpm for only 20.9 and 9.4 minutes, respectively. In contrast, the children were at heart rates less than 120 bpm more than 75% of the time during the 12 hour period. The amount of time the heart rate exceeded 140 bpm was greater for the boys. Gilliam et al concluded that the children, even though moderately active, seldom experienced physical activity of a high enough intensity to promote cardiovascular health.

Seliger et al (1974) attempted to elucidate the relationship between habitual physical activity and physical fitness by providing a comprehensive overview of the activity patterns of eleven 12-year old boys over a 24 hour period. Heart rate was recorded throughout the 24 hour period by telemetry. The boys also kept personal records of their activity, accounting for each minute. The activity records were evaluated in a subsequent personal interview and an attempt was made to quantify the activities as follows: 1)sleep (110% BMR); 2)awake, lying down (120% BMR); 3)moderate activity, sitting or standing, at rest (150% BMR); 4)low intensity activity (300% BMR); 5)moderate intensity activity (500% BMR); 6)medium intensity activity (800% BMR); and 7)heavy intensity activity, moving (1000% BMR).

The investigators found that the subjects spent 44% of the time sleeping, 27% and 25% of their time engaged in mild activities at levels 3 and 4, respectively, and only 3% of the time in moderate or medium intensity activity. At no time did the boys engage in heavy intensity activity.

The mean heart rates of the boys were as follows: 1)sleep=68 bpm; 2)awake, lying down=85 bpm; 3)moderate activity, rest=95 bpm; 4)low intensity=104 bpm; 5)moderate intensity=112 bpm; and 6)medium intensity=118 bpm. Heart rates of 150 bpm were rare and only encountered fleetingly. The individual twenty-four hour heart rate curves showed great variations both in sleep and while awake.

The subjects were also required to perform a bicycle ergometer test in the lab. The mean maximal heart rate obtained on the bicycle ergometer test was 204 bpm. The authors have suggested that the daily heart response implied that very little circulation response was required to support the daily activity. Seliger and his collegues concluded that the use of daily records of activity and heart rate monitoring provides a feasible method of estimating circulatory load from maximum and minimum values.

It was noted that each subject in their study was required to record activity for only one 24 hour period. It is not known whether this period occurred on a weekday or during the weekend. It was also possible that the results were biased in favor of inactivity if the child was unwilling to record a large number of activities.

Rutenfranz, Berndt, and Knauth (1974) investigated the relationship between physical performance capacities and daily activities in fifty boys, aged 11 to 12 years. The PWC 170, as measured on the bicyle ergometer, was used as an indicator of physical performance capacity. A time budget study, involving a questionnaire which each child had to fill out every day, was used to examine the daily activities. The questionnaire included queries about duration of sleep, lessons, way to school, homework, household duties, sports groups, and leisure time activity indoors and outdoors. Data was collected in the summer and winter for a total of 464 days, thus allowing seasonal variations to be noted in this time budget study.

The authors found that a large difference in physical performance capacity (PPC) existed between the boys in this study and therefore they divided the boys into 3 subgroups: 1) high PPC, N=12; 2) medium PPC, N=27; and 3) low PPC, N=11.

The high PPC group had the lowest body weight, while the low PPC group had the highest body weight. The fat content, as determined by skinfolds, increased correspondingly from the children with the high PPC to the children with the low PPC.

The results of their study demonstrated that children differing in PPC showed similar differences in their daily life patterns. The children with a high PPC slept less and spent a larger proportion of their movement activities at a high intensity during their leisure time than the children with a low PPC. Rutenfranz et al suggested that the differences in the daily activities alone cannot explain the differences in physical performance capacity between the groups, but that more attention, in the future, should be given to the behaviour of children with regard to their budgetting of daily hours, especially during their leisure time.

Kemper and Verschuur (1974) have also examined the role of habitual physical activity in young boys. They investigated the habitual physical activity of 71 Danish school boys, aged 12 to 13 years, through the use of a questionnaire-interview and by the measurement of scores obtained on pedometers. Their questionnaire categorized the total time spent during leisure time into three headings: transportation to and from school, participation in sporting clubs, and all other activities. The pedometer is an instrument that measures vertical displacements. The pedometer was attached to the waist of the subject, allowing all movements of the centre of gravity to be measured and totalled over a given period. The totalled score was used as a measure of the amount of physical activity. The pedometer was used to measure the leisure time activity during 3 periods of the week: from Monday afternoon to Tuesday morning, from Wednesday noon to Thursday morning, and from Friday afternoon to Monday morning. To avoid seasonal influences each measurement was performed for each boy twice a year, during the fall and during the spring.

From the questionnaire results, Kemper and Verschuur were able to conclude that of the total leisure time, 30.8% was spent for transportation , 16.1% was spent for organized activities, and 53.1% was spent for all other activities. The mean pedometer scores were higher in relation to the length of the measurement period. High inter-individual differences in habitual activity were demonstrated in the observed minimum and maximum pedometer scores.

Perhaps the most pertinent part of their study was the measurement of total activity during normal lessons of physical education. The score of each lesson was obtained by averaging scores of 5 randomly chosen pupils. The mean pedometer score for 10 lessons of physical education varied from 2670 to 3250, depending on the teacher. If a predicted pedometer score of 6000 is assumed as a result of two extra lessons of physical education a week, the increase in the total physical activity for a very inactive boy with a predicted weekly total pedometer score of 24,000 is 25%. On the other hand, for a very physically active classmate with a predicted weekly pedometer score of 180,000, the same two extra lessons result in an increase in the total habitual activity of only 3%. Kemper and Verschuur suggested that the same training effect can not be expected for both subjects.

PHYSIOLOGICAL VARIABLES

HEART RATE

Under normal conditions, the heart is under the control of the autonomic nervous system. Both the sympathetic and parasympathetic nerve impulses can modify the heart rate (Astrand and Rodahl, 1977). The sympathetic nervous system has an excitatory effect on the heart and acts via the cardiac plexus to increase the heart rate. The parasympathetic nervous system has an inhibitory effect on the heart, and thus causes a decrease in heart rate via the vagus nerve (Astrand and Rodahl, 1977; Mathews and Fox; 1976).

In addition to nervous control, the heart has it's own pacemaker, the sino-atrial node, that will initiate approximately 70 impulses per minute (deVries, 1974; Astrand and Rodahl, 1977).

FACTORS AFFECTING HEART RATE:

1. The Age and Sex Trends in Heart Rate

The resting heart rate is quite variable throughout life, with a wider variation between the extremes in younger persons (Lowrey, 1973). The resting heart rate at birth is between 130 and 160 bpm, and falls gradually and equally for both sexes each succeeding year until adolescence (Lowrey, 1973; deVries, 1974; Espenschade and Eckert, 1967). Between the ages of 10 to 15 years, the boys' rate decreases more rapidly (Clarke, 1979; Espenschade and Eckert, 1967; Iliff and Lee, 1952) so that in adults, the resting rate is approximately 10% greater in females than in males (Clarke, 1979; Espenschade and Eckert, 1967). The average rate in a resting adult male is approximately 78 bpm in the standing position (deVries, 1974).

Table I illustrates the fall in the resting heart rate from birth to adolescence.

TABLE I: AVERAGE HEART RATE FOR INFANTS AND CHILDREN AT REST*

AGE	AVERAGE RATE	2 STANDARD DEVIATIONS
birth	140	50
1 month	130	45
1-6 months	130	45
6-12 months	115	40
1-2 years	110	40
2-4 years	105	35
6-10 years	95	30
10-14 years	85	30
14-18 years	82	25

*adapted from LOWREY, 1973 (p. 214)

The maximal attainable heart rate shows a gradual decline with age in adults (deVries, 1974; Astrand and Rodahl, 1977; Vitale, 1973). Astrand and Rodahl (1977) stated that "there is a gradual decline in maximal heart rate with age, so that the ten-year-old attains 210, the sixty-five-year-old only about 165 beats per minute" (p.

189).

A conservative formula for estimating maximal heart rate is 220 minus the age of the individual (Vitale, 1973). However, this formula may provide an estimate that is too high for children as demonstrated by various training studies done on children . Eriksson and Saltin (1974) found maximal heart rate values of 196 for boys 11.6 and 12.6 years of age who exercised on an electrically braked bicycle ergometer. Kramer and Lurie (1964) found mean maximal heart rates of 191 beats per minute for trained, normal boys, aged 12 to 17 years, who exercised on a cycle mill. Wirth et al (1978) found a maximal heart rate of 180 bpm for seven prepubertal swimmers who were exercised on a bicycle ergometer. Their mean age was 10.8 years. Macek et al (1976) tested a group of ten boys, whose mean age was 12.75 years, on both the bicycle ergometer and the treadmill. They found maximal heart rate values of 200 bpm on the bicyle ergometer, and 203 bpm on the treadmill.

2. Physical Activity and Training

The heart rate is the most often used index of circulatory function during exercise because of its relationship to oxygen consumption, workload, and training, and its simplicity of measurement (Mathews and Fox, 1976). The heart rate has often been used as a measure of work intensity (Gilliam et al, 1981; Karvonen et al, 1957; Massicotte and Macnab, 1974).

Physical training results in a decrease in the heart rate that occurs in the resting state and at each level of work (Amsterdam et al, 1977; Mathews and Fox, 1976; Fox, 1979; Astrand and Rodahl, 1977; Karvonen et al, 1957). It is not uncommon to find resting heart rates between 40 to 55 bpm in highly trained male and female endurance athletes (Fox, 1979). There are indications that this resting bradycardia and reduced heart rate during a standard work load after a period of physical training is induced by an increase in vagus tone and a reduction in sympathetic drive (Astrand and Rodahl, 1977; Mathews and Fox, 1976). Another theory that has been put forth for the reduced heart rate during submaximal work deals with the stroke volume of the heart. There is an increase in stroke volume during submaximal workloads with training, so that a trained individual can obtain an adequate cardiac output at a lower pulse frequency than before training (Brouha, 1959; Fox, 1979). This slower beating of the heart with a larger stroke volume represents a more efficient energy utilization by the myocardium (Fox, 1979).

Response of Heart Rate to Exercise

The heart rate increases as soon as exercise begins and in many instances even before (Brouha, 1959; deVries, 1974; Hanson, 1967). The anticipatory rise in heart rate prior to exercise is commonly attributed to a diminution of the vagal tone reflexly produced by the mental preparation of the effort to be made; it originates in the CNS (Brouha, 1959).

The first increase in the heart rate takes place rapidly and is followed by a second phase during which the level and the behaviour of the heart rate are determined mostly by the workload (Brouha, 1959; deVries, 1974).

Brouha (1959) has outlined the heart rate response to variable workloads:

> "When the workload is variable, the pattern of heart rate follows each change closely: an increase in load produces an increase in heart rate and vice versa. The relative abruptness of the change depends on the degree of difference in workloads. For a small load increase the heart rate will rise smoothly to establish a new, more elevated plateau; for a marked load increase the change is rapid, the adaptation to the heavier load starts immediately and is achieved in a short time. The reverse is true for decreasing work loads."(p.181)

Recovery Heart Rate

The heart rate decreases almost immediately when work stops (Brouha, 1959). Several factors may influence the decrease of the heart rate during the beginning of the recovery period, including max VO2, the work heart rate, and the difference between the work and rest heart rates (Shapiro et al, 1976).

For a given individual, a heavier workload elicits a higher heart rate during exercise and causes a longer time period to be taken for the heart to return to it's normal resting level (Skubic and Hodgkins, 1965; Maxfield and Brouha, 1963; Brouha, 1959; Nandi and Spodick, 1977). Physical training results in a smaller increase in the heart rate for a given workload and a more rapid return of the heart rate to its resting value (Maxfield and Brouha, 1963).

When exercise is not continuous, the heart rate recovery reactions are determined by the total work performed and by the duration of the rest periods (Skubic and Hodgkins, 1965). The recovery can be complete for light work in a short time even when several periods of exercise have already taken place. For heavier work the recoveries become less and less complete for a given rest time, so that the recovery reactions remain at a progressively higher heart rate level as the number of exercise periods increase (Brouha, 1959).

Variations in Exercise

When only specific muscle groups are trained, the heart rate is subsequently lower when those muscles work but is not during exercise involving other muscles which were not included in the training process (Amsterdam, 1977). An isometric exercise will also increase the heart rate above the value expected from the workload (Astrand and Rodahl, 1977; Brouha, 1959). The heart rate at a given oxygen uptake is higher when the work is performed with the arms than with the legs (Astrand and Rodahl, 1977; Fox, 1979).

3. Body Position and Posture

The heart rate is lowest when lying, higher when sitting, and higher yet when standing (Vitale, 1973; Astrand and Rodahl, 1977). The typical response to the change from the lying to the standing position appears to be an increase of 10 to 12 bpm (deVries, 1974).

4. Body Temperature

An increase in body temperature above the normal value causes an increase in heart rate. It is estimated that for every degree fahrenheit that an individual's resting oral temperature lies above the average, the heart rate also lies 11 bpm above the average (Espenschade and Eckert, 1967). With a decrease in body temperature the heart rate also declines, until a temperature of approximately 26 degrees centigrade is reached, at which temperature abnormal electrocardiographs are obtained that illustrate a danger of heart failure (deVries, 1974).

5. Environmental Factors

Environmental temperature is one of the most important factors affecting the heart rate and total cardiovascular response to exercise. There is a linear relationship between the environmental temperature and the increase of the heart rate both at rest and during work (Brouha, 1959). At rest, small increases in heart rate are seen as temperature increases (deVries, 1974). Prolonged exercise in a hot environment causes a higher heart rate than exercise at a low room temperature (Astrand and Rodahl, 1977). Humidity also affects the heart rate. For any given temperature and workload, the rise in heart rate will be greater if the humidity is high and the air is motionless (deVries, 1974).

6. Food Intake

The resting heart rate is higher while the digestive processes are in progress than in the post absorptive state (deVries, 1974).

HEART RATE VERSUS OXYGEN CONSUMPTION RELATIONSHIP

The relationship of heart rate to oxygen consumption, while unique to each individual, is linear over the common range of daily activities (Spady, 1980; Shephard, 1971; Margaria et al, 1965; Astrand and Ryhming, 1954; Cumming and Danzinger, 1963). Astrand and Ryhming (1954) performed experiments with healthy subjects from 18 to 30 years of age and found that the relationship between oxygen consumption and heart rate was linear within the heart rate range of 125 to 170 bpm.

However, there is evidence to suggest that the relationship between heart rate and oxygen consumption is not linear at very low intensity exercise (Margaria et al, 1965), and very high intensity exercise (Davies, 1968). At the lower levels of work it is believed that the heart rate is more susceptible to emotional disturbances (Shephard, 1971). At the higher levels of work, near maximal effort, the relationship breaks down and the curve becomes asymptotic (Davies, 1968).

Shephard (1967) has suggested that over the full range of metabolic activity a sigmoid relationship exists between pulse rate and oxygen consumption due to the combined effects of hemoglobin level and stroke volume. Because there is normally a small increase in both the red cell count and the hemoglobin concentration per unit of blood with an increase in metabolic activity, there is a tendency for the heart rate to increase less than the oxygen consumption at work loads that are heavy enough to induce this effect. The variations that occur in stroke volume with exercise tend to be accompanied by a smaller increase in pulse rate for a given increment of oxygen consumption at low than at high work loads. Shephard (1967) does agree, however, that the relationship between oxygen consumption and heart rate is almost linear in moderate and vigorous activity, between 35 to 90% of the aerobic power.

Cumming and Danzinger (1963) found that the linear relationship between heart rate and oxygen consumption in children was maintained to a heart rate of approximately 180 bpm, after which the relationship became asymptotic. They tested 41 grade five boys and girls, aged 10 to 11 years, on a bicycle ergometer. Cumming and Danzinger found that the average oxygen consumption at a pulse rate of 170 bpm was 73% of the max VO2 of the children in this study. In the average adult the oxygen consumption at a pulse rate of 170 bpm was about 80% of the max VO2 (Wahlund, 1948).

There are various factors which affect the heart rate-oxygen consumption relationship. These factors include physical conditioning, age, sex, ambient temperature, fatigue, elapsed time after the previous meal, time of day, disease, stress and emotion, and the mechanical efficiency associated with the work task (Metz and Alexander, 1971; Rowell et al, 1974; Shephard, 1967; Hermansen and Oseid, 1971; Andrews, 1969). If an oxygen consumption-heart rate regression line is used, as many factors as possible must be standardized at levels or within ranges that are representative of those which are expected to accompany the anticipated uses of the regression lines (Andrews, 1969). Fitness level, environment, age, and sex are usually easily controlled in a study. However, fatigue, absorption, and possible illnesses are factors that are difficult to control and therefore these may cause limitations in the use of the regression lines.

THE DEVELOPMENT OF MAX VO2 DURING CHILDHOOD AND ADOLESCENCE

Difficulties with Childrens' Studies

A number of difficulties are encountered by investigators involved in research concerning training studies in children. The results from training studies are usually compounded by growth changes. The evaluation of training effects in children is difficult, particularly with regard to long-term training, since aging itself appears to simulate many physiological changes produced by training (Astrand, 1976).

It is also difficult to elicit changes in max VO2 in children with training because of the high training threshold that children possess. In the percentage of difference between the resting and maximal heart rate, it appears that the training threshold in children is above 75%, compared to 60% in adults (Massicotte and Macnab, 1974). This apparently high threshold for a training effect on the max VO2 in children is probably related to their naturally active and vigorous lives (Stewart and Gutin, 1976). It may be that the majority of the young children are already at or near their potential maximal working capacity (Shephard, 1971), and therefore training has little effect on a max VO2 value.

Another problem in measuring max VO2 in children is the difficulty with motivation on maximal tests. The young child may have a tendency to "give up" before the true maximal values are reached (Astrand, 1952).

There is also some evidence to suggest that children participating in athletic training may be a selective group who have a genetically inherited aerobic capacity that is superior to their peers (Sprynarova, 1974). Since regular training in previously trained persons can, in most cases, increase the max VO2 not more than 10 to 20%, it is evident that the natural endowment is the most important factor determining the individual's maximum VO2 (Astrand and Rodahl, 1977). Subject selection, therefore, could possibly bias a study towards high or low max VO2 values and should be considered in the critical analysis of research.

Trends in Max VO2 Values for Children and Adolescence

Investigators examining the area of max VO2 in children appear to be in two main camps: those who suggest that values for children and adolescents are relatively the same, and those who suggest that values for the adolescent are higher. Shephard (1971), after reviewing many studies on boys from 6 to 18 years of age, commented "that boys with an aerobic power of 48 to 50 ml/Kg-min are close to their potential and that rewards of training are small" (p. 337). Koch (1980) studied nine boys for three years, beginning at age 12, while they were engaged in a high amount of physical activity. The mean initial max VO2 of his subjects was 59.5 ml/Kg-min and there was no substantial increase in this particular parameter over the 3 years of high physical activity. Koch (1980) suggests that the results of this study imply that 60 ml/Kg-min represents the average upper limit of trainability at the ages of 12 to 15 years.

The results of many studies are presented in table II. It was interesting to note that when the prepubescent boys, that is, the boys before the age of 12, were considered, the max VO2 values were around 48 to 50 ml/Kg-min, with few exceptions. It was also interesting to note that most of the values for boys between 12 to 15 years were around 60 ml/Kg-min. A number of possible reasons for this apparent division of max VO2 values between prepubescent and adolescent children have been suggested and will now be presented.

Training in Children Prior to 11 to 12 Years of Age

Children can train or be trained to achieve high levels of health related fitness, but the cost in effort is high. As has been previously mentioned, children have a very high training threshold, and it may be that training during the years prior to puberty is very inefficient because their aerobic machinery has not reached its potential development.

TABLE II: MAX VO2 VALUES IN BOYS

AGES	N	ERGOMETER USED	VALUE (ml/kg-min)	REFERENCE
8.6	22	treadmill	47.6	Krahenbuhl et al, 1977
10.0	66	treadmill	56.5	Cunningham et al, 1977
10.8	45	bicycle	53.4	Gaisl et al, 1980
10-11	16	bicycle	48.3	Scmucker et al, 1974
10-12	13	treadmill	49.5	Stewart & Gutin, 1976
11.0	6	treadmill	59.4	Ekblom, 1969
11-13	9	bicycle	51.8	Massicotte et al, 1974
12.0	9	bicycle	59.5	Koch, 1980
12.5	20	treadmill	58.1	Hermansen et al, 1971
12-13	17	bicycle	52.9	Scmucker et al, 1974
10-15	14	treadmill	59.5	Daniels et al, 1971
13.0	120	treadmill	59.3	Kemper et al, 1980
14.0	64	treadmill	58.8	Kemper et al, 1980
16.0	9	bicycle	72.6	Koch, 1980
9-14	7	treadmill	63.2	Kobayashi et al, 1978
13-17	43	treadmill	52.2	Kobayashi et al, 1978
14-17	6	treadmill	73.2	Kobayashi et al, 1978

Corbin (1980) suggests that unless the child is extremely motivated to train or unless there is some compelling reason for the training, it appears that most children would be best encouraged to maintain reasonable levels of health related fitness in childhood but to save efforts at intense training for a time when the effort-benefit ratio is more efficient.

Kobayashi et al (1978) failed to find an effect of training before the age of 12 in their longitudinal study on Japanese school boys. They suggested that physical training at prepubescent ages may not appreciably improve aerobic power. Hamilton and Andrew (1976) found that stroke volume was similar in both trained and untrained prepubescent boys, which implies a limitation for cardiac development potential prior to puberty. Eriksson and Koch (1973) and Gatch and Byrd (1979) did, however, find an increase in stroke volume in pubescent and prepubescent boys with training.

However, this is not to suggest that physical training would be detrimental to a young child. Certainly, some of the training effects that have occurred in young subjects are desirable. For example, there have been many reports of an increased efficiency at submaximal workloads with training (Koch, 1980; Lussier and Buskirk, 1977; van Dobeln and Eriksson, 1972; Stewart and Gutin, 1976; Harmon et al, 1972). This allows a person to work for a longer time at the same heart rate, or for a given submaximal oxygen demand to be met with a slower heart rate (Stewart and Gutin, 1976). Aerobic training also alters the body composition, either by loss of fat, an increase in the muscle mass, or by both mechanisms (McMiken, 1976; Parizkova, 1980). Physically active children tend to have a higher proportion of lean body mass to body fat (Zaichowsky et al, 1980). Bailey and his collegues (1980) suggest that the adaptive responses that are generated through vigorous physical training during youth result in persistently favorable influences on the organism during growth and development and into adulthood.

Training in Adolescence

Although training in childhood seems to be inefficient, this does not appear to be the case in adolescence. Many changes that are associated with the pubertal growth spurt appear to enhance the aerobic power of an individual undergoing physical training.

Kobayashi et al (1978) longitudinally examined changes in max VO2 in relationship to chronological age and body growth as indicated by body height in fifty Japanese school boys and six superior junior athletes. They divided their subjects into three groups: group one, which trained for 1 to 1.5 hours per day, 4 to 5 times per week, (N=7); group two, which took part in regular physical education classes and recreation, (N=43); and group three, highly trained winners of Japanese Junior Championships for middle distance running events. Aerobic power increased in all three groups, particularly around the age of peak height velocity (PHV). From approximately one year prior to the age of PHV and thereafter, training effectively increased aerobic power above the normal increase attributable to age and growth. Kobayashi and his collegues suggest that the striking increase in aerobic power, observed for many subjects to be closely related to the age of PHV, might be mainly the result of the rapid increase in physical parameters occurring at that time.

An increase in aerobic power around the age of PHV makes sense when one considers the fact that the peak increment in height velocity closely coincides with the peak increment in weight and in lean body mass (Parizkova, 1976). The LBM, or the active tissue mass, is closely related to the max VO2. If a person possesses a larger LBM, he should therefore possess a proportionately larger max VO2.

Cheek (1969)(as cited in Bailey, 1975) provides further evidence for an increase in LBM during adolescence when he states:

> "Most muscle hyperplasia occurs in fetal life and early postnatal life, but during adolescence, presumably under the influence of adrogens, hyperplasia of muscle cells undergoes marked resurgence."

Further evidence for training effects during adolescence was provided by Sprynarova (1974), who longitudinally studied the maximal aerobic power of boys from age 11 through to 18. He divided his subjects into 3 groups: group one, who regularly trained for 2 hours 2 times a week up to 15 years of age, and 3 times a week thereafter, (N=8); group two, who trained, but not on a regular basis, (n=19); and group three, who were considered as untrained, (N=12). The age range studied was viewed as consisting of two parts according to the rate of the functional growth of the oxygen transport system. The results demonstrated a rapid increase in max VO2 to the age of 15 years followed by a slow down. An inspection of the greatest and least max VO2 per kilogram values obtained by each boy showed the greatest value to coincide with the pubertal growth spurt. The mean of the individuals' greatest max VO2 per kilogram value was significantly greater in group one than that of the other two groups. Sprynarova suggests that these results imply that the pubertal period is particularly susceptible to training effects.

D. EXERCISE INTENSITY STUDIES

Several investigators have examined the idea of an optimal means of obtaining a physiological training effect. The factors affecting the optimal achievement of the training effect most often studied are those of intensity, duration, frequency, and initial fitness level (Sharkey, 1970; Crews and Roberts, 1970; Burke and Franks, 1975).

Several investigators have examined the role of intensity during exercise and the idea of a training threshold heart rate. Unfortunately, these studies are often confounded by a factor relating to duration, total work, or energy expenditure (Sharkey, 1970). It is also unfortunate that a large number of these studies have used adult subjects. However, it was interesting to examine the idea of a minimal training threshold. A number of studies examining the minimal training threshold in older subjects will therefore be presented.

Karvonen et al (1957) studied six male medical students, aged 20 to 23 years. The medical students trained by running on a treadmill for thirty minutes a day, four to five days a week, for four weeks. The different subjects were trained at different heart rate intensities by adjustment of the treadmill speed. The investigators expressed the intensity of heart rate as a percentage of the total range of pulse rates from rest to the maximal attainable by running. They found that a more intense level of training, that is, taxing at least 60% of the available range of pulse rates, or a heart rate of approximately 150 bpm, caused a training effect as measured by the heart rate elicited at a given workload.

Sharkey and Hollman (1967) also found that it was necessary to work at a heart rate of 150 bpm to obtain a training effect. They studied the effects of a 6 week treadmill training program that went three days per week for 10 minutes a day on 16 college men, aged 18 to 19 years. Sharkey and Hollman had 4 groups in their study: 3 training groups who trained at heart rates of 180, 150, and 120 bpm, respectively, and a control group who participated in a fencing class. They found significant differences in the results of a step test and a Balke treadmill test between the 180 training group and all others and the 150 training group and all others. Sharkey and Hollman suggest that an intense activity is more effective in eliciting training changes than when a light or moderate activity is used as a training stimulus.

Thad and Crews (1976), utilizing a pre to post PWC 170 measurement, have also suggested that a heart rate of 150 bpm is effective in causing a training effect. They trained 43 sedentary men, with a mean age of 39.5 years, for 7 weeks with a running program. The subjects were divided into six training groups representing all possible combinations of 3 levels of frequency of training (5,3, or 1 day/ week), and 2 levels of intensity of training (exercise heart rates of 150 and 120 bpm). Their results revealed no significant interaction effect for any of the dependent variables. The results, however, did indicate a greater training effect, as demonstrated by a PWC 170 score, for the 150 heart rate groups over the 120 heart rate groups.

Burke and Franks (1975) studied the effects of a 10 week bicycle ergometer training program on the max VO2 of 16 males, aged 16 to 18 years. The subjects were randomly assigned to one of three training groups or a control group. The training groups trained 3 days per week on a bicycle ergometer at different intensities (85%, 75%, or 65% of heart rate maximum), with all groups doing the same total mechanical work (12,000 kpm per training session). The control group participated in physical education lessons. The investigators found significant post test differences in a max VO2 test between both the 85% and 75% groups and the control group. No significant differences were found between the 85% group and the 75% group or between the 65% group and the control group. Burke and Franks (1976) concluded that "when comparing between training intensities while holding total mechanical work constant at 12,000 kpm per training session, it is necessary to work at a minimum of 75% of the maximum heart rate to elicit a significant change in VO2 max" (p. 37). Training at 75% of the maximum heart rate in this study was equivalent to training at 143 bpm.

Faria (1970) studied the effects of a 4 week bench stepping training program on a PWC 180 measurement on 40 college men with a mean age of 20.55 years. The subjects were randomly assigned to one of three training groups or a control group. The training consisted of bench stepping until an assigned heart rate of 120 to 130, 140 to 150, or 160 to 170 bpm was elicited, 5 days per week, for four weeks. The control group participated in a regular physical education volleyball class three times per week. Analysis of the results revealed that there was no significant difference on a post-test PWC 180 measurement between the 140 to 150 and 160 to 170 training groups. Faria suggested that the training threshold for a training effect on the cardiovascular system, reflected by a lower heart rate for a given amount of work, lies somewhere below 140 bpm for the subjects in this study. Faria also notes that:

> "One might conclude that there is a threshold value in terms of working heart rate, below which no training effect will occur. However, this threshold may vary individually and be related to cardiovascular fitness status at the outset of the training program." (p. 49)

The preceding studies suggest that a heart rate of at least 140 bpm is necessary to elicit a training effect. The question as to the exact training heart rate threshold is still unsettled, however, and it appears that intensity is not the only factor to consider in obtaining a training effect. It is also interesting to note that the term "training effect" is applied to both an improvement in submaximal work, as reflected by a lower heart rate (Faria, 1970; Sharkey and Hollman, 1967; Karvonen, 1957); and an improvement in maximal aerobic power, as reflected by an increase in max VO2 (Burke and Franks, 1975). Perhaps the training intensity required to elicit a change in max VO2 is greater than that which is required to elicit a submaximal training effect, although the evidence provided in the study by Burke and Franks (1975) would suggest that it is not. They obtained an increase in max VO2 at a training heart rate of 143 bpm. However, studies involving children (Stewart and Gutin, 1976; Massicotte and Macnab, 1974) suggested that it was possible to elicit submaximal training effects at lower heart rates in children than those required to elicit changes in max VO2. The studies on training intensities in children will now be presented.

Massicotte and Macnab (1974) studied the effects of a bicycle ergometer training program on max VO2 in 36 boys, aged 11 to 13 years. The subjects were tested on a bicycle ergometer to determine their max VO2 prior to the study. They were then ranked according to their max VO2, blocked into three fitness levels, and randomly assigned to one of four treatment groups. The first group trained at a heart rate of 170 to 180 bpm (T1); the second group trained at 150 to 160 bpm (T2); the third group at 130 to 140 bpm (T3); and the fourth group acted as a control group (T4). The training was conducted on the bicycle ergometer three times a week, for 12 minutes a session.

Following the six week training period, the submaximal heart rates on the bicycle ergometer decreased significantly in the T1, T2, and T3 training groups by 16, 12, and 16 bpm.

There was no significant differences, however, in the control group and also between the decreases of the three training groups. The max VO2 improved significantly by 11% in the T1 group but remained essentially unchanged in the T2 and T3 training and control groups.

Massicotte and Macnab have postulated that as long as the training heart rate is above 130 bpm, substantial decreases in heart rate at a given submaximal work load can be achieved with children. However, they suggest that the training threshold necessary to increase the aerobic capacity is different to the stimulus decreasing the submaximal heart rate. The training threshold for an improvement in aerobic capacity in children appears to be above 170 bpm. This training stimulus corresponds to approximately 75% of the difference between the resting and maximum heart rates, compared to 60% in adults. Massicotte and Macnab (1974) suggested that "the training stimulus in terms of heart beats, necessary to improve the aerobic capacity in children, is higher than in adults, probably because their maximal heart rate is slightly higher and thus the relative intensity is different for the same heart rate when compared with adults" (p. 245). Gilliam et al (1981) have postulated that if the same standard of 60% of the heart rate range used for training adults is applied to children, the target heart rate would need to be at least 160 bpm. As Burke and Franks (1975) noted: "Two individuals working at a heart rate of 150 are not necessarily working at the same intensity if they have different maximal heart rates." (p.32).

Stewart and Gutin (1976) studied the effects of an eight week interval running program on the max VO2 of previously untrained children. Their sample consisted of 24 boys, aged 10 to 12 years, 13 of which trained, and 11 of which acted as controls. Each subject performed a pre and post submaximal bicycle ergometer test and a maximal treadmill test.

Interval training was conducted during the physical education classes. Training sessions were held four times a week for eight weeks. The control subjects participated in the regular physical education class which contained various stretching exercises and/or low-activity games. Telemetered heart rates of randomly selected subjects during the sessions indicated that the training group was working at approximately 90% of the mean maximal heart rate of 207 bpm, or 185 bpm; while the control group was working at approximately 55% of the mean maximal heart rate, or 115 bpm.

Stewart and Gutin found that no changes occurred with training for max VO2 and cycling VO2. However, they did find that the mean cycling heart rate and submaximal treadmill heart rates decreased significantly in the trained group while no change occurred in the controls.

It is possible that the interval training used was not of a sufficient intensity or ion to affect the children studied. As Stewart and Gutin noted:

> ". . . for training to be effective in increasing the VO2 max in children, it must clearly be of greater intensity than that to which the subjects are accustomed and administered over a prolonged period of time. The apparently high threshold for a training effect on the VO2 max in children is probably related to their naturally active and vigorous lives." (p. 117)

Stewart and Gutin suggested that the main effect of short-term physical training in children leads to improvements in submaximal cardiorespiratory function that are independent of changes at maximal efforts. They concluded, therefore, that the assessment of the training effect in children warrants the consideration of submaximal physiological and work performance measures as well as maximal ones.

Lussier and Buskirk (1977) studied the cardiovascular effects of a 12 week endurance training program in 26 prepubertal boys and girls, aged 8 to 12 years. Sixteen of the children trained, while ten acted as controls. The training regimen consisted of distance running for progressively longer periods (from 10 to 35 minutes), two times per week, with 2 additional sessions per week devoted to running games. A single session was 45 minutes long. The intensity of the work was assessed from running pace and heart rate. The target workout intensity was 75 to 80% of max VO2, which corresponded to a heart rate of approximately 185 bpm. Increased distances were covered by the experimental group during ten minute run trials, conducted at monthly intervals. The heart rate at submaximal workloads on the treadmill for both running and walking decreased significantly in the trained group. The max VO2 increased significantly in the trained group, by an average of 7%, but not in the controls. The authors concluded that prepubertal children respond to an endurance training program by improving their running capacity, which is, to a limited extent, associated with increased aerobic capacity.

III. METHODS AND PROCEDURES

A. THE SCHOOL

Millgrove Elementary School, situated in Spruce Grove, Alberta, is a progressive school that opened in September, 1977. One of the primary anticipated outcomes, which imply the general goals and objectives of the school, was improved pupil fitness (Millgrove School Proposal, 1977). Many of the teachers are physical education specialists, since each home room teacher is required to teach his or her class physical education. The students of the school are required to attend physical education class for one hour per day. Although a portion of this class time is theoretical, the emphasis is on physical activity.

B. THE SAMPLE

The sample selected for this study consisted of four randomly selected boys, aged 10 to 11 years, from one grade five class in Millgrove Elementary School. The sample was limited to males only because of the equipment difficulties associated with monitoring female heart rates during class. The principal of Millgrove School was asked to select a grade five teacher whom he considered a good physical educator. The investigator then met with this teacher, explained the study to him, and asked for his cooperation. The teacher granted full cooperation. The four subjects were then randomly selected from his class.

A brief letter explaining the study and a consent form were sent home with each child that had been selected for the study (Appendix A). The signed consent forms were returned to the school for all four initially chosen subjects.

C. PROCEDURES

The heart rate of each subject was monitored during 9 physical education classes by an exersentry heart rate monitor (Respironics, Inc.). The exersentry is a small lightweight device that is strapped to the chest of an individual. Soft plastic electrodes contained within the strapping monitor the electrical signal of the heart. The exersentry provides a digital readout of heart rate which is recomputed every 4 beats and displayed. The subjects were able to run, climb on apparatus, jump, roll, and do many other activities with no observable restrictions caused by the machines.

The exersentrys were brought into the chosen grade 5 physical education class at Millgrove Elementary School in the third week of January, 1982. The study was explained to the entire class and questions were received. All four of the randomly selected subjects wore the heart rate monitors for at least 2 classes before test data were collected. This was considered a reasonable amount of time for the child to become accustomed to wearing the monitor and calling heart rates.

DATA COLLECTION

The test data were collected at Millgrove School from January 20 to March 18, 1982. The grade five physical education curriculum consisted of 5 classes per week: 2 gymnastics classes, 1 dance, 1 games, and 1 outdoor education class. Data was collected for 3 classes for each subject in each of the areas of gymnastics, dance, and games, for a total data collection of 9 classes per subject. The outdoor education class was not monitored due to winter weather and clothing.

The investigator monitored 2 subjects per class. For the first three weeks of data collection, all 4 subjects wore an exersentry heart rate monitor during physical education class. However, only 2 subjects were monitored. The investigator felt that this allowed each subject to become more comfortable with the instrument. The subjects did not know prior to the class whether they were being monitored or not. This was considered to help decrease any anticipatory rise in heart rate that may have occurred. The investigator chose the subjects to be monitored in such a way that: 1) no subject was monitored for 2 consecutive classes, and 2) the same two subjects were not always monitored together.

After the subjects dressed for physical education class, they reported immediately to the investigator in the gymnasium. For the first three weeks of the study, the investigator applied the exersentrys to all four of the subjects for the physical education classes. Following this period, the investigator applied the exersentry to only those subjects to be monitored for that day.

The heart rate was recorded at the beginning of the class, and a stop watch was started. Approximately every 30 seconds the investigator received heart rate information from the subjects being monitored. Heart rate information was obtained by the investigator either visually or verbally. If the subject was sitting or standing quietly, the investigator visually observed and recorded the value. If the subject was in activity, the investigator called to the subject, who then looked at the digital display and relayed the heart rate to the investigator verbally. At the end of the class the heart rate was recorded for the last 30 second segment and the exersentry was removed.

During each 30 second interval, the investigator noted the activity that was being performed to elicit the heart rate. These ancedotal records were used in the description of the data.

HEART RATE CATEGORIZATION

The heart rates recorded during each class were graphically displayed (Appendix B). The longest plateau of the heart rate above 130 bpm was noted from each graph and recorded. The heart rates were then categorized as follows: resting ($\leq$100 bpm); mild (101-130 bpm); moderate (131-159 bpm); and severe ($\geq$160 bpm). In addition, the following heart rates were categorized: high mild (120-130 bpm), and high moderate (150-159 bpm). The total number of heart rates recorded in each category during all the classes for each of the gymnastics, dance, and games areas was divided by the total number of heart rates recorded during each area to provide the percentage of class time spent in each heart rate category (See Appendix C for sample calculation).

LABORATORY VISIT

The subjects visited the exercise physiology laboratory at the University of Alberta twice during the study: once on February 6 and once on February 27. Both visits occurred from 12 noon to 4 o'clock p.m. Each subject was instructed to eat lightly before visiting the laboratory. The types of measurements taken on each subject during the two laboratory visits are reported in table III.

TABLE III: MEASUREMENTS TAKEN DURING LABORATORY VISITS

FEBRUARY 6	FEBRUARY 27
height weight bicycle ergometer	height weight skinfolds bicycle ergometer

LABORATORY PROCEDURES

Height and Weight

Height and weight were recorded on a medico-detecto scale. Height was recorded to the nearest .5 of a centimeter while weight was recorded to the nearest tenth of a kilogram. Shoes were removed for both measurements. Subjects were clothed in shorts or sweat pants.

Skinfolds

Skinfold measurements, consisting of the triceps, biceps, subscapular, and suprailiac sites, were taken on each child (Quinney and Conger, 1981). Each site was located on the right side of the body and then marked with a felt pen. A harpenden skinfold caliper was used for all measurements. Each skinf[illegible]d was recorded to the nearest 0.1 [illegible]imeter. Each site was measured twice. If the measurements for one site differed by more than 0.4 millimeters, a third measurement was taken and the mean of the closest pair was recorded. The skinfold measurements were taken in the following order: triceps, biceps, subscapular, and suprailiac.

Triceps Skinfold

The site was located halfway between the acromion and olecranon on the back of the right arm and marked with a felt pen. The subject stood with the arms extended by the side in a relaxed position. The skinfold, which was parallel to the long axis of the arm, was raised with the thumb and forefinger of the left hand of the investigator over the subject's triceps muscle and measured.

Biceps Skinfold

The site was located on the front of the right arm, directly opposite the triceps site. The subjects stood with the arms extended by the side in a relaxed position. The skinfold, which was parallel to the long axis of the arm, was raised with the thumb and forefinger of the left hand of the investigator over the subject's biceps muscle and measured.

Subscapular Skinfold

The site was located just lateral to the inferior angle of the right scapula and marked. The subject stood in normal, relaxed posture. The skinfold, which was at an approximately 45 degree downward sloping angle to the inferior angle of the scapula, was raised with the thumb and forefinger of the left hand of the investigator and measured.

Suprailiac Skinfold

The site was located approximately 2 centimeters above the right anterior superior iliac spine and marked. The subject stood in normal, relaxed posture. The skinfold, which sloped slightly downward, was raised with the thumb and forefinger of the left hand of the investigator and measured.

Bicyle Ergometer Test

The bicycle ergometer test was a continuous test which consisted of two parts. The first part of the test was considered as a calibration procedure, at which time an individual heart rate-oxygen consumption relationship was obtained for each subject. The second part of the test allowed the investigator to obtain each subject's maximal oxygen consumption. Gases were collected and analyzed during the test by the Beckman Metabolic Measurement Cart (Beckman Instruments), which was programmed to provide information on gas analysis every 30 seconds.

Before a subject performed the bicycle test, his previously determined weight was inserted in the Beckman computer (Beckman Instruments) to enable readings of oxygen consumption in ml/kg-min to be obtained during the test. An exersentry was worn by the subject to enable heart rate readings to be obtained. A speak-easy stress mask (Respironics, Inc.) was attached to the subject's head and face: this allowed the subject to breathe into the metabolic cart without having to wear a mouthpiece and noseclips.

The subject was instructed to sit on the bicycle ergometer and the seat height was adjusted so that the leg was slightly bent when the pedal was in the down position. Gas analysis and heart rate were monitored every 30 seconds.

Stage One: Establishment of VO2-HR Relationship

Approximately 3 minutes of pre-exercise measurements were taken. The subject was then instructed to begin pedalling at 20 kilometers per hour and maintain that pace until told to do otherwise. The tension on the bicycle was initially at zero and was subsequently increased so that a slow, gradual increase in both the heart rate and oxygen consumption occurred. When a heart rate of 170 bpm was reached, no further increments in tension occurred.

Stage Two: Establishment of Max VO2

The general procedure for establishing an individual's max VO2 was as follows: once a subject reached a heart rate of 170 bpm, he was instructed to increase his pedalling speed to 40 kilometers per hour, which he pedalled at for approximately one minute. From this point, the speed was increased 5 kilometers per hour every minute until exhaustion occurred.

A subject was considered to have reached his maximal oxygen consumption if the oxygen consumption showed no rise greater than 2 ml/kg-min with an increasing workload (Stewart and Gutin, 1976; Mayers and Gutin, 1979; Cunningham et al, 1977), or if the subject was unable to continue due to fatigue (Burke and Franks, 1975; Boileau et al, 1977).

During the second laboratory visit the heart rate during the bicycle ergometer test was monitored by both an exersentry and an ECG machine (Sanborn.500.Viso-Cardiette). The ECG machine was connected to the subject via metal plate electrodes: 2 electrodes were placed on the chest and 1 electrode was placed on the back of the subject. The ECG machine allowed the investigator to check the validity of the exersentry heart rate monitors. A Pearson product-moment correlation coefficient was calculated between the heart rate values obtained from the exersentry and the ECG machine for each subject. The algorithm for a Pearson's r was obtained from Ferguson (1976) and a program was written for the Hewlett Packard 9825B micro computer.

D. DATA DESCRIPTION

Due to the small number of subjects and the non-parametric nature of the data collected, it was decided to descriptively analyze the data.

COMPOSITE DESCRIPTION

The percentage of class time spent in each heart rate category for each type of class was calculated (Appendix C).

HEART RATE PLATEAUS

The longest amount of time each subject was able to maintain a heart rate above 130 bpm in each class was determined. The heart rate plateaus were compared between classes and within classes for each subject, and between subjects.

INDIVIDUAL DESCRIPTIONS

The percentage of class time spent in each heart rate category for each type of class for each subject was calculated (Appendix D). The individual results were presented in four separate tables. These results were compared to the composite percentages and discussed.

PERCENTAGE OF MAX VO2

From the second bicycle ergometer test the heart rate and oxygen consumption values obtained during the heart rate range of 120 to 170 bpm were used in the establishment of an individual regression line for each subject. Values from the second bicycle test were used because the subjects were more familiar with the equipment and procedures used and therefore the values were more indicative of the usual state than the first test. Individual regression lines of heart rate and oxygen consumption (ml/kg-min) were calculated by the method of least squares-straight line fit on the Olivetti Programma 101 electronic desk computer. From this individual regression line it was possible to predict oxygen consumption values from the heart rate values that were obtained during the physical education classes. In particular, the oxygen consumption values at heart rates of 130 and 160 bpm were calculated (see Appendix E for sample calculation). Because a maximal value of oxygen consumption was obtained for each subject , it was possible to establish the percentage of max VO2 that the heart rates of 130 and 160 bpm elicited, thereby providing further information on the intensity of activity (see Appendix F for sample calculation). The highest of the two max VO2 values that were obtained for each subject was considered to be a subject's max VO2 and this value was used whenever a percentage of the max VO2 was calculated.

IV. RESULTS AND DISCUSSION

A. PHYSICAL CHARACTERISTICS OF SUBJECTS

Table IV presents the physical characteristics of the subjects.

TABLE IV: PHYSICAL CHARACTERISTICS OF SUBJECTS

SUBJECT	AGE (yrs)	HEIGHT (cm)	WEIGHT (kg)	SUM OF SKINFOLDS (mm)
CS	10.8	133.0	34.1	28.9
KA	11.0	128.0	29.3	24.4
KK	11.5	139.5	39.5	39.2
JR	10.7	152.0	52.7	42.9

As can be seen in table IV, there was a wide variation in the height, weight, and the sum of skinfolds for the four subjects. Although the puberty status of the four subjects was not measured, it was assumed that they had not yet reached puberty. This assumption was based on observation of their physical characteristics.

According to the CAHPER (1980) Fitness-Performance II test normative data, a value of 145 cm represents the fiftieth percentile for height for 11 year old boys. This would suggest that subjects CS, KA, and KK were slightly short for their age, while subject JR was tall for his age. Indeed, JR's value of 152 cm lies in the eightieth percentile for 11 year old boys according to the CAHPER norms, while KA's value of 128 cm lies below the fifth percentile for 11 year old boys.

According to the CAHPER norms for weight, a value of 36.7 kg represents the fiftieth percentile for 11 year old boys. Subjects CS and KA were slightly below this value, approaching approximately the thirty-fifth and fifth percentiles, respectively. Subjects KK and JR were both heavier than the fiftieth percentile value, approaching the sixty-fifth and ninety-fifth percentile values, respectively.

To assess the skinfold data, comparisons were drawn with normative data that had been established from a random sample of 600 Edmonton school children (Quinney and Conger, 1981). A sum of 31.80 mm for a 4-site skinfold measurement, consisting of the triceps, biceps, subscapular, and suprailiac sites, constituted the fiftieth percentile score for the 10 to 12 year old boys in the Edmonton sample. The skinfold values of subjects CS and KA were above the fiftieth percentile values, approaching the sixtieth and seventy-fifth percentiles, respectively. Subjects CS and KA would therefore appear to be lean for their age. The values for subjects KK and JR were below the fiftieth percentile value, approaching the thirty-fifth and twenty-fifth percentiles, respectively. Subjects KK and JR appeared to be fatter than most boys their age.

It appeared, therefore, that both subjects CS and KA were small, light, and lean for their age, while subject JR was tall, heavy, and relatively fat for his age. Subject KK was shorter, heavier, and fatter than most boys his age.

Rutenfranz et al (1974) found that active children had a lower body weight and a lower fat content when compared to less active children. The values obtained for the weight and skinfold measurements appeared to be logical and support Rutenfranz's (1974) study when the activities the subjects were involved in were considered. Subjects CS and KA were both considered light and lean for their ages. Subject CS was actively involved in boxing, and, as will be discussed later, was a very fit child. Subject KA was a hockey player. Their involvement in extracurricular sports may have aided in maintaining the fat component of their bodies at a relatively low level. The relatively high skinfold value for subject KK came as somewhat of a surprise because he was actively involved in a soccer program. However, the soccer program was only run once per week and therefore may not have been as effective as the boxing and hockey programs in terms of maintaining the fat component of the body at a relatively low level. The high skinfold sum for subject JR was not surprising since this subject appeared to be relatively inactive in comparison to the other three subjects. He was not actively involved in a community league program.

B. COMPOSITE DESCRIPTION

Table V shows the percentages of class time that were spent in each heart rate category for each activity. Table V contains the composite results of all four subjects and therefore is representative of 12 classes in each activity.

TABLE V: COMPOSITE PERCENTAGES OF CLASS TIME SPENT IN GYMNASTICS, DANCE, AND GAMES.

ACTIVITY	REST	MILD LOW	MILD HIGH	MODERATE LOW	MODERATE HIGH	SEVERE	CLASS LENGTH (min)
		HEART RATE CATEGORIES					
GYMNASTICS	16.7	51.6	(18.4)	29.5	(5.0)	2.2	47.7
DANCE	24.5	54.6	(19.6)	19.6	(3.7)	1.3	29.5
GAMES	6.0	30.4	(12.5)	39.5	(12.3)	24.2	25.8

As can be seen in table V, the gymnastics-orientated class was longer in duration than either the dance or games orientated class. The dance and games classes were very similar in length.

The gymnastics and dance orientated classes appeared to be very similar in terms of the percentage of class time spent in each heart rate category. The gymnastics classes provided slightly more activity in the moderate heart rate range, as indicated by the 29.5% obtained in gymnastics compared to the 19.6% obtained in dance. The subjects also spent 24.5% of the class time in the dance-orientated classes with a heart rate below 100 bpm, while in gymnastics they only spent 16.7% of the time with a heart rate below 100 bpm. A gymnastics orientated class, therefore, may have provided slightly more intensive activity than a dance orientated class, but generally the percentages obtained for both types of classes in the heart rate categories were very similar. The similarity between the gymnastics and dance orientated classes in the percentages of class time spent in each heart rate category is illustrated clearly in FIGURE I. It should be noted that in both types of classes the majority of the class time was spent below a heart rate of 130 bpm.

The games-orientated classes appeared to provide more intensive activity than either the dance or gymnastics orientated classes, particularly in the higher heart rate categories. These differences can be seen clearly in figure one. The subjects spent 24.2% of their time in severe activity in a games orientated class, whereas they spent only 2.2% and 1.3% of the class time in severe activity in gymnastics and dance orientated classes, respectively. This difference appears to be quite large. One might assume that because the games orientated classes were shorter in duration than the other two types of activities, that more intensive activity could occur. However, the games orientated classes and dance orientated classes were of a similar duration.

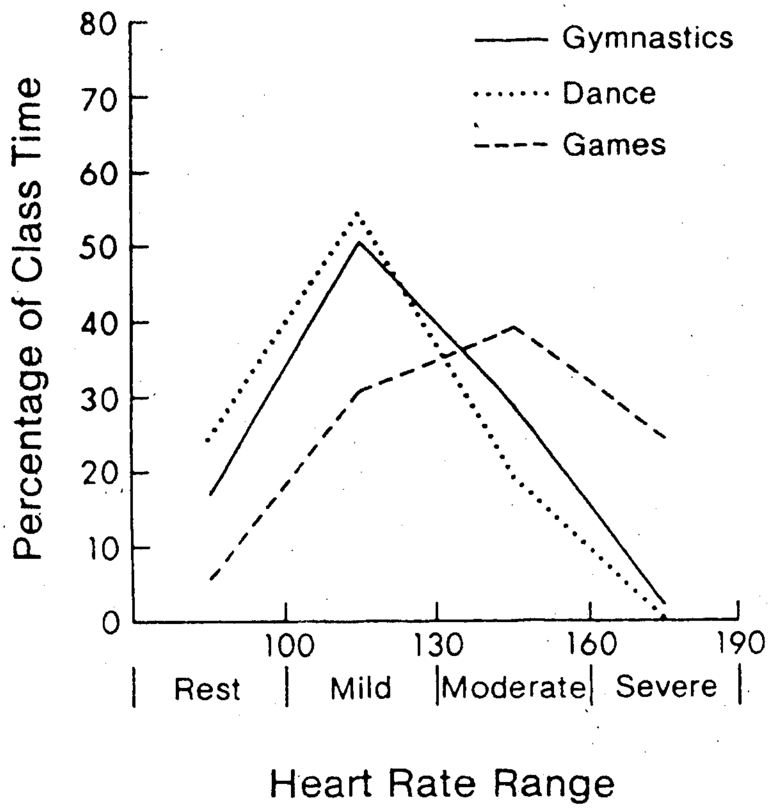

Figure 1. The percentage of class time spent in each heart rate category for each activity.

The similarity between the gymnastics and dance orientated classes in the percentage of class time spent in each heart rate category appeared to be logical when the type of activity that was occurring in each class was considered. The gymnastics orientated classes involved a movement education approach to physical education and contained activities such as flight, balancing, rolling, jumping, and combinations thereof. The dance orientated classes involved movement to music, and in fact, many students used the skills they had learned in the gymnastics orientated classes during the dance orientated classes. Both types of classes started with an aerobic warm up, where two students in the class were asked to lead the others in calisthenic-type exercises to music. These warm ups were approximately 10 minutes in duration and appeared to be similar for both the gymnastics and dance orientated classes.

The games orientated classes appeared to provide more intensive activity than the gymnastics or dance orientated classes. The games classes that were investigated in the present study contained a basketball and scoopball orientation. Each subject was studied for two basketball classes and one scoopball class. The games results in table V therefore represent the composite scores of 8 basketball classes and 4 scoopball classes.

The games orientated classes involved skill development in the respective games, and the playing of lead up games and actual games. The warm up prior to a games orientated class appeared to be much more vigorous than the warm up prior to either a dance or gymnastics orientated class. The games warm up usually involved sprints and relays from one side of the gym to the other, as well as some calisthenics. The activity in a games orientated class was usually at a high pace and the children seldom were still. In a dance and gymnastics orientated class it was not uncommon for children to sit and listen to instructions or to wait for relatively long periods in a line-up.

Costello (1977), using the BESTPED System, described the behaviour of 193 elementary physical education students. He found that 35.4% of the class time was spent awaiting and 25.4% of the class time was spent receiving information, which generally involved listening to the teacher. Only 29.4% of the time was spent either practicing, game-playing, exercising, or exploring. The type of class that Costello was describing appeared to be similar to the gymnastics and dance orientated classes in the present study. In the gymnastics and dance orientated classes the activity level was not constant. The children seemed to spend a large amount of time waiting to perform their activities. Periods of instruction where the children were required to sit and listen were also fairly frequent. The games orientated classes, however, provided a more constant flow of activities and therefore a more consistently elevated heart rate was achieved. It should also be noted that the children studied appeared to enjoy the games orientated classes much more than either the gymnastics or dance orientated classes and therefore did not seem to mind or notice that they worked harder in a games orientated class.

C. HEART RATE PLATEAUS

It is important to examine the intensity of activities when studying fitness benefits. However, the measurement of intensity alone is almost meaningless if the duration of the activity is not considered. For this reason, the investigator measured the longest period of time that each subject maintained the heart rate at 130 bpm or greater during each class. This measurement was known as the heart rate plateau and the values for each subject for each class are contained in table VI. A value of 130 bpm was chosen because Massicotte and Macnab (1974) have suggested that as long as the heart rate is above 130 bpm, substantial decreases in heart rate at a given submaximal workload can be achieved in children. That is, it may be possible to elicit submaximal training effects in children at a heart rate of 130 bpm.

As can be seen in table VI, there was a wide variation in the heart rate plateau values within the same type of class and between the different types of classes. There also appeared to be a variation in the heart rate plateaus between the subjects. Faulkner et al (1963) found similar variations in heart rate in 42 boys during swimming,

TABLE VI: HEART RATE PLATEAUS (MINUTES)

SUBJECT	CLASS	GYMNASTICS	DANCE	GAMES
CS	1	1.5	2.0	9.0
	2	5.0	2.0	4.0
	3	2.0	0.5	9.0
KA	1	1.0	1.0	3.0
	2	1.5	1.0	6.5
	3	2.5	1.5	4.5
KK	1	6.0	2.5	7.5
	2	2.5	2.0	7.5
	3	3.0	2.5	3.5
JR	1	9.0	3.0	11.0
	2	2.0	1.5	9.5
	3	3.5	2.5	8.5

gymnastics, and sports skills classes. They found that the mean heart rate varied among different activities; that the heart rate varied in some activities from day to day; and that the mean peak heart rates of individual participants varied greatly while exposed to the same class structure.

However, a few general trends appeared to exist in the present study. The heart rate plateau for the games orientated classes appeared to be higher than those obtained for either the gymnastics or dance orientated classes. The heart rate plateau values for the dance and gymnastics orientated classes appeared to be similar, with few exceptions. Subjects KK and JR appeared to be fairly active in one gymnastics class each, demonstrated by the obtained heart rate plateaus of 6.0 and 9.0 minutes, respectively.

However, the most noteworthy fact concerning the heart rate plateaus was that they demonstrated the discontinuity of the activity that was encountered in the different types of physical education classes. For example, although the subjects spent approximately 64% of their class time, or about 19 minutes, above a heart rate of 130 bpm in a games orientated class, this time was seldom continuous. The pattern of heart rate during all of the classes can be seen more clearly in the separate class graphs for each subject in Appendix B.

It is doubtful that 1.5 or 3.0 minutes of continuous activity above a heart rate of 130 bpm is sufficient to elicit a submaximal cardiovascular training effect. The subjects in Massicotte and Macnab's (1974) study exercised for 12 minutes a day, three times per week. Some of the heart rate plateau values in the games orientated classes approached 12 minutes, such as the 11 minutes demonstrated by subject JR. However, a games orientated class only occurred once per week. The heart rate plateau values in the gymnastics and games orientated classes were relatively small in comparison to 12 minutes, with few exceptions. It appeared, therefore, that the intensity and duration of activities encountered in the physical education classes studied may not have been of a sufficient level to elicit submaximal training effects. The classes studied, particularly the gymnastics and dance orientated classes, did not appear to be that intense.

The lack of intensity in the physical education classes studied was not surprising since the literature relating to the intensity of children's activities suggests this finding. Hale and Bradshaw (1978) found a mean value of 129.7 bpm for a 25.1 minute physical education class for 7 school girls in England. Gilliam et al (1981) studied the heart rate patterns in children aged six to seven years and found that for the 12 hours monitored, the boys in the study had heart rates greater than 160 bpm for only 20.9 minutes. Seliger et al (1974) found that heart rates of 150 bpm for 12 year old boys were rare and only fleetingly encountered in a 24 hour period.

With reference to the lack of intensity found in the physical education classes studied, it must be remembered that the development and improvement of cardiovascular fitness is only one of the objectives of the physical education program in the school. Furthermore, the emphasis on the development of cardiovascular fitness may have been different for the three types of classes studied.

D. INDIVIDUAL DISCUSSIONS

Since the heart rate response to exercise varies with the fitness of an individual (Brouha, 1959; Fox, 1979), it is possible that the same physical education class could be very intense for one individual, and not so intense for another. Consequently, the results obtained for each subject will be discussed individually.

SUBJECT CS

Subject CS was a very fit child who was actively involved in boxing. He appeared to enjoy all of the physical education classes, particularly the games orientated classes. The results of the classes studied for subject CS are contained in table VII.

The results for subject CS are fairly close to the composite results reported in table V. However, it appeared that subject CS spent a slightly higher percentage of class time in the resting heart rate category in both the gymnastics and dance orientated classes when compared to the composite scores reported for all 4 subjects. His values were 28.0% versus 16.[illegible] for the composite gymnastics score, and 28.6% versus 24.[illegible] for the composite dance score. Subject CS spent approximately the same percentage of class time as the group did in the mild and moderate heart rate ranges for all three activities. However, he spent a slightly smaller percentage of time in the severe heart rate category in both the gymnastics and dance orientated classes than the total group. These differences were relatively small: with 0.7% versus [illegible].2% for the gymnastics orientated class and 1.0% versus 1.3% for the dance orientated class. The percentage of time spent in the severe heart rate category for the games orientated classes was slightly lower than the group score: 23.9% for subject CS versus 24.2% for the group.

TABLE VII: PERCENTAGES OF CLASS TIME SPENT IN GYMNASTICS, DANCE, AND GAMES FOR SUBJECT CS.

		HEART RATE CATEGORIES		
ACTIVITY	REST	MILD HIGH	MODERATE HIGH	SEVERE
GYMNASTICS	23.0	48.9 (16.7)	27.5 (5.2)	0.7
DANCE	28.6	51.0 (15.3)	19.4 (5.1)	1.0
GAMES	6.3	30.2 (10.1)	39.6 (18.9)	23.9

As stated previously, subject CS was a very fit individual. His results suggest that, when compared to the other 3 subjects studied, he may not have been as highly stressed during the physical education classes studied as the total group scores indicated. He appeared to spend more time in the resting category then the total group, and slightly less time than the group in the severe category. It appeared that subject CS spent approximately the same amount of class time as the group in the mild and moderate heart rate categories, although it should be noted that he spent a larger percentage of time in the high moderate category when compared to the group in all three activities.

Because subject CS was fit, his heart rate would be lower at a specific level of work than an unfit child (Amsterdam et al, 1977; Mathews and Fox, 1976; Fox, 1979; Karvonen et al, 1957). This may explain why subject CS demonstrated a higher percentage of class time in the high moderate heart rate range, but a relatively smaller percentage of class time in the severe heart rate range when compared to the group scores.

When a person is physically fit, he is also able to recover more quickly from exercise. Physical training results in a smaller increase in the heart rate for a given workload and a more rapid return of the heart rate to its resting value (Maxfield and Brouha, 1963). Since subject CS was fit, his heart rate probably did not increase as much as his unfit classmates and he was able to recover faster. Therefore, he spent a relatively larger percentage of class time in the resting heart rate category when compared to the group.

It appeared that the activities encountered in the physical education classes studied by subject CS were not that stressful for him. Indeed, in the gymnastics and dance orientated classes he spent 71.9 and 79.6% of the class time, respectively, in a heart rate below 130 bpm.

SUBJECT KA

Subject KA was a relatively fit subject who participated in hockey fou[illegible] five times per week for the duration of the present st[illegible] He seemed to enjoy the physical education classes, but he was not as keen as some of the others in his class. He did not appear to enjoy the dance orientated-classes. The results for subject KA are presented in table VIII.

Subject KA spent a larger percentage of class time in the lower heart rate categories in all 3 of the activities, with the exception of the rest category in games, when

TABLE VIII: PERCENTAGES OF CLASS TIME SPENT IN GYMNASTICS, DANCE, AND GAMES FOR SUBJECT KA.

	HEART RATE CATEGORIES			
ACTIVITY	REST	MILD HIGH	MODERATE HIGH	SEVERE
GYMNASTICS	25.6	50.8 (17.6)	23.2 (2.7)	0.4
DANCE	32.8	57.1 (18.5)	10.1 (0.5)	0.0
GAMES	4.2	43.1 (17.4)	34.4 (9.7)	18.8

compared to the composite scores. Consequently, he spent a smaller percentage of class time than the group in the higher heart rate categories in all three activities.

The gymnastics and dance orientated classes were not very stressful for subject KA. He spent 76.4% and 89.9% of his time at a heart rate below 130 bpm in the gymnastics and dance classes, respectively. Heart rates above 160 bpm for subject KA were rarely encountered in the gymnastics orientated classes and were never encountered in the dance orientated classes. The low percentages of class time spent in the higher heart rate ranges in the dance classes could be partially explained by his apparent dislike of the dance class content.

Subject KA spent a relatively smaller percentage of class time in the games orientated classes above a heart rate of 130 bpm than the total group. He spent 52.8% of the time in activity greater than a heart rate of 130 bpm, while the group spent 63.7% of the class time above 130 bpm. This relatively large difference may be related to the content of the games class. Two basketball classes were investigated for each subject during the present study. Subject KA was very small and light for his age and this may have influenced his activity level during the basketball classes. Whenever the students were involved in a game, they tended to pass to their taller classmates, although it appeared that the teacher made some attempt to match the height of the respective teams. It was also possible that subject KA did not enjoy basketball because his height placed him at a disadvantage.

It appeared that generally the physical education classes were not very stressful for subject KA. Although subject KA appeared to enjoy the classes, he was not as keen as others to do the activities and therefore his heart rates were not as high. He was a relatively fit subject in terms of max VO2 and therefore the activities provided for him may not have provided sufficient stress to elevate his heart rate. It was subjectively felt by the investigator, however, that subject KA performed the activities that were presented to him at a consistent level, regardless of the activity. He was unlike other students in the class, who were really excited to do some activities, and not so excited to do others. This attitude possibly influenced the heart rates that were obtained for him.

It was also noted that subject KA spent a relatively shorter time at a heart rate plateau for each class than the other subjects (see table VI). This was logical since subject KA appeared to have spent a smaller percentage of class time above 130 bpm.

SUBJECT KK

Subject KK, in terms of max VO2, was the least fit of the four subjects studied. Subject KK participated in soccer once a week for the duration of the present study. He enjoyed participating in physical education classes in total, but he did not seem to enjoy some specific activities that he was asked to perform. In particular, he did not appear to enjoy some of the movement to music activities in the dance classes. The results for subject KK are contained in table IX.

Subject KK spent a relatively larger percentage of class time at a heart rate over 130 bpm when compared to the group results in the gymnastics and dance orientated classes. These were 39.1% in gymnastics [illegible]5.7% in dance, while the group scores were 31.7% and 20.9%, respectively. Consequently, he spent a relatively smaller percentage of class time in the lower heart rate categories in gymnastics and dance. The games results for subject KK were very similar to the group scores.

The relatively high percentage of class time that was spent at the higher heart rate ranges in the gymnastics orientated classes could be partially explained by the active ending in one of the three gymnastics classes that was studied. During this particular class, subject KK was involved in demonstrating partner work at the end of the

TABLE IX: PERCENTAGES OF CLASS TIME SPENT IN GYMNASTICS, DANCE, AND GAMES FOR SUBJECT KK.

	HEART RATE CATEGORIES			
ACTIVITY	REST	MILD HIGH	MODERATE HIGH	SEVERE
GYMNASTICS	12.8	48.1 (20.4)	33.2(5.9)	5.9
DANCE	16.6	47.8 (26.1)	34.4(4.5)	1.3
GAMES	9.7	28.5 (13.2)	38.2(10.4)	23.6

class. His heart rate was elevated above 160 bpm for the last 4 minutes of this class. The inclusion of the last 4 minutes of this class caused an increase of 3% in the percentage of time spent in the severe heart rate category. By excluding this 3% the percentage of time spent in the severe heart rate category would have been closer to the composite score for the group. However, the percentage of time that KK spent above a heart rate of 130 bpm in the gymnastics orientated classes would still have been slightly above the group value.

The relatively large percentage of class time that subject KK spent in the dance orientated classes above a heart rate of 130 bpm was a surprising result since he appeared to not particularly enjoy these classes. It appeared that he was more highly stressed in the dance orientated classes than subject CS and KA were. This may have been due to the fact that subject KK was not as fit as the previously described subjects, and therefore his heart rate was higher for similar tasks (Amsterdam et al, 1977;

Karvonen et al, 1957; Astrand and Rodahl, 1977). The same rational could explain the relatively higher heart rates found in the gymnastics classes.

The games results for subject KK were also surprising in that they did not demonstrate a larger percentage of class time in the higher heart rate categories. Subject KK appeared to be very active in all of the games classes. One possible explanation for the slightly higher percentage of class time spent in the lower heart rate categories in the games classes was that subject KK tied his shoes twice during one warm up period, which caused his heart rate to be abnormally lower. He was also told to leave one games class 5 minutes early. The other subject who was monitored in this class demonstrated heart rates above 130 bpm for the last 5 minutes of the class. This extra 5 minutes of activity could undoubtly have raised the percentage of time spent in the higher heart rate categories.

It appeared that generally subject KK was stressed to a higher degree in the physical education classes studied than subjects CS and KA. This was probably related to the relative fitness of the 3 subjects. Since subject KK was not as fit as the others, higher heart rates would be expected for similar tasks.

SUBJECT JR

Subject JR, in terms of max VO2, was not as fit as subjects CS and KA. Subject JR did not participate actively in a community program during the present study. He did not enjoy either the gymnastics or dance classes, but he liked to play games. In particular, he strongly disliked any type of calisthenic exercise. The results for subject JR are contained in table X.

Subject JR spent a smaller percentage of class time in the resting heart rate range in all 3 activities when compared to the group scores. The resting category percentages for subject JR in gymnastics, dance, and games were 5.9%, 18.1%, and 4.1%, compared to the group values of 16.7%, 24.5%, and 6.0%, respectively. In the gymnastics orientated classes, subject JR spent a larger percentage of time in the mild and moderate heart rate categories than the group. He also spent a larger percentage of time in the mild heart rate category during the dance orientated classes than the group.

Subject JR spent a larger percentage of class time at a heart rate above 130 bpm in both the gymnastics and games orientated classes than the group. These values for JR were 35.3% (gymnastics) and 74.6%(games), compared to the group values of 31.7% and 63.7%, respectively. The amount of time subject JR spent above 130 bpm in the dance orientated classes was similar to that of the group. The amount of time spent in the severe heart rate category was higher in the games orientated classes for subject JR (29.6%) than for the group (24.2%), as it was in the dance class (2.9% vs. 1.3%).

Since subject JR was relatively unfit when compared to subjects CS and KA, it was not unexpected that he

TABLE X: PERCENTAGES OF CLASS TIME SPENT IN GYMNASTICS, DANCE, AND GAMES FOR SUBJECT JR.

ACTIVITY	HEART RATE CATEGORIES			
	REST	MILD HIGH	MODERATE HIGH	SEVERE
GYMNASTICS	5.9	58.8 (19.0)	33.6 (5.9)	1.7
DANCE	18.1	62.0 (19.9)	17.0 (4.7)	2.9
GAMES	4.1	21.3 (10.1)	45.0 (10.1)	29.6

demonstrated higher heart rate values during the physical education classes. Generally, the results obtained for subject JR suggest that he was more highly stressed during the physical education classes than the other three subjects. This occurred in spite of the fact that he did not enjoy some of the classes.

Although subjects JR and KK had relatively longer heart rate plateaus than subjects CS and KA, the activities performed in the physical education classes studied did not appear intense for a long period of time.

E. OXYGEN CONSUMPTION AND HEART RATE

The results for the maximal bicycle ergometer test and the percentages of maximal heart rate and maximal oxygen consumption at heart rates of 130 bpm and 160 bpm for each subject are presented in table XI.

MAX VO2

It can be seen in table XI that there was a wide variation in the max VO2 scores that were obtained by each

TABLE XI: BICYCLE ERGOMETER TEST RESULTS AND PERCENTAGES OF MAX VO2 AND MAXIMAL HEART RATE.

SUBJECT	MAX VO2 (ml/Kg-min)	MAX HR (bpm)	HR = 130 %MAXVO2	HR = 130 %MAXHR	HR = 160 %MAXVO2	HR = 160 %MAXHR
CS	61.4	206	35.3	63.0	52.0	78.0
KA	51.5	197	43.5	66.0	69.7	81.0
KK	45.6	184	46.3	71.0	70.6	87.0
JR	47.8	208	42.1	63.0	64.6	77.0

subject in the bicycle ergometer test. Shephard (1971), after reviewing many studies on boys from 6 to 18 years of age, suggested "that boys with an aerobic power of 48 to 50 ml/Kg-min are close to their potential and that rewards of training are small" (p.337).

Subject CS' max VO2 value of 61.4 ml/Kg-min was well above the value of 48 to 50 ml/Kg-min that Shephard has suggested for potential development. However, values close to 60 ml/Kg-min for boys his age have been reported in the literature. Cunningham et al (1981) found that twenty-eight 12 and 13 year old school boys had a mean max VO2 of 57.2 ml/Kg-min when measured on the treadmill. Daniels et al (1978) found a mean max VO2 of 61.1 ml/Kg-min for 10 year old runners when measured on a treadmill. Andersen et al (1976) found a mean max VO2 of 60.0 ml/Kg-min in 10 year old Norwegian boys when they pedalled a bicycle ergometer. The authors have suggested that the boys tested were fit. Subject CS' active involvement in boxing probably aided in developing his high level of fitness.

The max VO2 value of 51.5 ml/kg-min reported for subject KA was very close to the potential development value of 48 to 50 ml/kg-min reported by Shephard (1971). However, the values for subjects KK and JR of 45.6 ml/kg-min and 47.8 ml/kg-min, respectively, were slightly below this value. Subject KA was actively involved in hockey. His max VO2 value of 51.5 was slightly below the value of 56.5 ml/kg-min that Cunningham et al (1977) found for sixty-six 10 year old hockey players. However, Cunningham's subjects were exercised on a treadmill and differences in the ergometer used makes comparisons difficult. Subject KA's max VO2 value was very close to the 51.8 ml/kg-min that Massicotte and Macnab (1974) reported for nine 11 to 13 year old boys that were exercised on a bicycle ergometer.

The value of 47.8 ml/kg-min reported for subject JR was very close to the potential development value described by Shephard (1971). This value was somewhat surprising since subject JR was not actively involved in a community program. Although he was more highly stressed in the physical education classes than the other subjects, the intensity of his performed activities was still not very high. Subject JR's habitual physical activity was probably fairly high to maintain the level of fitness that he demonstrated.

The value of 45.6 ml/kg-min reported for subject KK was somewhat below the values that have been reported in the literature for children his age. Subject KK, at 11.5 years, was the oldest subject in the group studied. It is not uncommon to find max VO2 values of approximately 60 ml/kg-min for fit 12 year old boys (Koch, 1980). The low value that was obtained for subject KK was somewhat surprising since he was an active soccer player and he seemed to enjoy physical activity. However, he was short, heavy, and relatively fat for his age. The max VO2 value was expressed relative to body weight and consequently he would have a smaller max VO2 than someone his own height who was lighter. Another possible explanation for the low max VO2 value obtained for subject KK may have been his habitual physical activity level. Although he was active in soccer once per week, that may have been all he was involved in.

Rutenfranz et al (1974) found that children differing in physical performance capacity showed similar differences in their daily life patterns. They found that the children with a high physical performance capacity slept less and spent a larger proportion of their movement activities at a high intensity during their leisure time than children with a low physical performance capacity. The subjects in the present study may have been similar to those in Rutenfranz's study. Subjects CS and KA were actively involved in community sports programs and exhibited higher max VO2 values than subjects JR and KK.

MAXIMAL HEART RATE

As can be seen in table XI, there was a fairly wide variation in the maximal heart rates that were obtained for each subject. It was difficult to describe a representative maximal heart rate since wide variations in maximal heart rate for children have been reported in the literature. In addition, it is well known that there is a great deal of biological variability in heart rate. Eriksson and Saltin (1974) found maximal heart rate values of 196 bpm for boys 11.6 and 12.6 years of age who exercised on an electrically braked bicycle ergometer. Kramer and Lurie (1964) found mean maximal heart rates of 191 bpm in average, normal boys, aged 9 to 16 years, and 192 bpm for trained, normal boys, aged 12 to 17 years, who exercised on a cycle mill. Wirth et al (1978) found a maximal heart rate of 180 bpm for seven prepubertal swimmers who were exercised on a bicycle ergometer. Their mean age was 10.8 years. Macek et al (1976) tested a group of ten boys, whose mean age was 12.75 years, on both the bicycle ergometer and the treadmill. They found maximal heart rate values of 200 bpm on the bicycle ergometer and 203 bpm on the treadmill. Thiart and Wessels (1974) found maximal heart rate values of 203 bpm in thirty-six 10 to 11 year old boys who were exercised on the treadmill. It appeared that the values obtained for the 4 subjects in the present study were acceptable maximal heart rate values when compared to the values in the literature.

The value of 184 bpm that was obtained for subject KK was low. However, his pre-exercise heart rate value in the laboratory was 65 bpm, which was also low, considering that he was not extremely fit. It may have been that subject KK had a lower heart rate than could normally be expected for someone his age.

PERCENTAGES OF MAXIMUM VALUES

As can be seen in table XI, the percentage of max VO2 and the percentage of maximal heart rate that each subject was eliciting at a heart rate of 130 and 160 bpm was quite different. The results would seem to suggest that each subject was stressed to a different extent at the specified heart rates. Subject CS, for example, was only working at 52.0% of his max VO2 at a heart rate of 160 bpm, while subject KK was working at 70.6% of his max VO2 at the same heart rate. It was doubtful that the same physiological effect could have been expected for both subjects if they were required to work at a specified heart rate for a period of time.

Subject CS was relatively more fit than the other subjects and it was therefore expected that he would not have been stressed as much as the other subjects. It was surprising that subject KA, who was also relatively fit in terms of max VO2, had to work at the percentages of max VO2 that he did at the respective heart rates of 130 and 160 bpm. His value of 69.7% of max VO2 at a heart rate of 160 bpm was very close to the value of 70.6% that subject KK obtained. Subject KK was relatively unfit. This particular finding was difficult to explain. One possible explanation may be that a true max VO2 was not obtained for subject KA. In both bicycle tests that he performed a plateau in oxygen consumption with an increasing workload was not reached because he voluntarily quit cycling due to exhaustion. It is difficult to motivate children to their maximal limit (Astrand, 1952). If, in fact, subject KA did not reach a true max VO2 value, the percentages that have been presented for him were erroneous. The percentage values of max VO2 would have been lower if his max VO2 was higher. This would have been an expected result. It can be seen from table XI that subject KA and subject CS work at very nearly the same percentage of maximal heart rate at heart rates of 130 and 160 bpm. The values of the percentages of max HR for subjects CS and KA were 63% and 66%, respectively, at a heart rate of 130 bpm, and 78% and 81% at a heart rate of 160 bpm, respectively.

It was difficult to assess the meaning of the varied percentages of max VO2 and max HR that were obtained for each subject. It appeared that these results were similar to those of Kemper and Verschuur (1974), who hypothesized that the same two physical education classes per week could cause an increase of 25% of the total physical activity in a week for a very inactive boy, and only a 3% increase in the total physical activity for an active boy. Kemper and Verschuur suggested that the same training effect can not be expected for both subjects. Similarly, it was unlikely that the boys in the present study received the same stress from their physical education classes. The amount of time spent in each of the heart rate categories was essentially the same for each subject. The less fit subjects spent slightly more time in the higher heart rate categories. However, the less fit subjects were working at a higher percentage of their maximum values in terms of max VO2 and max HR and therefore probably received more stress from the physical education classes.

F. VALIDITY

Campbell and Stanley (1966) have presented eight different classes of extraneous variables, that, if not controlled in the experimental design, will affect the internal validity of a study. These classes of variables include: history, maturation, testing, instrumentation, statistical regression, selection biases, experimental mortality, and selection-maturation interaction.

In the present 9 week study, it is unlikely that maturation and history affected the results of the study. With regards to history, extracurricular activities may have had an effect on the fitness level, and therefore the heart rate during the physical education classes of each subject. However, the experiment was conducted over a period when the extracurricular activity was fairly constant for each subject. Three subjects participated regularly in either boxing, hockey, or soccer for the duration of the study, while the fourth subject appeared to be relatively inactive in comparison.

The testing procedure had a novelty effect at the beginning of the study. However, the initial pilot work that was done allowed the subjects to become accustomed to the exersentrys and therefore it was felt that the novelty effect was reduced.

It appeared that the exersentrys were a valid measuring instrument. During the second bicycle test, a heart rate was recorded from the exersentry and a heart rate recording was taken from an ECG machine every 30 seconds. The correlations between the heart rate values ranged from r=.955 to r=.977. If the ECG measurement of heart rate can be assumed to be accurate, it appears that the exersentry would provide a valid measurement of heart rate. In addition, the battery in each exersentry was changed whenever the digital display dimmed or when the machine beeped continually, ensuring that an adequate power supply was maintained to run the machines.

It was unlikely that statistical regression or selection biases affected the study, since the subjects were randomly selected and not selected on the basis of extreme scores. Experimental mortality also did not have an effect on the study, since all 4 initially chosen subjects completed the study.

Campbell and Stanley (1966) have also presented factors that jeopardize the external validity of a study. These factors include: the reactive or interaction effect of testing; the interaction effects of selection biases and the experimental variable; the reactive effects of experimental arrangements; and multiple-treatment interference.

The reactive or interaction effect of the testing procedure probably had an effect on this study and would therefore reduce the ability to generalize the results. However, the initial period of testing, in which the subjects became accustomed to wearing the exersentrys, reduced the novelty effect of the exersentrys. The testing also occurred in the normal environment, allowing the subjects to behave as they typically would once they became accustomed to both the investigator and the exersentrys. It was believed, therefore, that the subject's sensitivity to the heart rate measurement was representative of a typical situation in a physical education class.

The reactive effects of experimental arrangements was considered a problem in the generalization of the results of this study. Millgrove School represented a special type of school and it was probable that other schools did not employ a similar type of curriculum. It was unlikely that children in other schools received instruction in dance, gymnastics, and games during the same week, and such classes, if held, were probably not arranged in the same way as they were at Millgrove. It was difficult, therefore, to generalize the findings of this study to other populations.

The multiple treatment interference was controlled to some extent in this study because the study occurred within the regular framework of the physical education curriculum. However, it was once again difficult to generalize the findings because the "regular framework of the physical education curriculum" at Millgrove School was probably not a typical situation.

G. GENERAL DISCUSSION

Massicotte and Macnab (1974) have actually quantified the work intensity of boys 11 to 13 years of age. From their results, Massicotte and Macnab have suggested that in children, a training heart rate above 130 bpm appears to cause a submaximal training effect. To elicit changes in max VO2 in children, they suggested that the heart rate should be above 170 bpm. Their subjects exercised on a bicycle ergometer three times per week for 12 minutes a session. Stewart and Gutin (1976) were able to elicit submaximal training effects in previously untrained children. These children performed interval training four times a week for eight weeks in their regular physical education classes, at a heart rate of approximately 185 bpm. No increases in max VO2 were reported. However, it was doubtful that the interval training was of a high intensity for a long enough duration to effect the max VO2. Lussier and Buskirk (1977) utilized a running program with a target workout intensity of 75 to 80% of max VO2, which corresponded to a heart rate of approximately 185 bpm, to elicit both submaximal and maximal training changes in previously untrained children. It appears that the intensity in their study was of sufficient duration to elicit maximal training effects. The subjects trained 4 times a week for 45 minutes a session.

In the present study, the intensity of physical education classes was relatively low in comparison to the intensity described in the previously mentioned studies. The intensity in the dance and gymnastics was particularly low, where 79.1% and 68.3% of the time, respectively, was spent below a heart rate of 130 bpm. Although approximately 20 to 30% of the time spent in these activities was above a heart rate of 130 bpm, this time was seldom continuous. Therefore, the submaximal training effect that may have been obtained from the heart rate being above 130 bpm was probably lost.

The games classes resulted in a higher percentage of class time spent above a heart rate of 130 bpm (63.7%). Once again, however, the time spent at a heart rate above 130 bpm was seldom continuous. Therefore, it was doubtful that a submaximal training effect could be elicited from the games classes. However, the games classes appeared to be much more intense than either the gymnastics or dance classes. Possibly, more games orientated activities should be incorporated into the physical education curriculum if a fitness objective is to be achieved.

The relatively less fit subjects in the present study appeared to be stressed to a larger degree than the relatively fit subjects. It was difficult to say, however, whether the degree of stress the unfit subjects encountered was sufficient to elicit training effects. Although they were stressed to a higher degree, the duration of the elevation of the heart rate was still relatively short. It appeared that these fit children were fit because of the activities they were involved in outside of school, not because of their physical education classes.

The students at Millgrove Elementary School were required to attend physical education classes 5 days per week. Although the classes that have been studied at this school were not that intense, the daily program of physical education that was offered served to educate the students in the importance of physical activity. Shephard et al (1979) found that children who received daily physical education remained more active on the weekend than children who received physical education only once per week, demonstrating that the habits of physical activity acquired during the week continued to influence the daily physical education students' behaviour when they were not required to attend school. The habit formation for physical activity that may be developed from a daily physical education program is important. If children are encouraged and learn to become involved in activities outside of school time, a greater possibility exists for fitness development. Therefore, although the actual classes may not be intense enough to cause a physiological adaptation, the habit formation for physical activity that may be developed from a daily physical education program may aid in the development of fitness.

V. SUMMARY AND CONCLUSIONS

A. SUMMARY

Four boys were randomly selected for the present study from one grade five class in Millgrove Elementary School. Heart rate data was collected every 30 seconds from an exersentry heart rate monitor in 3 of each of the gymnastics, dance, and games orientated physical education classes for each subject. The heart rates that were collected were categorized as follows: resting (≤ 100 bpm); mild (101-130); high mild (120-130); moderate (131-159); high moderate (150-159); and severe (≥ 160 bpm). The percentage of class time spent in each category was calculated for the total group and for each individual subject. In addition, laboratory measures of height, weight, skinfolds, max VO2, and max HR were obtained for each subject. An individual regression line of heart rate and oxygen consumption was also established for each subject, allowing the investigator to determine the oxygen consumption values for each subject at heart rates of 130 and 160 bpm.

The group results indicated that the gymnastics and dance classes were similar in terms of the relatively low activity intensity that was exhibited by the subjects, while the games classes resulted in a slightly higher activity intensity shown by the subjects. While at times the activities were intense during the physical education classes, this activity intensity was seldom sustained for a long period of time.

The individual results suggested that the relatively unfit children were stressed slightly more during the physical education classes studied than the fit children. The unfit children not only spent a slightly higher percentage of the class time above a heart rate of 130 bpm, they also appeared to work at higher percentages of their max VO2 and max HR at specified heart rates than the fit children.

B. CONCLUSIONS

From the results and within the limitations of the present study, the following conclusions appear justified:

1. The gymnastics and dance classes investigated during the present study did not appear to be intense enough to cause a training effect in the subjects studied, as indicated by the high percentage of class time spent in the lower heart rate categories.
2. The games classes studied provided more intensive activity than either the gymnastics or dance classes in the present study, but it was doubtful that the intensity was of sufficient duration to cause a training effect.
3. The less fit subjects appeared to be more highly stressed than the fit subjects in the physical education classes studied.

C. RECOMMENDATIONS FOR FURTHER STUDY

1. The present study should be done on a larger scale, including females.
2. Future studies of this nature should utilize telemetry equipment to ensure that the interruption to the class and individual being studied is kept at a minimum.
3. Future studies should try to include some measure of the habitual physical activity of the subjects being studied.
4. Future studies should try to include a physical activity attitude questionnaire.
5. If the primary objective of a physical education program is improved pupil fitness, then possibly more games orientated activities should be included in the program.

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APPENDIX A: LETTER AND CONSENT FORM

DEPARTMENT OF PHYSICAL EDUCATION
FACULTY OF PHYSICAL EDUCATION AND RECREATION

January 14, 1982

Dear Parents,

I am a Masters' student at the University of Alberta, specializing in the area of exercise physiology. I am particularly interested in studying the intensity of activities during physical education classes. Mr. John Oldham and Mr. Bob Mitchell have given their approval and are interested in the results of this study. I have randomly selected 4 boys from Mr. Bob Mitchell's class to participate in my study. Your son has been chosen to participate.

The study I am planning will involve approximately four to six weeks of data collection at the school. There will be two main requirements of each child in the study. Firstly, each child will be required to wear a small heart rate monitor for nine physical education classes. The heart rate monitor will be strapped to the chest of each child. This is a common device used to measure exercise intensity today and there is virtually no risk to the child wearing a heart rate monitor. Each child will also be required to perform a fitness test on a bicycle ergometer. This procedure will involve the measurement of heart rate while the child rides a bicycle at moderate intensity. This is a standard procedure, and once again there is virtually no risk to the child.

Your child has been randomly selected to participate in this study. The interruption to his school work and physical education classes will be minimal and the knowledge gained in a study of this nature will aid the exercise physiologist in further quantifying childrens' activities. However, before this study can occur, parental consent is required.

A consent form is enclosed for your convenience, that your child may deliver to the school. If you have any questions regarding the study, please feel free to phone me at 432-5503 (University) or 488-[illegible] (home).

Sincerely,

Dru Marshall

Dru Marshall

CONSENT FORM

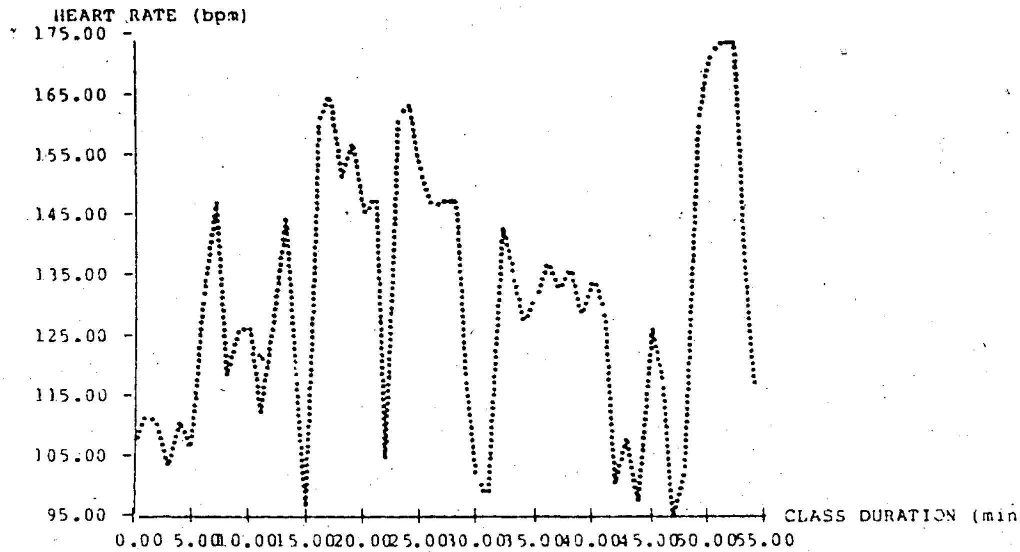
I give my consent for ______________________________ to take part in the study that Dru Marshall is conducting at Millgrove Elementary School.

I understand that the child will be required to wear a heart rate monitor and complete a physical fitness test of moderate intensity. Every effort will be made to minimize discomfort and potential risk, although past experience has indicated that risk of any nature associated with this test is minimal.

Signature: ______________________

Phone Number: __________________

APPENDIX B: INDIVIDUAL CLASS GRAPHS



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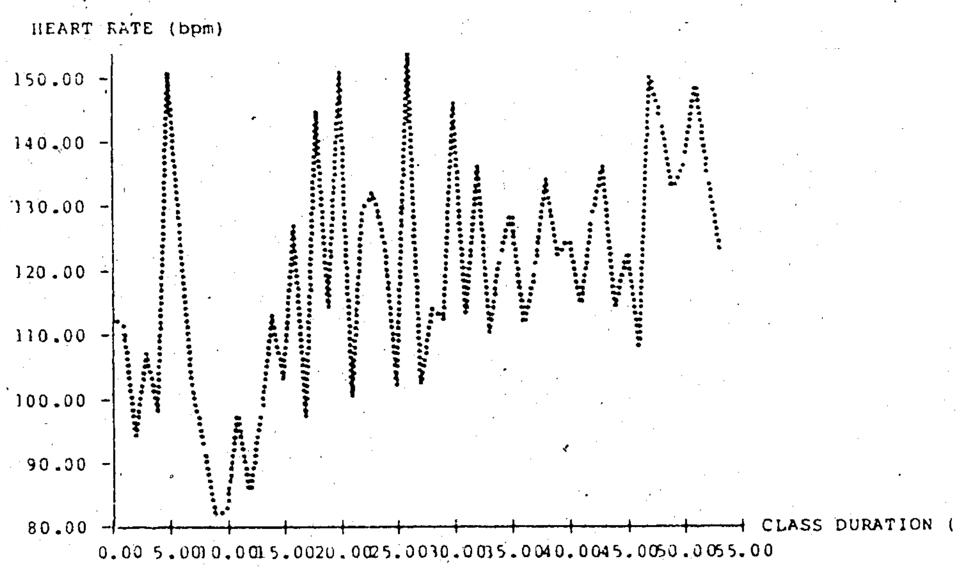

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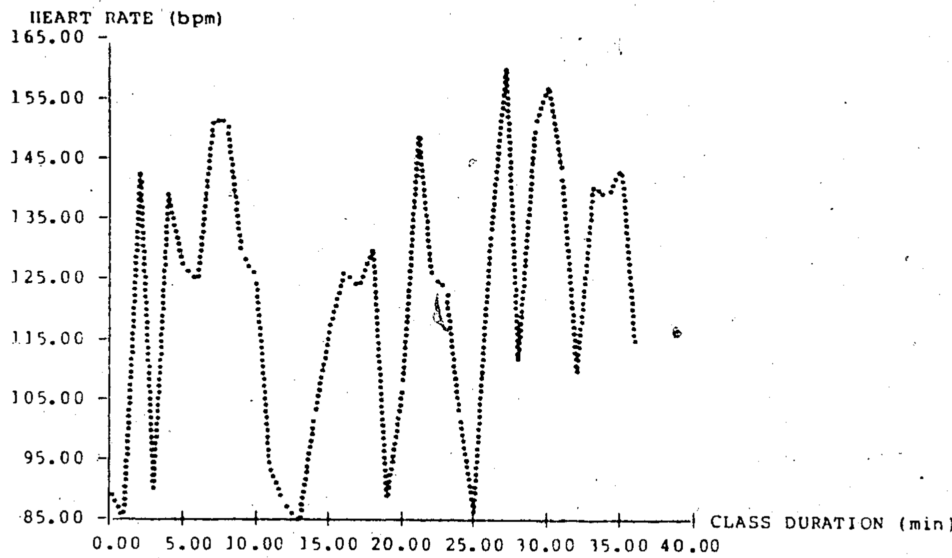

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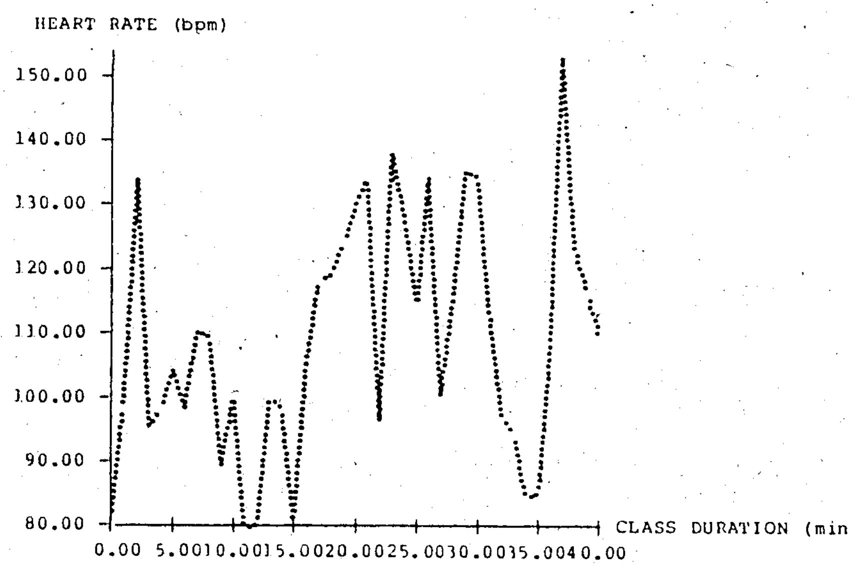

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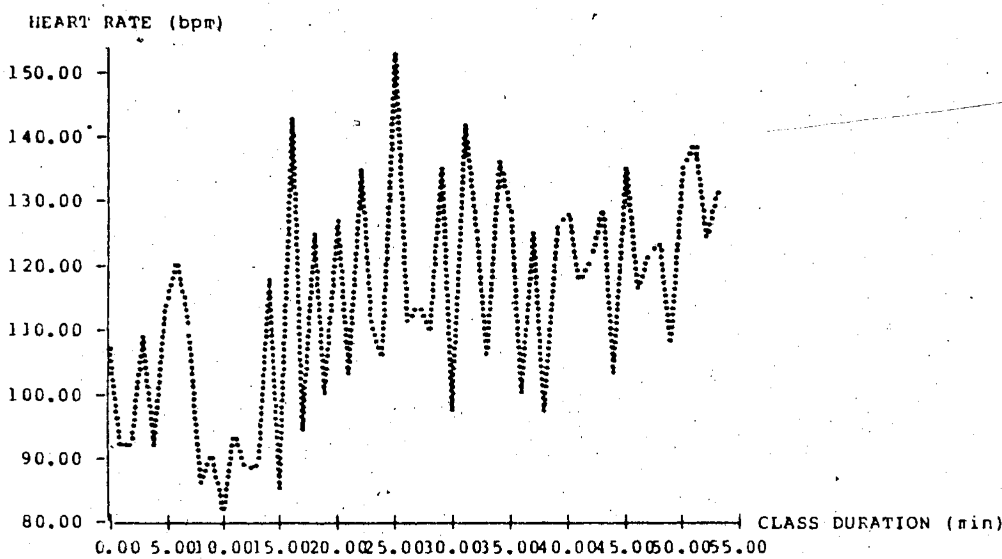

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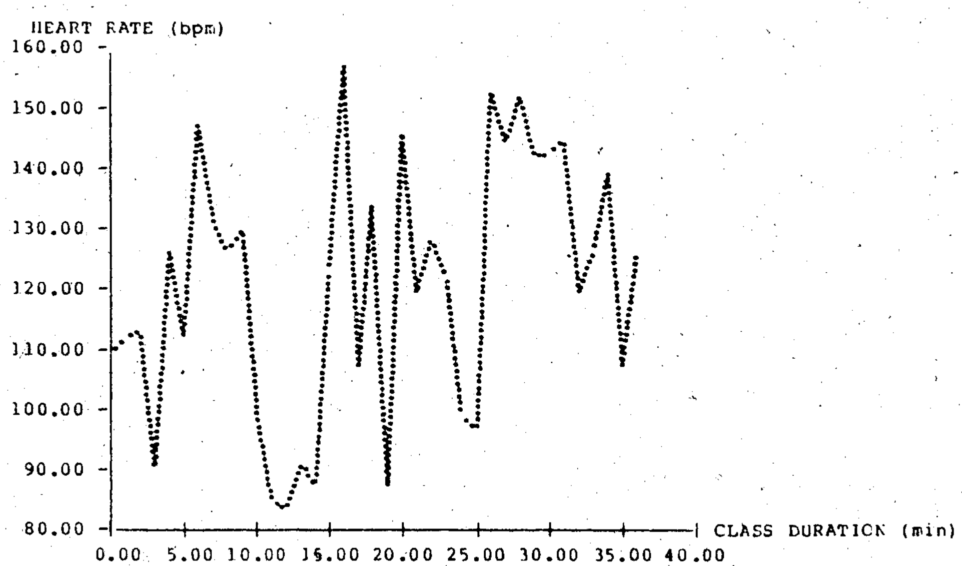

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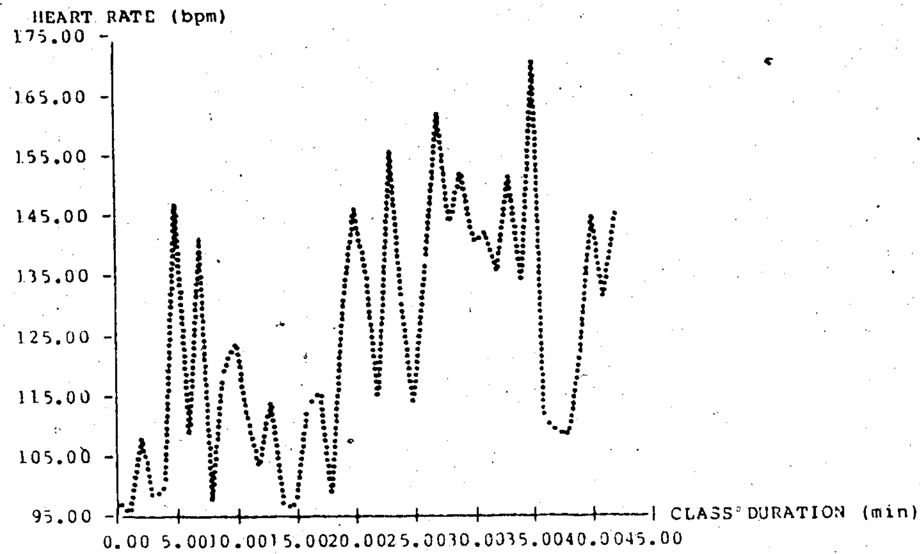

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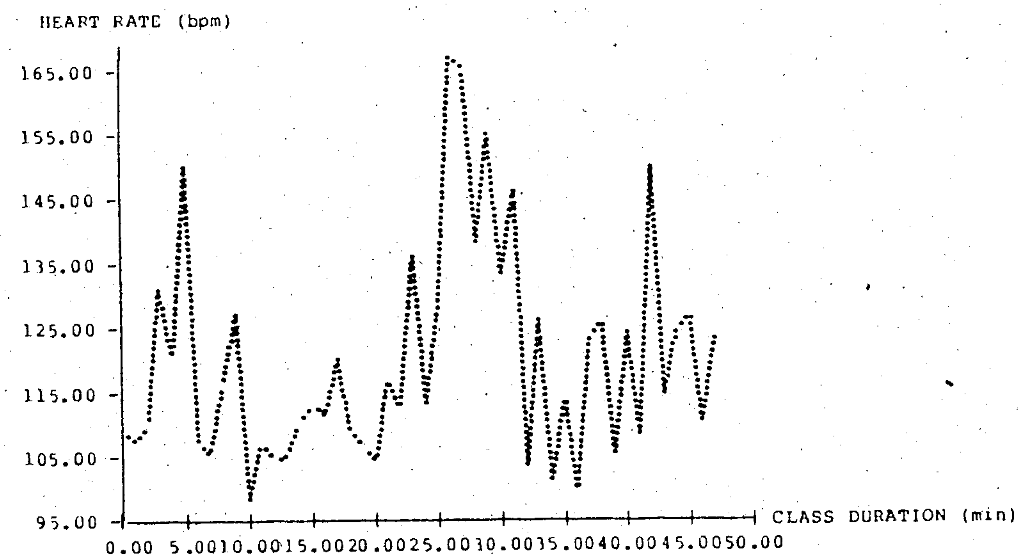

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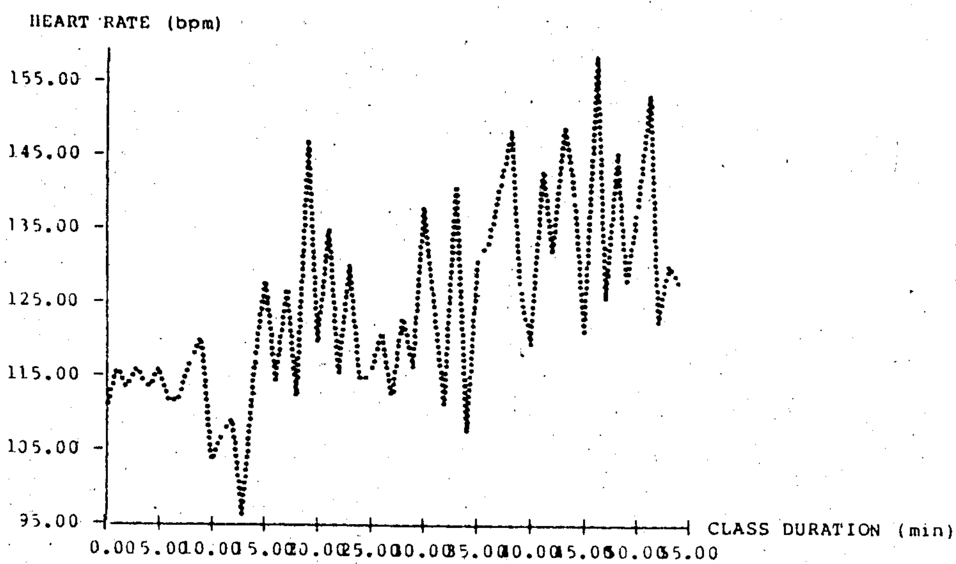

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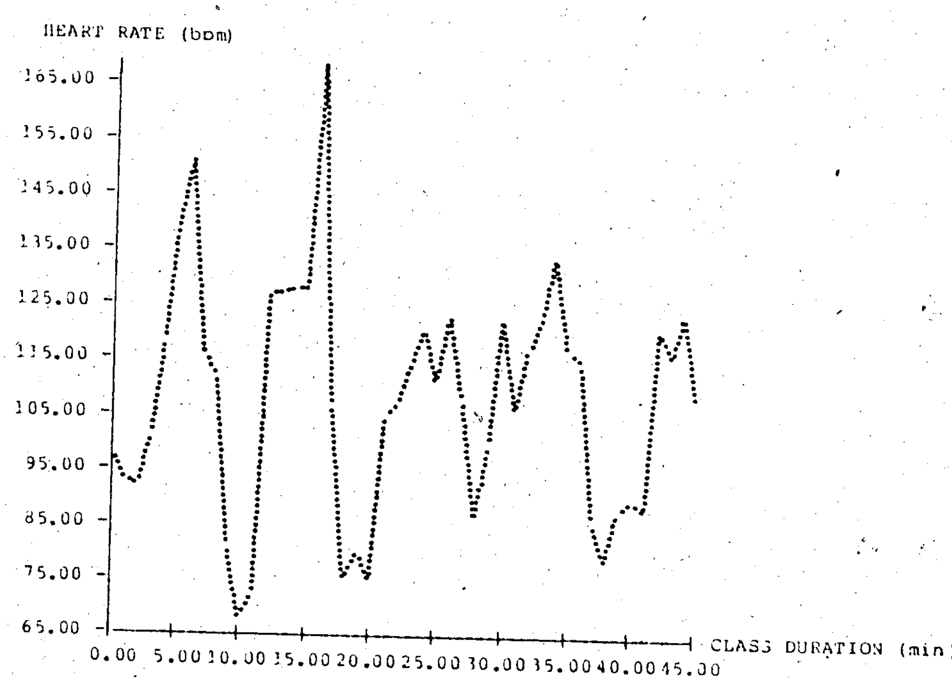

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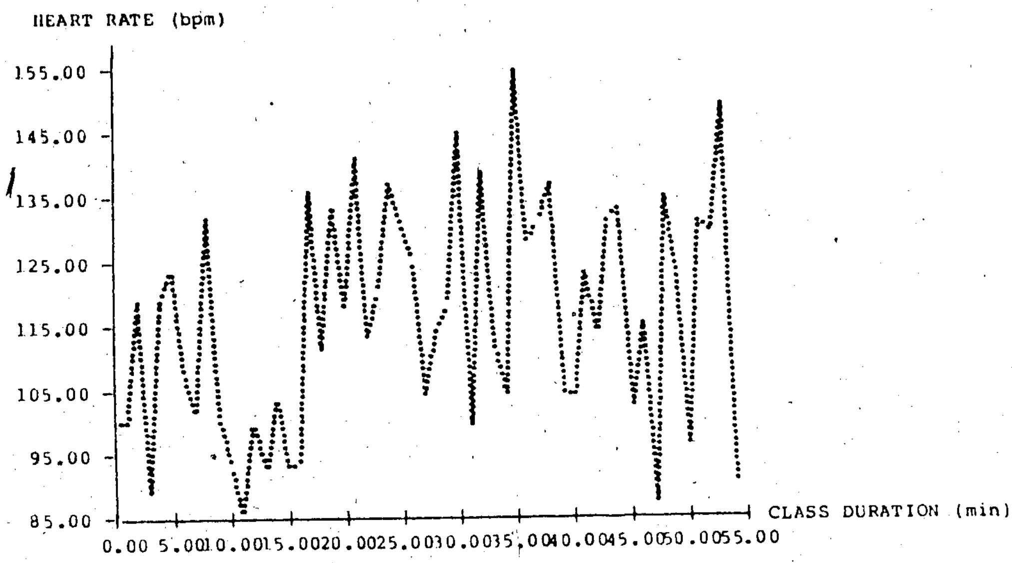

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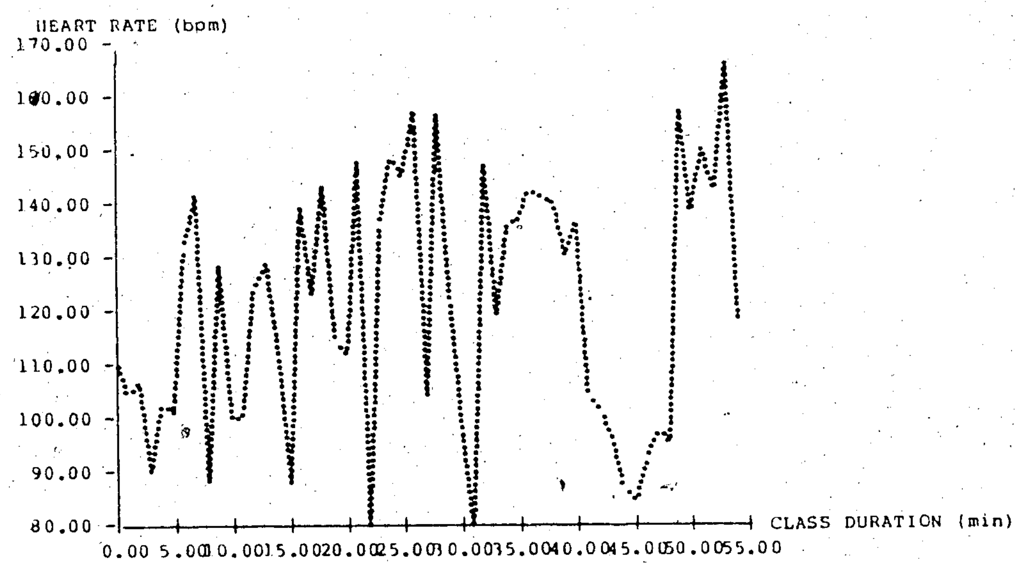

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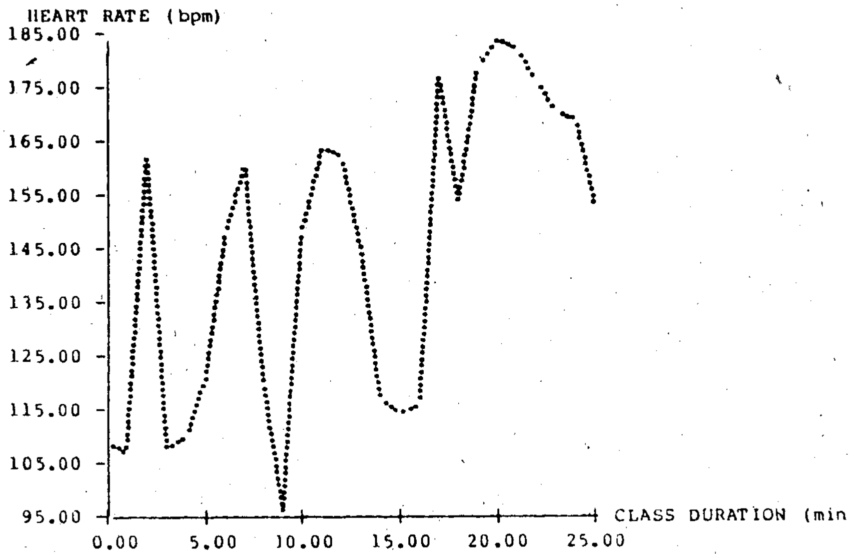

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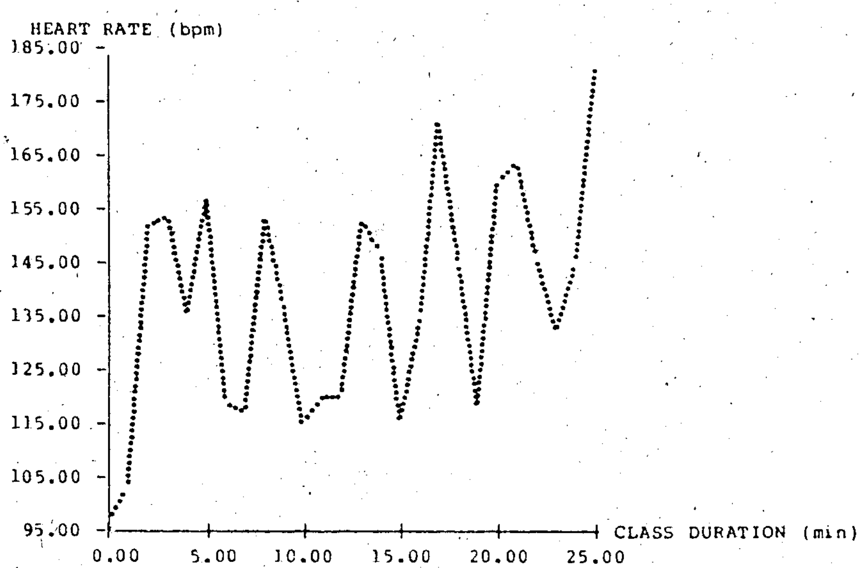

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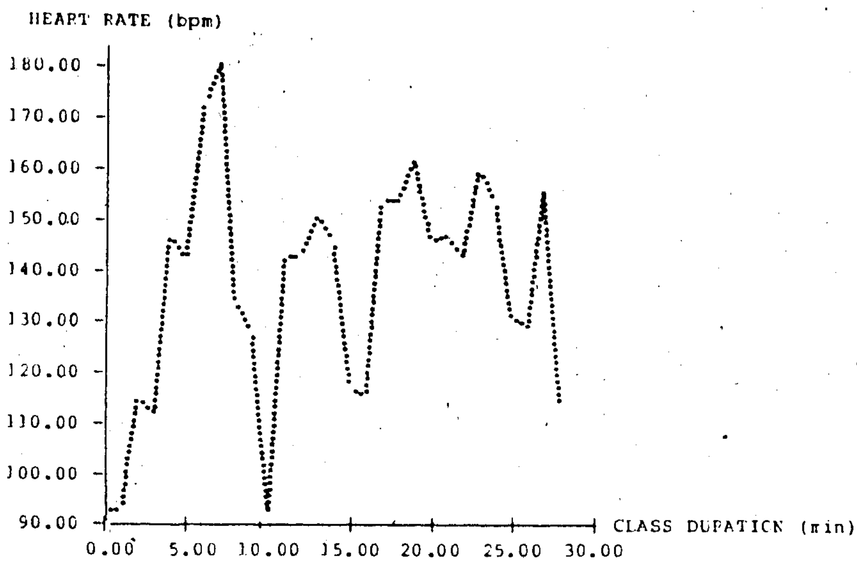

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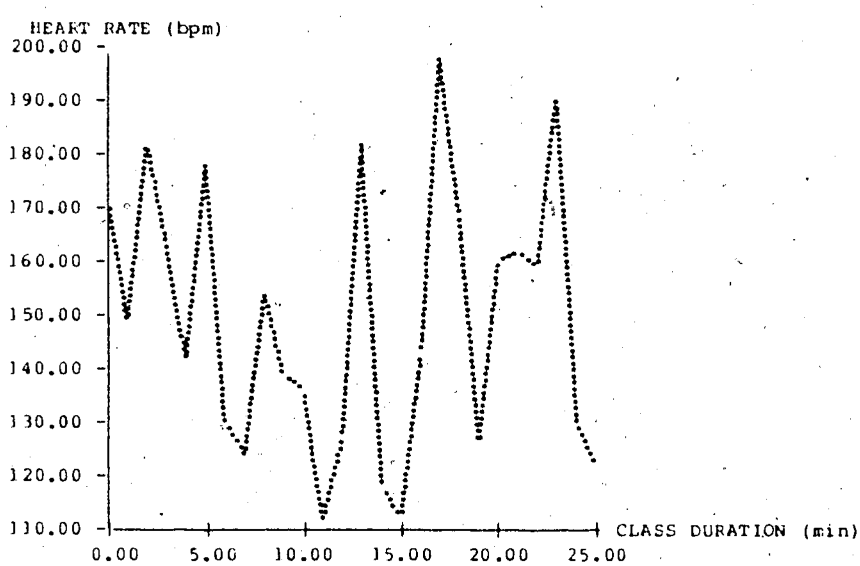

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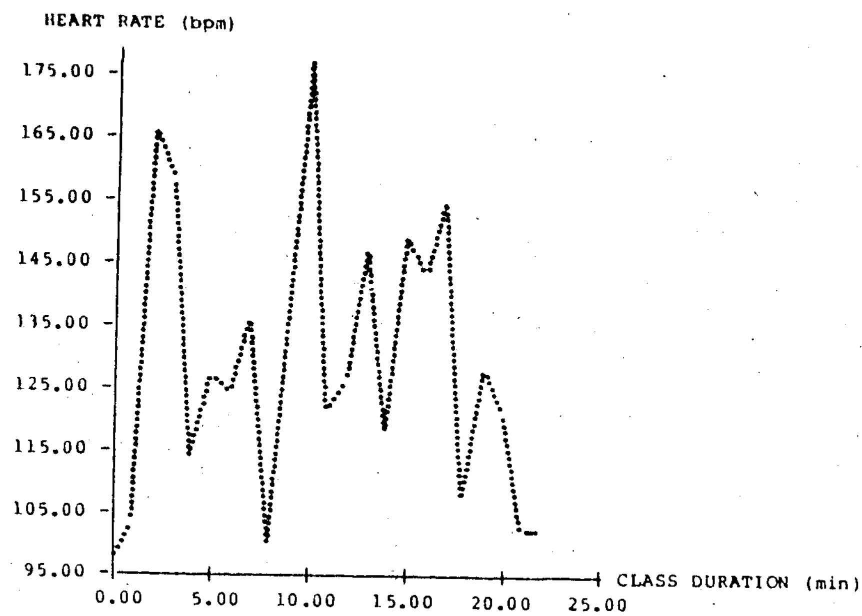

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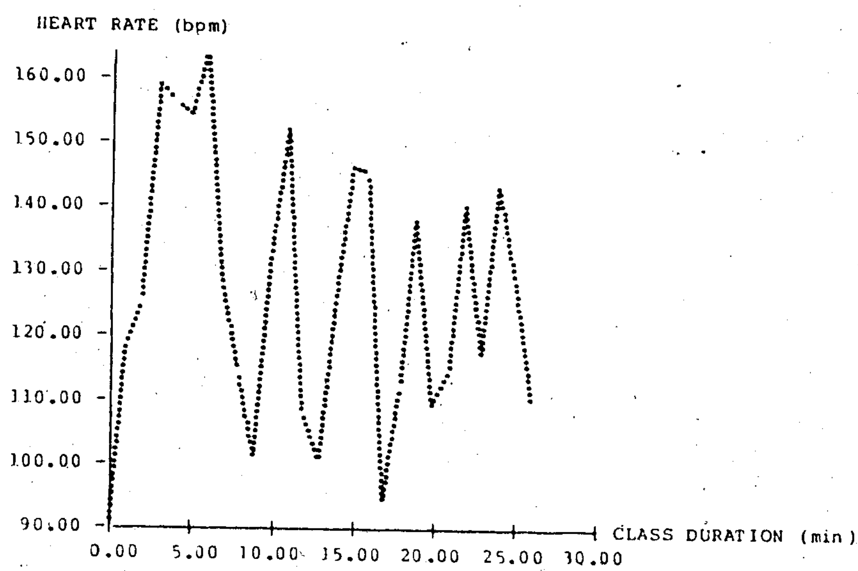

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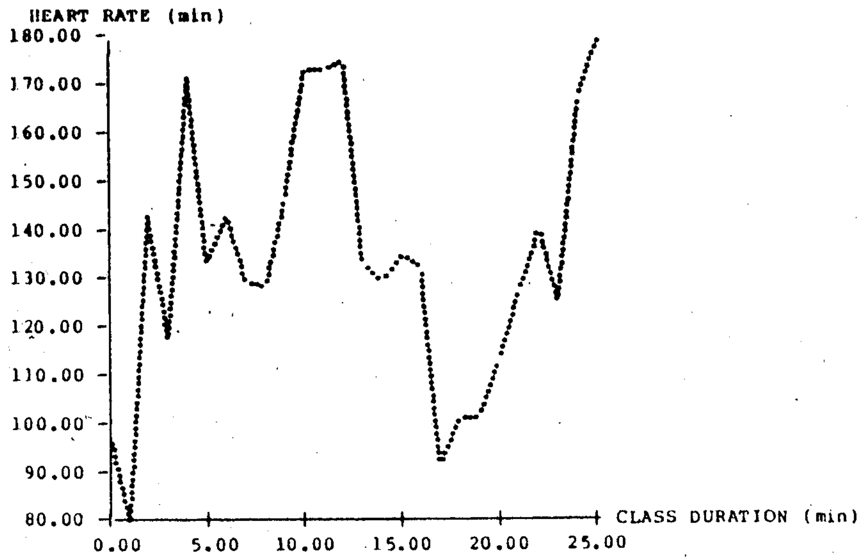

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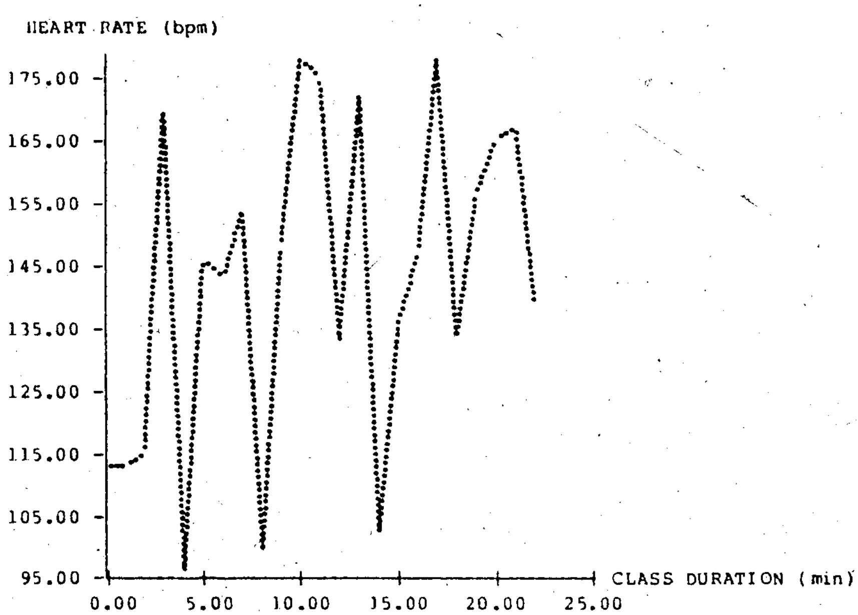

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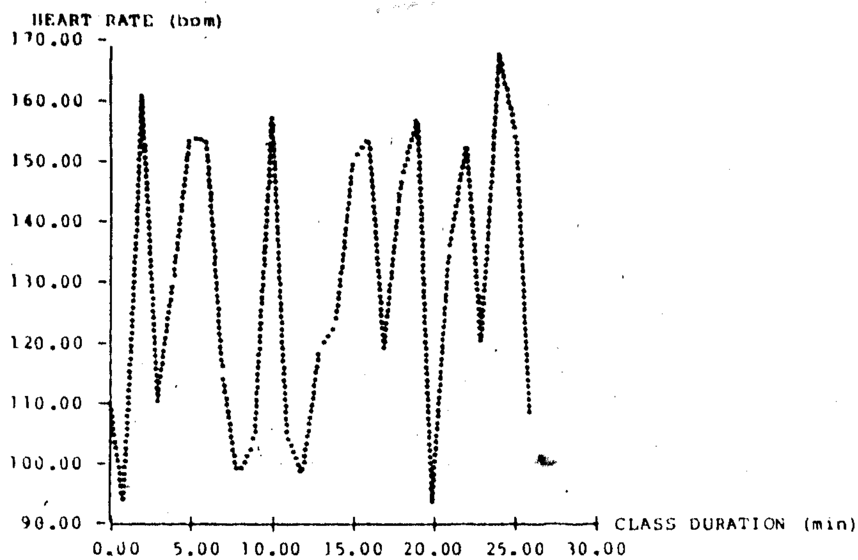

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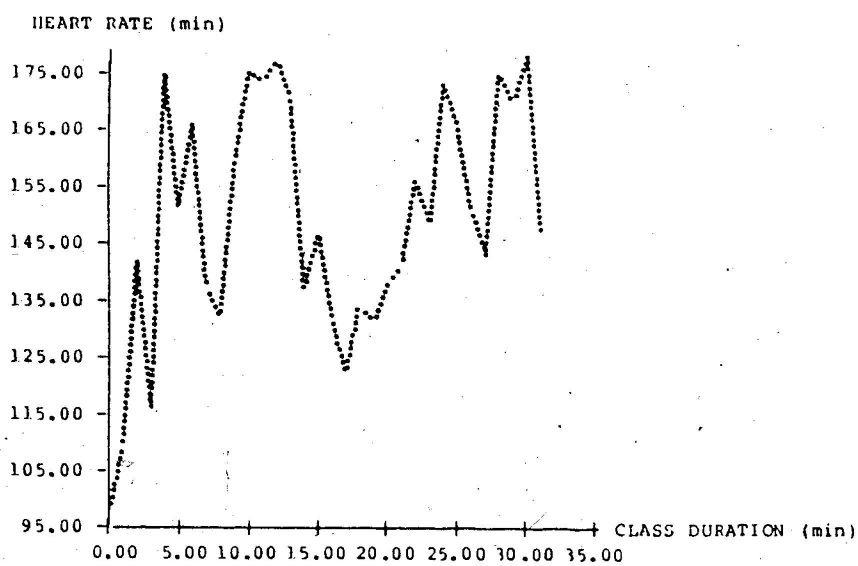

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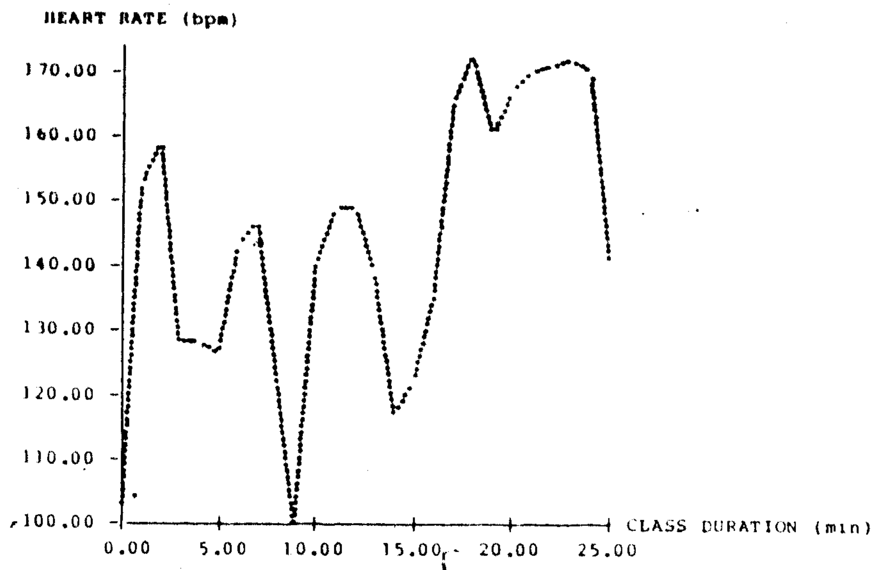

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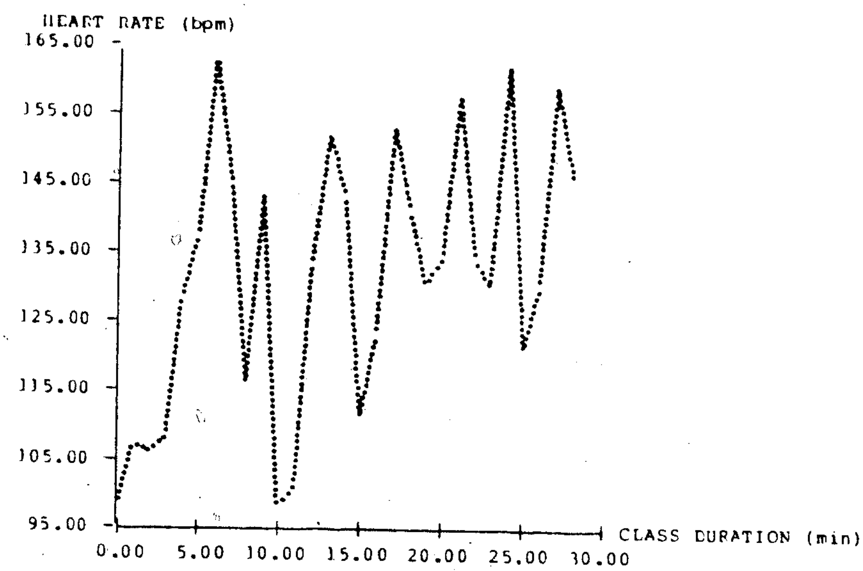

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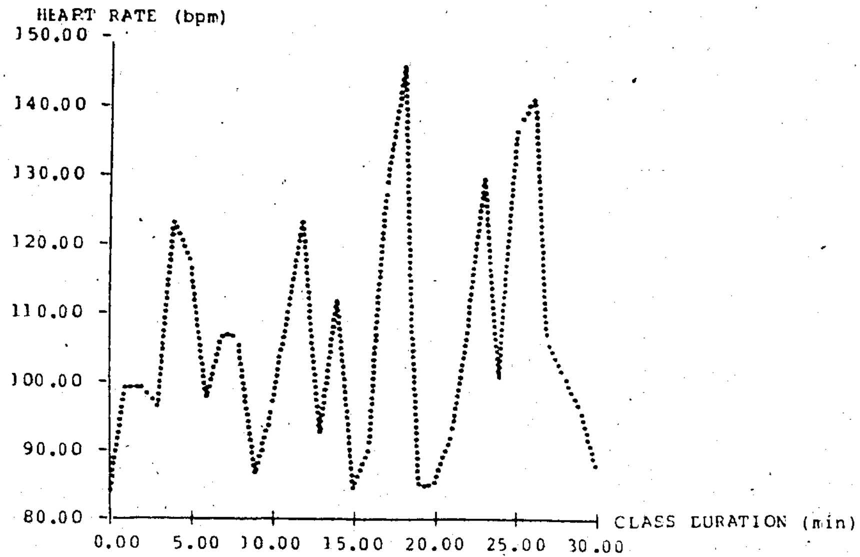

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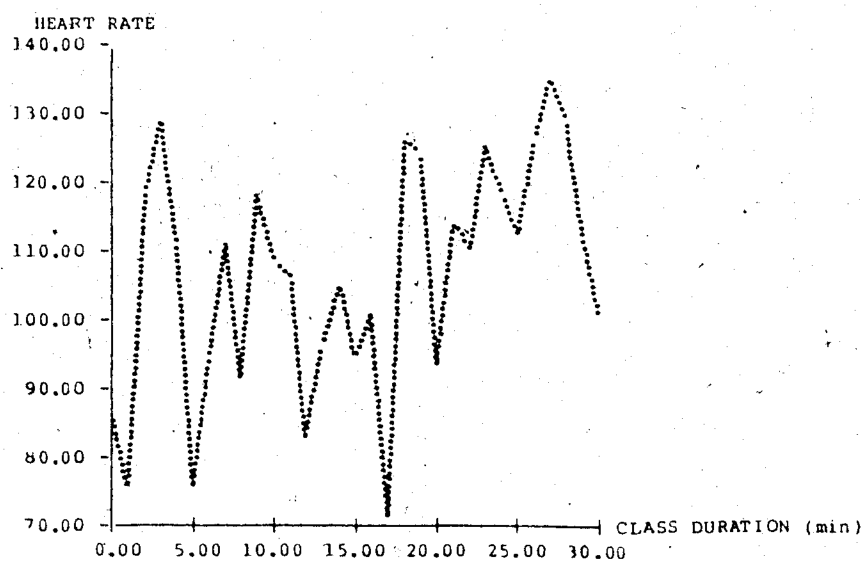

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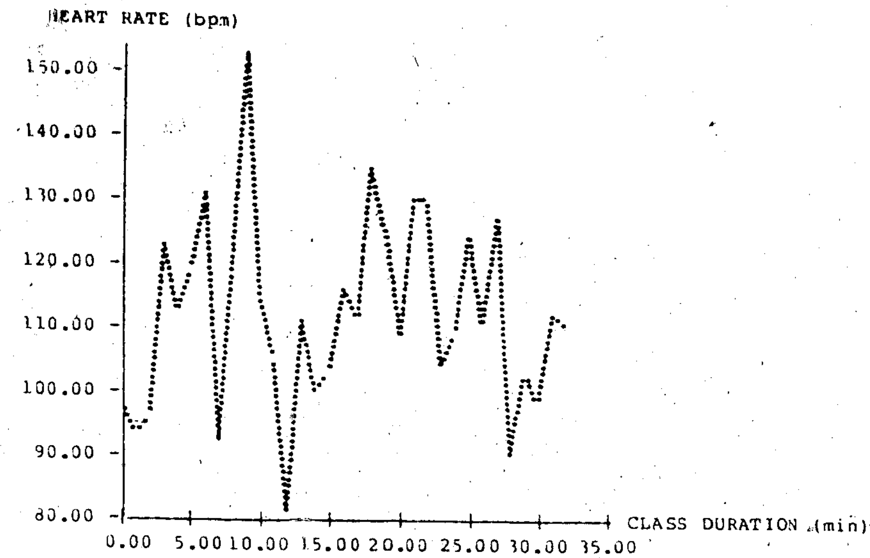
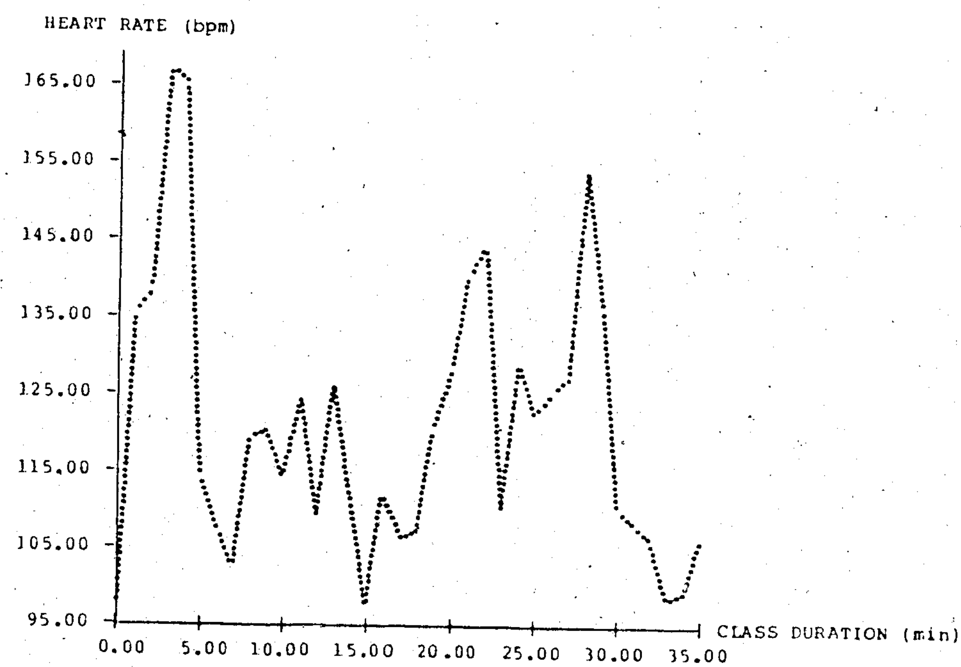
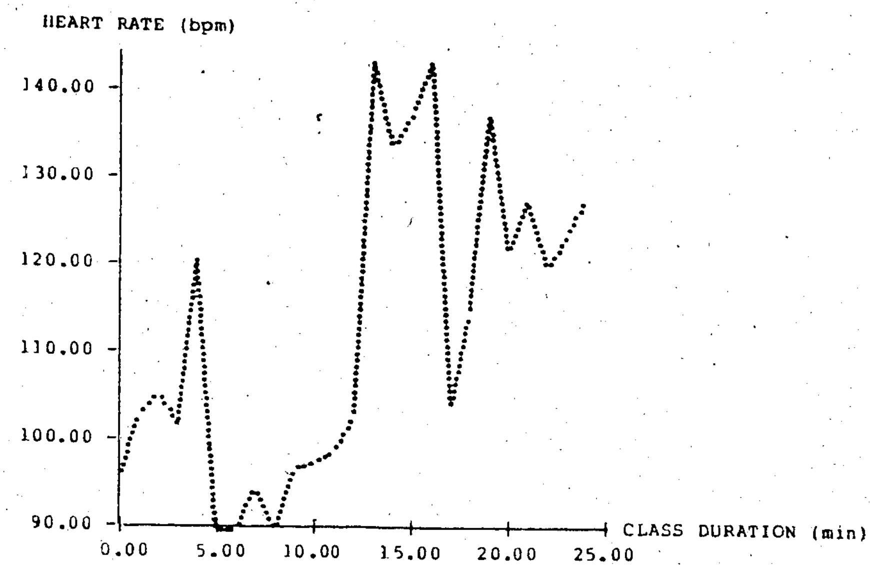


DANCE CLASS #3 FOR KA



DANCE CLASS #1 FOR JR



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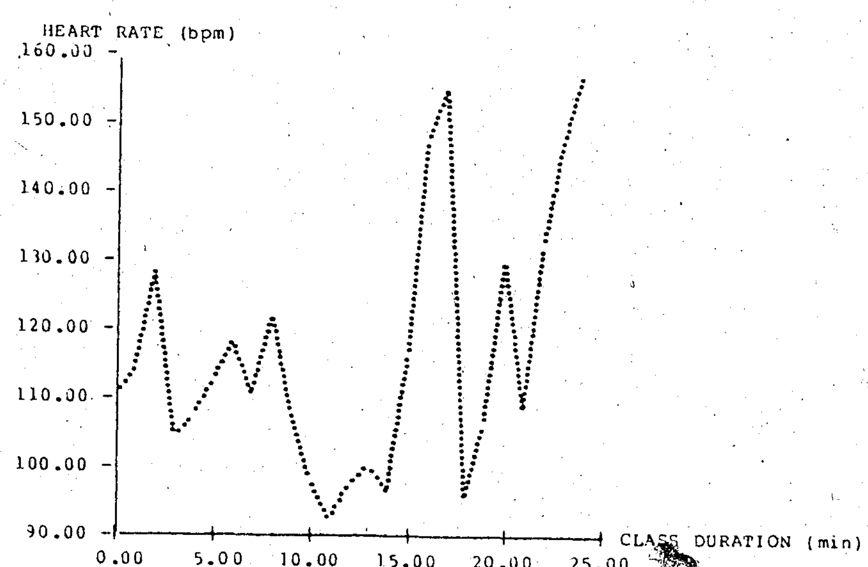

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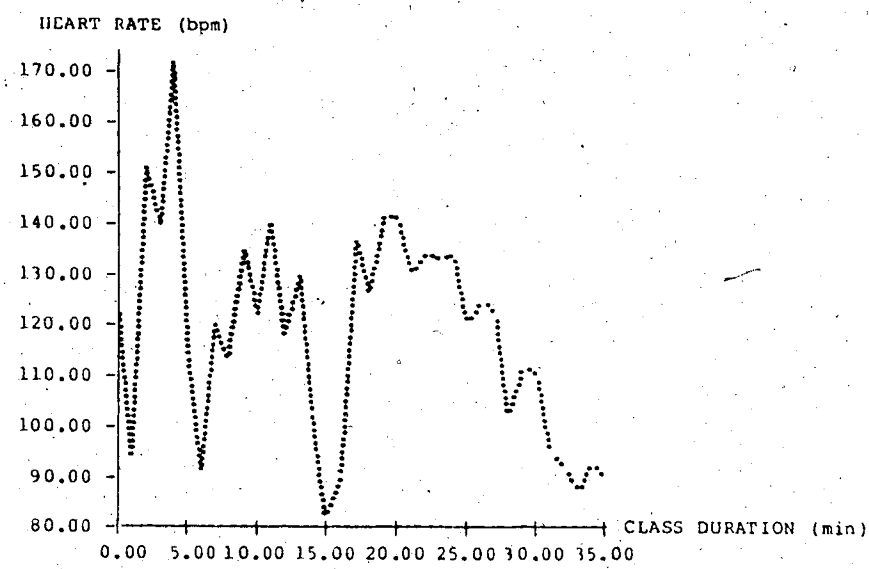
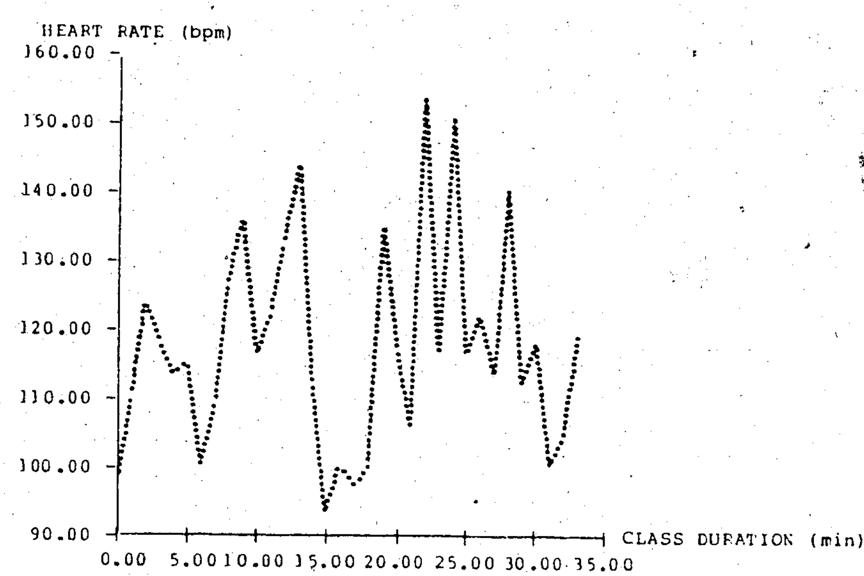
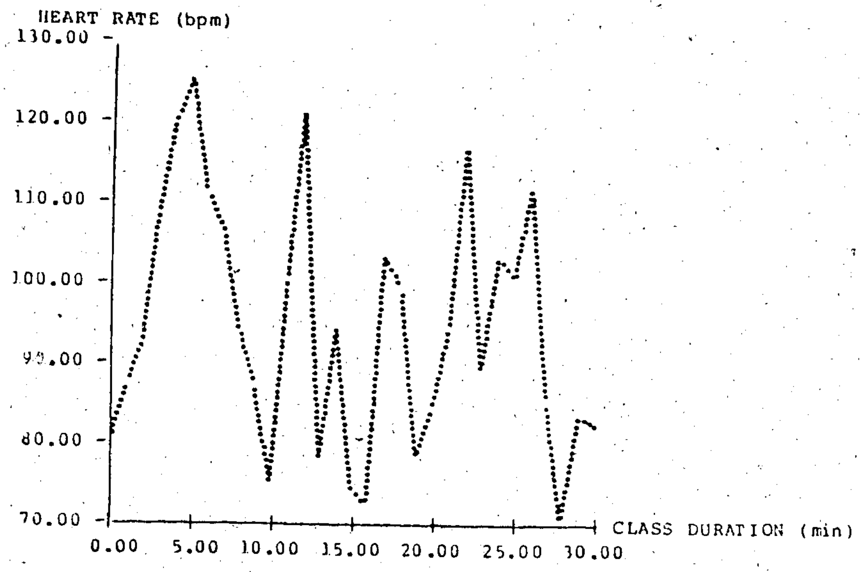


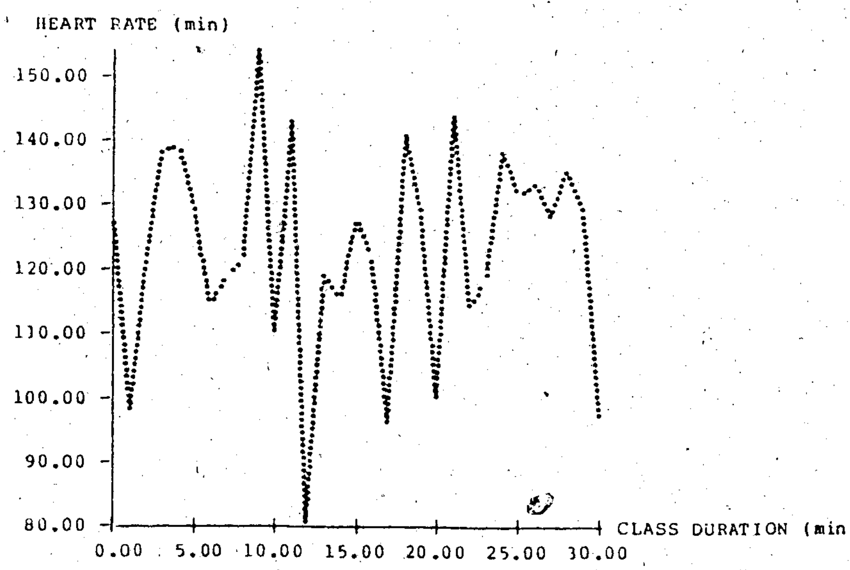
DANCE CLASS #1 FOR CS



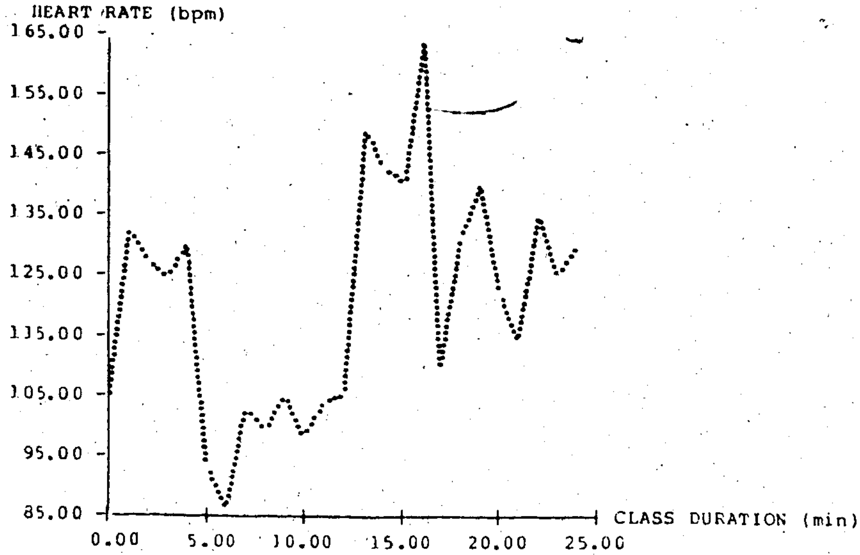
DANCE CLASS #2 FOR CS



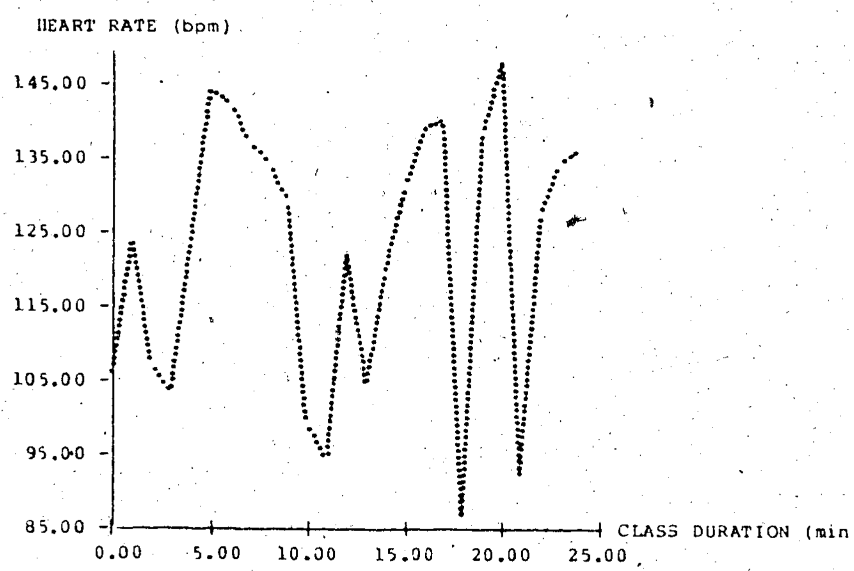
DANCE CLASS #3 FOR CS



DANCE CLASS #1 FOR KK



DANCE CLASS #2 FOR KK



DANCE CLASS #3 FOR KK

APPENDIX C: COMPOSITE PERCENTAGES
SAMPLE CALCULATIONS

RAW DATA:

ACTIVITY	REST	MILD HIGH	MODERATE HIGH	SEVERE	TOTALS
GYMNASTICS	191	591 (211)	338 (57)	25	1145
DANCE	175	389 (140)	140 (26)	9	713
GAMES	37	187 (77)	243 (76)	149	616

PERCENTAGE EXAMPLE:

1) REST CATEGORY FOR GYMNASTICS:

191/1145 x 100 = 16.7%

2) LOW MODERATE CATEGORY FOR DANCE:

140/713 x 100 = 19.6%

3) SEVERE CATEGORY FOR GAMES:

149/616 x 100 = 24.2%

APPENDIX D: INDIVIDUAL RESULTS

RAW DATA (1 = 30 seconds)

ACTIVITY	REST	MILD HIGH	MODERATE HIGH	SEVERE	TOTALS
CS					
GYM	70	149 (51)	84 (16)	2	305
DANCE	56	100 (30)	38 (10)	2	196
GAMES	10	46 (16)	63 (30)	38	159
KA					
GYM	67	133 (46)	61 (7)	1	262
DANCE	62	108 (35)	19 (1)	0	189
GAMES	6	62 (25)	49 (14)	27	144
KK					
GYM	37	139 (59)	96 (17)	17	289
DANCE	26	75 (41)	54 (7)	2	157
GAMES	14	41 (19)	55 (15)	34	144
JR					
GYM	17	170 (55)	97 (17)	5	289
DANCE	31	106 (34)	29 (8)	5	171
GAMES	7	36 (17)	76 (17)	50	169

APPENDIX E: CALCULATION OF OXYGEN CONSUMPTION
SAMPLE CALCULATION

SUBJECT: CS

SLOPE = 2.9251   Y-INTERCEPT = 66.5254

Y = HEART RATE
X = OXYGEN CONSUMPTION

$$y = bx + a$$

therefore $x = y - a/b$

FOR A HEART RATE OF 130 bpm, THE OXYGEN CONSUMPTION IS:

$$x = 130 - 66.5254/2.9251 = 21.7 \text{ ml/kg-min}$$

APPENDIX F: CALCULATION OF PERCENTAGE OF MAX VO2

SAMPLE CALCULATION

SUBJECT: CS

VO2 VALUE AT 130 bpm = 21.7 ml/kg-min

MAX VO2 = 61.4 ml/kg-min

PERCENTAGE OF MAX VO2 = 21.7/61.4 x 100 = 35.34%