THE RELATIONSHIP BETWEEN PERCEIVED EXERTION AND HEART RATE OF THE OLDER POPULATION DURING TWO DIFFERENT WALKING ACTIVITIES

by

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Abstract

The relationship between Rate of Perceived Exertion (RPE) and Heart Rate (HR) was studied in order to evaluate Borg's RPE-Scale as an accurate and complementary measure to HR monitoring in determining safe intensity levels during physical performance testing of older people. Specifically, this study examined the relationship between RPE and HR with regard to: (a) participants aged 50 years and over; (b) differences between performance test I (600 meter walk) and II (2 minute on-the-spot walk); (c) differences between men and women. Subjects included 105 females ($\overline{X}$ = 64.8 years) and 97 males ($\overline{X}$ = 64.3 years) who participated in either a timed 600 meter walk or a 2 minute on-the-spot walk. To measure individual exertion, Borg's 15 point RPE-Scale was administered immediately following the activity, HR was also measured at this time by an Exersentry monitoring device. Pearson product moment coefficients of correlation were calculated to deter-

mine the relationship between RPE and exercise HR. Significant correlations between RPE and HR were found for females in both the 600 meter walk (r=.48, 54 subjects, p=.0003) and 2 minute on-the-spot walk (r=.43, 51 subjects, p=.002). For males a significant correlation was found only in the 2 minute on-the-spot walk (r=.25, 62 subjects, p=.05). The significance of the difference between two correlation coefficients for independent samples was calculated to determine the difference between correlation values of performance test I and II, and between male and female participants. No significant difference was found between the correlation values of performance test I and II. Regarding male and female participants the analysis illustrated a significant difference in the correlation values (p=.05). It was concluded that: (a) the low correlation values obtained may illustrate the difficulty encountered when exercise intensity does not consist of progressively increasing workloads where the RPE of a particular workload is based on the RPE from previous workloads; (b) a similar relationship exists between RPE and HR for both performance test I and

II; (c) a stronger relationship exists between RPE and HR for women than for men.

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FOR MY

MOTHER AND FATHER

CHAPTER 1

Introduction

Statistics on population trends indicate that we are rapidly becoming a nation of older people (deVries, 1980). Shephard (1978) projects that by the year 2001, people over the age of 65 will represent 11 to 12% of the Canadian population.

Ten years ago the fitness level of the older population was cause for concern. Statistics Canada (1972) reported that less than 9% of those over the age of 55 years participated in any deliberate exercise (Shephard, 1978). Recently this problem has received the attention of an increasing number of professionals who are devoting more time to research and exercise program development for the older populace.

There is a wealth of information which proclaims the advantages for maintaining fitness levels in later life (Clarke, 1977; Harris, 1977). Research indicates that when this maintenance function is not realized, fitness parameters will normally decrease more quickly with advancing age (Kraus, 1977).

Gore (1977) states that while many older individuals are limited in their ability to pursue regular physical activity, the need for a minimum level of daily exercise to prevent the problems associated with hypokinetic disorders (disease produced by lack of exercise), has been established.

Although there has been a dramatic increase in requests for physical activity programs for the older population (Serfass, 1980), there remains a dearth of information. deVries (1980) states that the decline in physical performance with age deserves a great deal more emphasis by scientific investigators than it has been accorded in the past. Only recently has attention been focused on the problems of maintaining and improving physical fitness and associated functional capacities in the elderly male and female.

Physical activity programming for the older adult requires more care and thought than for any other age group. This is necessary in part because of the dire medical consequences of improper fitness programming (Morse & Smith, 1980).

Shephard (1978) notes that some exercise programmes for middle-aged and older citizens have had a more than 50% toll of sprains, strains and bone injuries within the first few weeks of conditioning. It is, therefore, necessary to balance the risks of physical activity with the risks of a sedentary lifestyle.

One of the concerns for fitness leaders involved in exercise programmes for the older populace, is the monitoring of intensity levels. The standard heart rate (HR) monitoring technique is the method most commonly used. However, this method is often ineffective for various reasons, such as, inaccuracy of self-assessment, difficulty in finding pulse, and higher HR measures for women in relation to work intensity (Burke, 1979).

An alternate, complementary measure to HR monitoring might be the use of the Rate of Perceived Exertion Scale (RPE-Scale) designed by Gunnar Borg of Sweden in 1962 (Appendix A). Studies by Borg (1962), Borg and Linderholm (1967), Skinner et al. (1969), and Bar-Or et al. (1972) report good linearity and high correlations ranging from r=.77 to .90, between RPE and HR. Use of

the RPE-Scale requires that the participant concentrate on subjective feelings of fatigue, and report a number based upon his/her perception of effort.

The review of related literature to be covered in Chapter II indicates numerous studies of perceived exertion under varying experimental conditions, however, very little relates specifically to the older population.

The challenge that confronts the fitness leader when prescribing exercise to the older populace is to ensure that the participant is working at a safe and progressive level. This study will attempt to provide viable information toward this end.

Statement of the Problem

The purpose of this study was to evaluate Borg's RPE-Scale as an accurate and complementary measure to HR monitoring in determining intensity levels during performance testing of male and female participants aged 50 years and over. In particular, this study tests the following null hypotheses:

1. There will be no significant correlation between RPE and HR of male and female participants aged 50 years and over as measured by (a) Borg's RPE-Scale and (b) Exersentry HR monitor.
2. There will be no significant difference in the correlation coefficients between RPE and HR regarding performance test I (600 meter walk) and II (2 minute on-the-spot walk).
3. There will be no significant difference in the correlation coefficients between RPE and HR regarding female and male participants.

CHAPTER 2

Review of Related Literature

There is substantial research dealing with perceived exertion especially in relation to younger and middle-aged men during bicycle ergometer and treadmill work. In contrast, older men and women have received only marginal attention. This chapter presents related literature drawn from a number of sources: Borg's definition of perceived exertion; the first psychophysical studies in the area; the development of the RPE-Scale; and the effects on RPE in regard to age; sex; activity level; body composition; training; and differing physical work.

Borg's Definition of Perceived Exertion

According to Borg (1962:10) the subjective perception of effort, exertion and fatigue, is very difficult to define in a general way. He stated:

> This perception is of a comparatively complex nature and consists of contributory factors: sensations from the organs of circulation and respiration, from the muscles, the skin, the joints,

etc. From a subjective point of view one may speak of the perception of force or pedal resistance, effort, fatigue, strain exertion, heat, pressure, pain or anxiety, etc.

Borg (1962) differentiates between short-time work and long-time work on the bicycle ergometer, in that the former allows for the muscular force to be decisive in perceiving exertion as effort or pedal resistance. For work of long duration more stress is placed on the organs of circulation, therefore, it may be more appropriate to speak of perceived exertion as laboriousness, fatigue or perceived exhaustion.

The First Psychophysical Studies on Perceived Exertion

The first studies by Borg and Dahlstrom (1959, 1960) dealt with general psychophysical problems of subjective force and perceived exertion. These studies were concerned with how subjective force during short-time work (less than 1 minute) on a bicycle ergometer, varies with pedal resistance.

In these studies, the production methods known as halving or doubling, were utilized. For example, sub-

jects worked at a specified power level for a certain time and then adjusted the power level until it was perceived to be half, or double, the intensity of the initial level. The deviations of the settings from the actual physical values revealed the size of the psychophysical exponent. The results showed that the subjective perception of the force applied (or perceived pedal resistance) followed a positive accelerating function. These ratio-scaling experiments revealed an exponent of 1.6 for subjective force.

In studies of subjective perception of handgrip force, positively accelerating functions with an exponent of 1.7 have been found (Stevens & Mack, 1959). An exponent of 1.6 was found for isometric leg force in a study by Eisler (1962). In psychophysical studies of weight lifting, an exponent of 1.45 has been reported by Stevens and Galanter (1957). Hueting (1965), Hueting and Sarphati (1966) and Sjoberg (1968), found positively accelerated functions during bicycle ergometer work.

Therefore, it has been demonstrated in many different areas of physical work, that subjective inten-

sity grows according to a positively accelerated function with the physical working load.

Development of the RPE-Scale

The afore mentioned studies demonstrate the first ratio-scaling methods used to measure perceived exertion. These methods give measurements on a ratio-scale with an absolute zero point and equidistant values (Borg, 1961).

The applicability of the ratio-scaling methods has been ascertained in many studies (Stevens, 1957, 1966; Ekman, 1958, 1959). However, according to Borg (1962) they do not give absolutely true values in a physical or mathematical sense, but rather, provide rough mathematical descriptions of differences between modalities or groups of subjects.

Borg (1962:20) noted that ratio-scaling methods are not applicable for interindividual comparisons:

> Psychophysical ratio experiments do not make possible immediate interindividual comparisons of the intensity of perception. The ratio scale yields relations between perceptions, but not levels

revealing anything about the intensity in relation to some general intersubjective point of reference. In most practical situations a simple rating method is, therefore, superior to a ratio method.

To make possible direct interindividual comparisons, simple rating methods of a category type were developed. The first scale used consisted of 21 points, where every second number on the scale was anchored with verbal expressions (Borg, 1962) (Appendix B). In the first differential studies on groups of patients and healthy subjects, perceived exertion was investigated with a step-wise increase in workload on the bicycle ergometer. The ratings according to the scale gave high correlations with HR, e.g., in groups of healthy people correlations between .80 and .90 were found (Borg, 1962).

By trial and error during several studies conducted by Borg (1962), the numerical values and verbal expressions on the 21-graded scale were manipulated in order to increase the linearity of the relationship between RPE values and HR. The scale now consists of

15-grades from 6 to 20, where every second number is accompanied by a written description (Appendix A). For healthy middle-aged men the HR at moderate to high intensities may be roughly predicted from the RPE values simply by multiplying by 10 (Borg, 1971).

Borg's "RPE-Scale", has been used in many different studies in many countries (Borg & Noble, 1974). Some of the first studies on perceived exertion during bicycle ergometer work concerned differences in perceptual and physiological responses among groups of subjects of different ages (Borg & Linderholm, 1967); different groups of patients, e.g. vasoregulatory asthenia syndrome, arterial hypertension and coronary heart disease (Borg & Linderholm, 1970); and various other subjects during differing modes of work and situations (Borg & Noble, 1974).

Perceived Exertion in Various Age Groups

Many studies have shown that maximal HR decreases with age (Robinson, 1938; Astrand, 1960; Strandell, 1964; and Borg & Linderholm, 1967). According to Borg and Noble (1974) this implies that the relationship between RPE and HR also changes with age.

In bicycle ergometer studies by Borg and Linderholm (1967) this relationship was studied in four different age groups of Swedish lumber workers (N=61, 27-63 years) and a mixed group of men of different occupations (N=271, 18-79 years). It was found that the relationship betwen RPE values and HR changed with age, older people rating the exertion higher in relation to HR, than young people. It was noted that this change clearly reflects the decrease of maximal HR with age. Similar findings were reported by Bar-Or (1977) when he assembled data on eight different research projects, where the subjects also performed bicycle ergometer work (N=1316, 7-68 years).

Since it is known that physical working capacity decreases with age, Borg and Linderholm (1967:205) suggested that RPE gives a better and more direct indication of the "real" change in physical stress with age, than do heart rates.

Perceived Exertion in Men and Women

Sex differences can be examined from the data of a number of studies. Borg and Linderholm (1970) worked

with both male and female subjects of three age groups, 18-20, 20-24 and 50-59 years of age. All subjects performed a work test on a bicycle ergometer with a stepwise increase in the workload. Ratings of perceived exertion according to the 21-graded scale were obtained at the same time as heart rates. Findings indicated that females had on average, a slightly higher HR at equal ratings of perceived exertion. However, the difference was not statistically significant except at low ratings (Rg= "rather light" work) in the group 20-24 years of age.

Henriksson et al. (1972:541) found that when performing concentric and eccentric work on a modified Krogh cycle ergometer:

> The female subjects perceived the exertion, in concentric as in eccentric exercise, as greater than male subjects, both in relation to exercise intensity and oxygen consumption. If compared on the basis of heart rate, only slight differences in perceived exertion were found.

Michael et al. (1972) studied 4 female and 4 male subjects to determine physiological responses when sub-

jects subjectively estimated workloads on a treadmill and on a bicycle that would exhaust them if carried out for 15 minutes. Findings indicated that men chose work levels that resulted in HR's and respiratory quotients (RQ) similar to the women's, while energy levels and debts were twice the level of female subjects.

Arstila et al. (1977) studied the relation between RPE and HR in over 400 men and women aged 30, 45 and 60 years. The work was performed on an electrically braked cycle ergometer, with RPE's recorded every 2 1/2 minutes at HR 100, 120, 140 and 160. The study found that the linearity of RPE in relation to HR was far better in men than in women.

Effects of Activity Level and Body Composition on Perceived Exertion

A number of studies have demonstrated the effects of various activity levels and body composition on the relationship between RPE and HR. Skinner and Borg (1969) studied bicycle ergometer work of young men between the ages of 17 and 24 who differed in activity level and body size. It was found that at the same

submaximal workloads, active subjects had lower HR's and lower RPE's than did sedentary subjects. In addition, heavier subjects had a lower HR than lean subjects, but there was no difference in RPE. However, differences between activity and body size subgroups were not found at given percentages of maximum working capacity (relative workload).

Similar findings were reported by Bar-Or and Skinner (1972) in a study examining RPE during exercise of 51 physically active and 19 sedentary men, 41-60 years old. The study presented evidence that RPE is closely related to HR, and therefore, to the relative workload (% maximal working capacity), irrespective of conditioning or adiposity.

Effects of Training on Perceived Exertion

The effects of training on RPE in physical work has been studied by several investigators. Linderholm (1967) studied Swedish soldiers before and after 4 months of training. Results indicated that both RPE and HR were reduced approximately 20% at the same submaximal workload following training. Similar findings

were reported by Docktor and Sharkey (1971), following a 5 week training program.

Ekblom and Goldbarg (1971:405) studied 19 healthy subjects (mean age 24 years), before and after 8 weeks of training. It was found that RPE was 1.5-2.0 points lower after training for a given level of oxygen uptake. Since maximum VO_2 increased with training, RPE differences did not occur when VO_2 was expressed in "relative" terms (% of maximum VO_2). The relationship between RPE and HR remained unchanged with training, but the VO_2-RPE relationship changed in terms of raw values but not in relative terms. As noted by the investigator:

> The explanation for the lower scoring for a given load after training can be found in both the relative lesser strain on the cardio-respiratory systems and in the improved function of the working muscles, which is reflected in the lower oxygen deficit and blood lactate concentration.

Effects of Differing Physical Work on Perceived Exertion

In recent years, various studies have been pursued in an attempt to understand the physiological parameters in the subjective perception of exertion. Such studies include Borg, 1962; Borg and Noble, 1974; Ekblom and Goldbarg, 1971; Henriksson, 1972; Noble and Metz, 1973; Pandolf and Noble, 1972, 1973; and Pandolf and Burse, 1975. According to Pandolf (1977:371), many psychophysiological studies conclude that: "...the overall perception of exertion during physical work represents a gestalt or integration of various physiological sensations and feelings."

Ekblom and Goldbarg (1971:405) found that RPE's for given levels of oxygen uptake were higher during arm work than during leg work, as well as during cycling when compared with running or swimming. They, therefore, proposed a two-factor model to explain the variation in RPE during different types of physical work. These two factors involve a local factor, i.e., feelings of strain in the working muscles, and a central factor, i.e., feelings primarily involving the cardiopulmonary systems. They stated that:

> In work with small muscle groups the local factors seem to be dominant, while work with large muscle groups will tend to stress the pulmonary ventilation and the circulation and thus give an addition to the local strain.

Kay and Shephard (1969) found the central factor to be more prominent during treadmill work, while Ekblom and Goldbarg (1971), Henriksson et al. (1972), and Pandolf and Noble (1973) agreed that the local factor appears to dominate the perception of exertion during bicycle work.

Henriksson et al. (1972) examined RPE during concentric and eccentric work on the bicycle ergometer at 30 and 60 rpm pedal frequencies, where HR, VO_2, and power output were held constant. The study found that, at the same power output, 30 rpm was perceived greater than 60 rpm for both types of work. A similar study by Pandolf (1973) using concentric work only, found that 40 rpm work was subjectively judged to be more stressful than 60 and 80 rpm work. Both of these experiments indicate that factors other than HR, VO_2 and power output, account for the increased RPE at the lower pedal

frequencies. Henriksson et al. (1972) suggests that muscle tension may be a factor in the higher RPE values since it must be doubled during the contraction to sustain the same power output at half the frequency. Pandolf (1973) holds that local factors, i.e., muscle joint discomfort and/or anaerobic products, contribute to the high RPE values.

Another study which also suggests that local muscle involvement effects RPE values, was conducted by Noble et al. (1973). RPE and metabolic responses were measured during treadmill work of walking and running at similar velocities between 2.5 and 5.5 mph. HR while walking was found to be less than running at velocities less than 4.0 mph. Walking and running curves intersected at 4.92 mph and reversed so that walking HR was higher following this point. RPE displayed a similar pattern except the curves intersected at a significantly lower velocity of 4.31 mph. This led the investigators to propose that local muscular discomfort encountered at higher walking velocities was responsible for the earlier RPE intersection.

Summary

The review began by attempting to clarify the meaning of perceived exertion with a definition from the originator of the RPE-Scale, Gunnar Borg.

The first ratio-scaling methods aimed at providing a calculable measurement of psychophysical phenomena, were examined. Briefly outlined were numerous experiments and consequent modifications by Borg (1962), which led to the development of the 15-graded RPE-Scale. This has since become internationally accepted as a valid and reliable measurement of perceived exertion (Borg & Noble, 1974).

Based on the material presented in this review of literature, the following statements summarize the effects of various factors on RPE values.

1. Older people rate exertion higher in relation to HR, than young people.
2. Women, on average, have slightly higher HR's than men at equal RPE values, and the linearity of RPE in relation to HR is better in men than in women.

3. RPE is related to HR, irrespective of activity level, body composition or training.
4. The variation in RPE values during different types of physical work can be attributed to either a local factor of muscular strain, and/or a central factor involving the cardiopulmonary systems.

CHAPTER 3

Method

Design

It was the purpose of this study to determine whether Borg's RPE-Scale provides an accurate and complementary measure to HR monitoring, in determining intensity levels during physical performance testing of older people.

The physical performance tests involved either a timed 600 walk, or a 2 minute on-the-spot walk, to which subjects were alternately assigned, and at the completion of which RPE, HR, time (600 walk), and number of steps (2 minute on-the-spot walk), were recorded.

Subjects

Subjects of the present study were volunteers of the Post 50 '3-S' Physical Performance Test (Bell, Collis & Hoshizaki, 1982) which was a project designed to create a self-administered fitness test for the older population. Volunteers were recruited by mail correspondence and by telephone soliciting to eight senior

citizen clubs (Appendix F) in Victoria, British Columbia, and surrounding area.

The Physical Activity Readiness Questionnaire (PAR-Q) (Appendix C) was administered as a screening tool to identify those subjects considered to be at possible risk. A total of 11 subjects were rejected by the PAR-Q and were unable to participate in the test (four due to previous heart problems and seven due to high blood pressure). This resulted in a total of 202 volunteers, 105 females ($\bar{X}$=64.8 years) and 97 males ($\bar{X}$=64.3 years).

Independent Variables

Independent variables in this study were:

1. Performance Test. The performance test was either a timed 600 meter walk or a 2 minute on-the-spot walk.
2. Participant's Age. Restricted to participants 50 years of age and over.
3. Participant's Sex. Males and females participated in the physical performance tests.

Dependent Variables

Dependent variables in this study were:

1. HR Measurements. An Exersentry HR monitoring device (Appendix D) was attached to each participant to enable continuous monitoring and to accurately determine working HR at completion of the timed 600 meter walk and the 2 minute on-the-spot walk.
2. Perceived Exertion. The RPE-Scale (Borg, 1962) (Appendix A) was used to determine subjective ratings of perceived exertion at completion of the timed 600 meter walk and the 2 minute on-the-spot walk.

Delimitations

The following delimitations were in effect for this study:

1. The study was restricted to men and women 50 years and over.
2. The study was restricted to men and women who successfully completed the Physical Activity Readiness Questionnaire (PAR-Q) (Appendix C).

Limitations

The following limitations occurred in this study:

1. The study was limited by the reliability of the instruments used for gathering data, namely, the RPE-Scale and Exersentry HR monitoring device.
2. The study was limited by the participants' comprehension of the correct use of the RPE-Scale.
3. The study was limited by the researcher's ability to accurately and reliably record information.

Definition of Terms

Perceived Exertion: One's subjective rating of the intensity of work being performed (Morgan, 1973). A gestalt or integration of various physiological sensations and feelings of effort and stress due to physical work. Peripheral sensations from muscles and joints and central sensations from the cardiovascular system, form together with previous experiences the perception of exertion (Borg & Noble, 1974).

Psychophysiological Studies: Investigation of perceived exertion in an attempt to understand the relative importance of various physiological parameters in the subjective perception of exertion.

Cardio-Respiratory Fitness: The combined efficiency of the respiratory system in taking in oxygen, the circulatory system in delivering it to the muscles and then the utilization of the oxygen by the muscles in producing energy.

Instrumentation

The following instruments were used for the study:

1. Exersentry HR monitoring device. An Exersentry HR monitoring device was used to measure HR during all test sessions. The Exersentry was chosen because of its suitability and reliability as a HR measuring device (Miller, 1982) (Appendix D). The instrument works on the same principle as the electrocardiogram (ECG) by detecting the electrical signal (R wave) produced by the beating heart which the Exersentry picks up through its soft plastic electrodes. Every 4

beats the heart rate is recomputed and displayed in beats/minute.

2. RPE-Scale (Borg, 1962). Explicit instructions regarding the use of the scale were presented prior to each performance test (Appendix A). Immediately on completion of the test, a large diagram of the RPE-Scale was placed in front of each participant, at which time he/she pointed to a number most closely corresponding to his/her feelings of exertion. The RPE-Scale is designed to translate feelings of exertion into numbers. The range of numbers represents a range of feelings from "No exertion at all" (number 6) to "maximal exertion" (number 20). In order to help select a number which corresponds to subjective feelings, every other number has an attached verbal expression (Appendix A). The goal of the participants was to rate their feelings caused by the work and not the work itself. These feelings should be general, that is, about the body as a whole. Participants were instructed to choose any number that

they thought was appropriate and to keep in mind that there was no right or wrong.

Procedure

Collection of data was performed over the months of May, June, July and August, 1982. Following successful completion of the PAR-Q, physical characteristics of the subjects, e.g., height, weight, resting HR, and age were recorded. Subjects were assigned alternately to the two walking tests, excepting where inclement weather affected the outdoor 600 meter walk. In such cases all subjects performed the 2 minute on-the-spot walk.

Prior to the walks each subject was fitted with an Exersentry HR monitoring device which was secured against the skin just below the chest. The shoulder strap of the Exersentry was removed to provide an easier method of fitting. Before attaching, electrodes on the Exersentry were dampened with a wet cloth to provide sufficient electrical conductivity. In addition, explicit instructions regarding the use of the RPE-Scale were presented prior to each test (Appendix A)

and a 2'x3' board displaying the RPE-Scale was constructed, allowing for easy reading and recording of exertion.

600 meter walk. The distance was measured prior to the test using an odometer wheel. Fifty-four female and 35 male subjects were individually instructed to proceed at a brisk, comfortable pace. Directions of the walk were explained and each subject was accompanied by the tester who monitored HR closely. RPE, HR and time were recorded at the completion of the walk.

2 minute on-the-spot walk. Fifty-one female and 62 male subjects were individually instructed to raise knees waist high and proceed at a brisk comfortable pace. To aid with balance and stability a table or chair was positioned beside the testing area, and each subject placed one hand on either the top of the table or the back of the chair for support, while performing the on-the-spot walk. RPE, HR and number of steps were recorded at the completion of the walk.

Data Analysis

Means for RPE and HR were calculated for the timed 600 meter walk and the 2 minute on-the-spot walk. Pearson product-moment correlations were calculated to determine the relationship between RPE and HR. The significant difference between correlation values of the 600 meter walk and the 2 minute on-the-spot walk, and between male and female participants were tested using the significance of the difference between two correlation coefficients for independent samples.

CHAPTER 4

Results and Discussion

Introduction

The purpose of this study was to provide information on the use of the RPE-Scale as an accurate and complementary measure to HR monitoring in determining safe intensities during physical performance testing of older people. This chapter presents the results and analysis for each of the three hypotheses listed in Chapter I.

Results

Physical characteristics of the subjects are reported in Table 1, e.g., mean age, weight, height and resting HR.

Table 1

Physical Characteristics of Participants

Variable	N	Mean	S.D.	Minimum	Maximum
Female					
Age (yrs)	105	64.8	6.8	50.5	90.3
Weight (kg)	105	62.3	8.8	42.5	85.6
Height (cm)	105	160.1	5.6	149.0	175.5
Resting HR (b/m)	105	85.8	12.9	46.0	123.0
Male					
Age (yrs)	97	64.3	7.8	50.3	84.6
Weight (kg)	97	76.6	10.9	53.3	110.6
Height (cm)	97	170.5	11.2	154.0	185.5
Resting HR (b/m)	97	84.5	12.3	51.0	119.0

At the completion of the timed 600 meter walk, a mean RPE of 11.35 and a mean working HR of 126 beats/min. were elicited. At the completion of the 2 minute on-the-spot walk, a mean RPE of 12.22 and a mean working HR of 131.69 beats/min. were elicited. Male and female differences for the 600 meter walk are reported in Table 2, and for the 2 minute on-the-spot walk in Table 3. The frequency of RPE scores and working HR's are also displayed graphically in Figures 1 through 4.

Table 2

Mean RPE, HR and Time Recorded at Completion of the 600 Meter Walk for Female and Male Participants

Variable	N	Mean	S.D.	Minimum	Maximum
Female					
RPE	54	11.13	1.67	6	14
HR (b/m)	54	127.76	15.87	94	175
Time (sec.)	54	373.52	43.50	254	532
Male					
RPE	35	11.69	1.43	8	15
HR (b/m)	35	124.37	19.03	75	172
Time (sec.)	35	358.00	76.81	276	710
Total					
RPE	89	11.35	1.60	6	15
HR (b/m)	89	126.43	17.16	75	175
Time (sec.)	89	365.76	60.15	254	710

Table 3

Mean RPE, HR and Number of Steps Recorded at Completion of the 2 Minute On-The-Spot Walk for Female and Male Participants

Variable	N	Mean	S.D.	Minimum	Maximum
Female					
RPE	51	12.24	1.63	7	15
HR (b/m)	51	133.59	17.17	93	165
No. of Steps	51	166.37	29.18	97	226
Male					
RPE	62	12.21	1.51	7	18
HR (b/m)	62	130.13	14.75	94	171
No. of Steps	62	169.48	37.43	100	240
Total					
RPE	113	12.22	1.56	7	18
HR (b/m)	113	131.69	15.91	93	171
No. of Steps	113	167.92	33.31	97	240

FEMALES

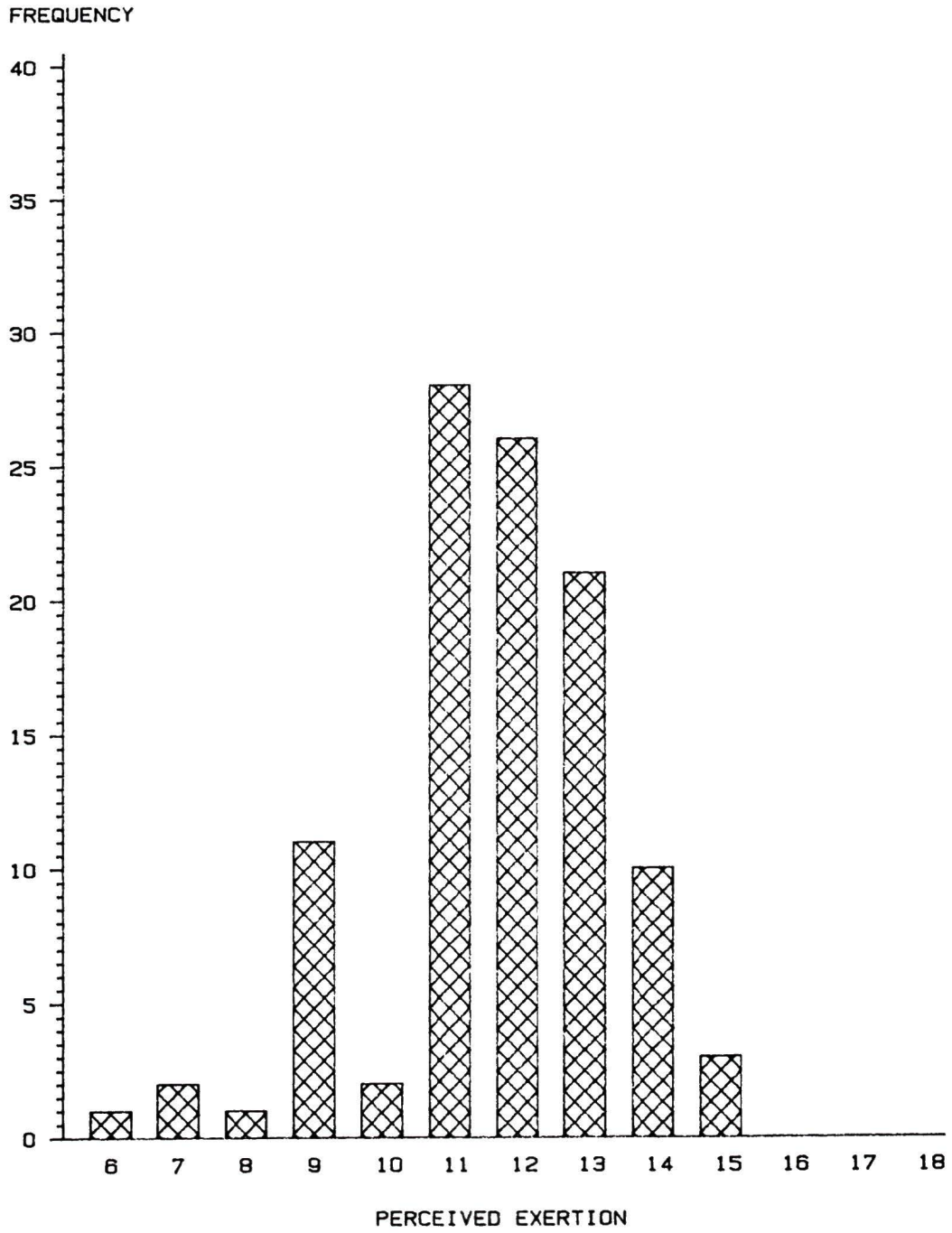

Figure 1. Frequency of RPE Scores recorded at the completion of the 600 meter and 2 minute on-the-spot walk for female participants.

MALES

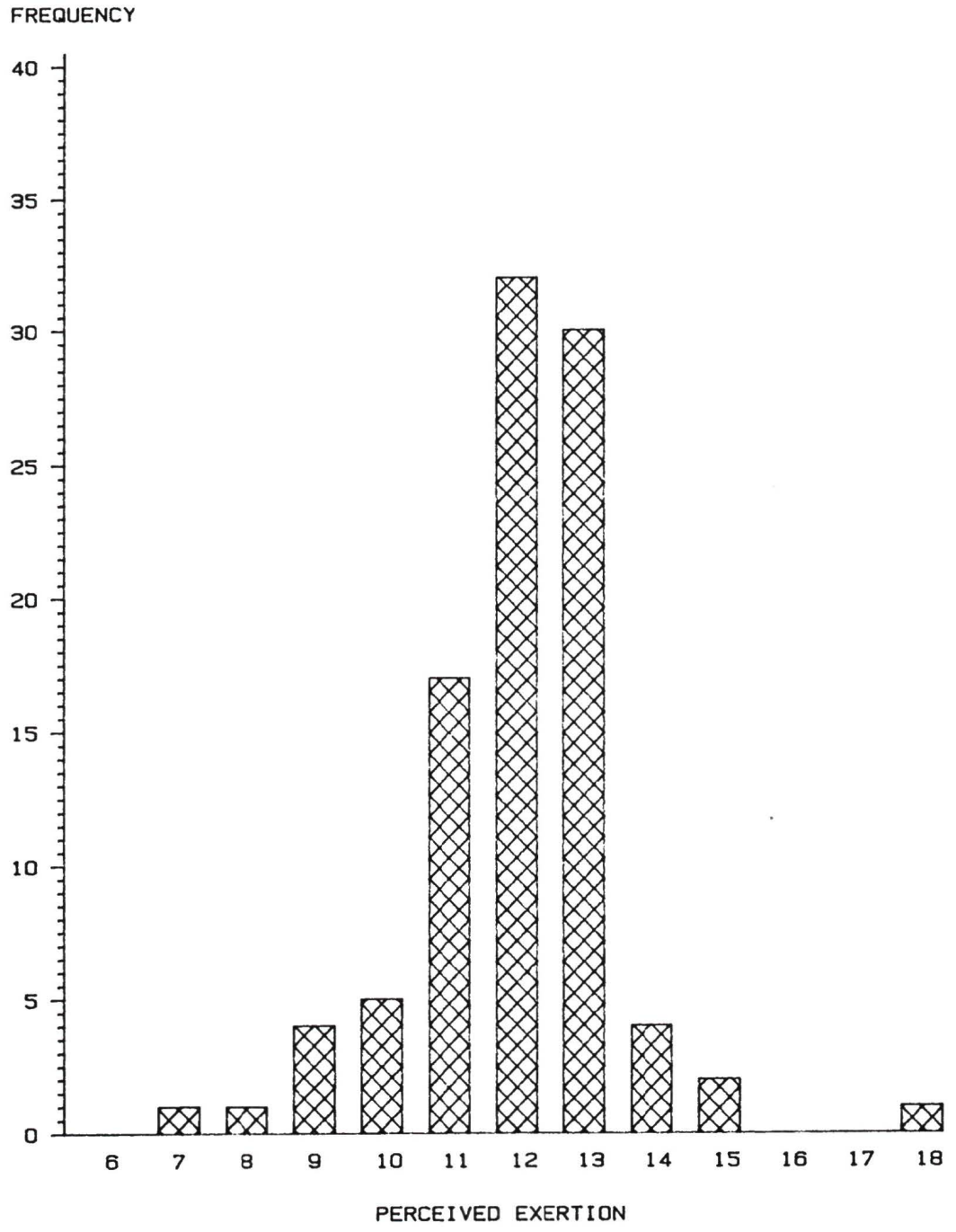

Figure 2. Frequency of RPE Scores recorded at the completion of the 600 meter and 2 minute on-the-spot walk for male participants.

FEMALES

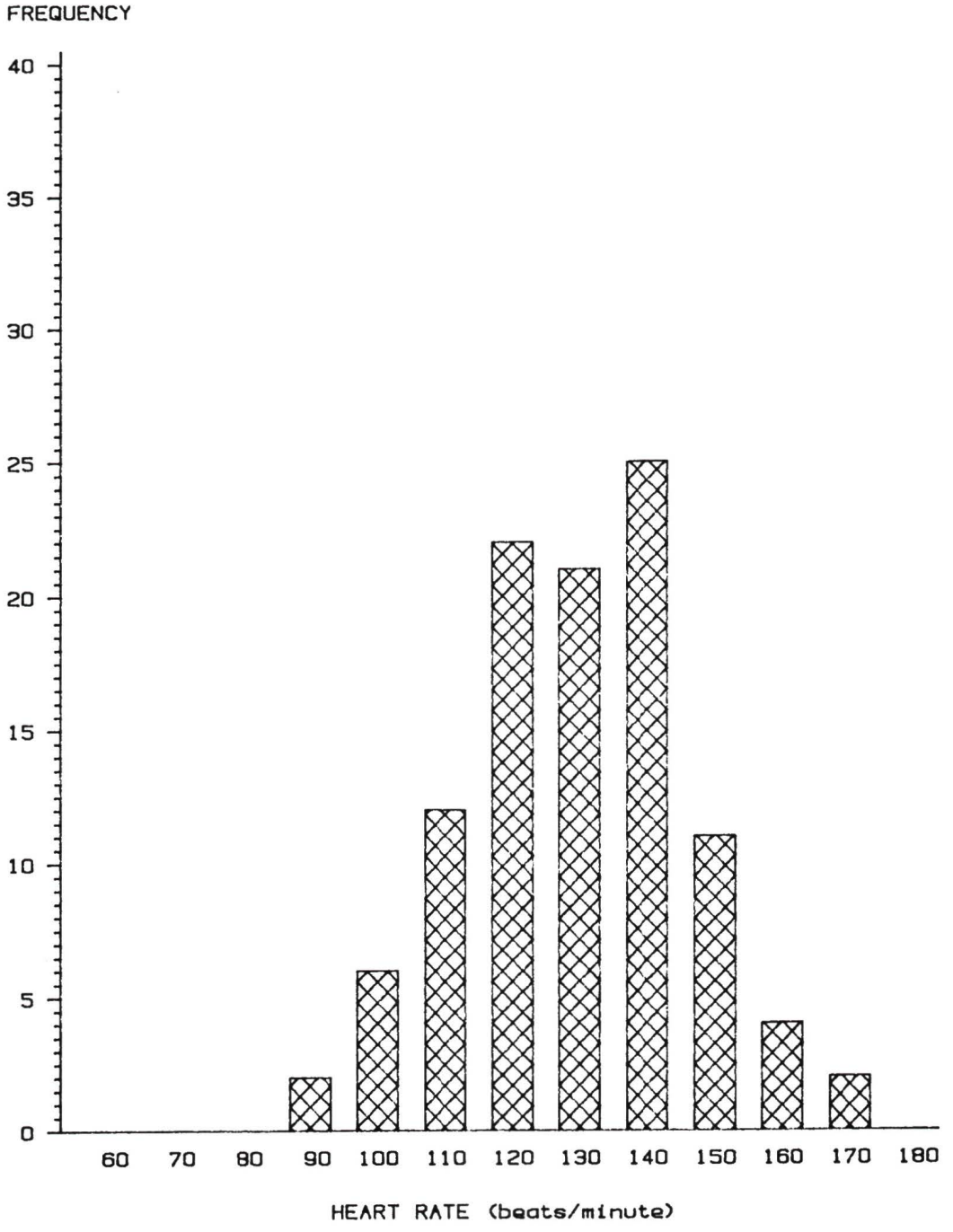

Figure 3. Frequency of HR s recorded at the completion of the 600 meter and 2 minute on-the-spot walk for female participants.

MALES

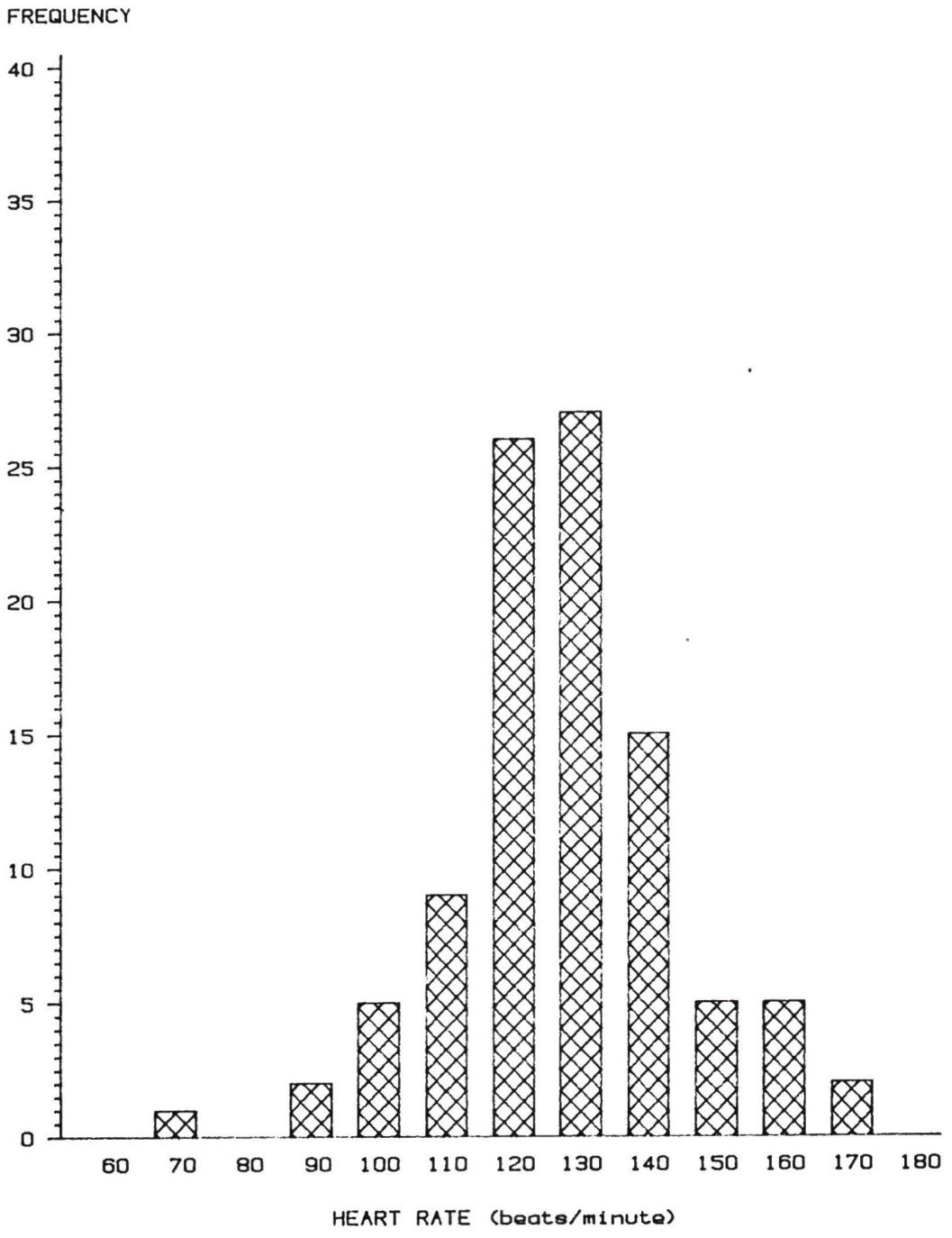

Figure 4. Frequency of HR s recorded at the completion of the 600 meter and 2 minute on-the-spot walk for male participants.

Hypothesis No. 1. There will be no significant correlation between RPE and HR of male and female participants aged 50 years and over as measured by (a) Borg's RPE-Scale, and (b) an Exersentry HR monitor.

The relationship between RPE and HR was analyzed using Pearson product-moment correlations. A summary of the findings is presented in Table 4.

Table 4

Pearson Product Moment Correlation Coefficients Between RPE and HR for the 600 Meter and the 2 Minute On-The-Spot Walks

Variable	N	r	P
600 Meter			
Female	54	.48	.0003
Male	35	.17	.33
Total	89	.33	.002
On-The-Spot			
Female	51	.43	.002
Male	62	.25	.05
Total	113	.34	.0002
600 Meter + On-The-Spot			
Female	105	.47	.0001
Male	97	.23	.02
Total	202	.36	.0001

Significant correlations between RPE and HR were found for females over the age of 50 years in both the 600 meter walk (p=.0003) and the 2 minute on-the-spot walk (p=.002). For males over the age of 50 years a significant correlation was found only in the 2 minute on-the-spot walk (p=.05).

Hypothesis No. 2. There will be no significant difference in the correlation coefficients between RPE and HR regarding performance test I (600 meter walk) and II (2 minute on-the-spot walk).

The significance of the difference between two correlation coefficients for independent samples was calculated to determine the difference between performance test I and II. The findings are presented in Table 5.

Table 5

Significance of the Difference Between Correlation Coefficients of the 600 Meter and the 2 Minute On-The-Spot Walks

Variable	N	Z	P
Female	105	.29	.77
Male	97	.37	.71
Total	202	.07	.94

No significant difference was found between the correlation values of performance test I and II.

Hypothesis No. 3. There will be no significant difference in the correlation coefficients between RPE and HR regarding male and female participants.

The significance of the difference between two correlation coefficients for independent samples was calculated to determine the difference between female and male participants. The findings are presented in Table 6.

Table 6

Significance of the Difference Between Correlation Coefficients of Female and Male Participants

Variable	N	Z	P
600 Meter	89	1.54	.12
On-The-Spot	113	1.07	.28
Total	202	1.97	.05

The difference between the correlation values of female and male participants is significant (p=.05).

Discussion

Correlations. Although the correlation coefficients ranging from r=.17 to .48 between RPE and HR found in this study are lower than the correlations ranging from .77 to .90 reported by Borg (1962), Borg and Linderholm (1967), Skinner et al. (1969), and Bar-

Or et al. (1972) using bicycle ergometer work, it is uncertain whether the correlation values from these other studies reflected the subjects' ability to perceive effort, or were a product of experimental protocol or technique. Skinner et al. (1973) and Stamford (1976) stated that in numerous studies it is questionable whether the high correlations between RPE and HR were due to accurate predictions by the subjects as to physical work intensity, or were the results of the testing technique. Work intensity was increased in a step-wise progressive manner and HR, which is linearly related to work intensity, increased accordingly. In a like manner, RPE may have also increased due to subject awareness of increased work requirements.

In examining this particular problem further, Skinner et al. (1973) and Stamford (1976) found high correlations ranging from .71 to .80 for RPE elicited from subjects performing randomly presented work intensities.

Stamford (1976) was also one of the few investigators who studied the validity of the RPE-Scale when used only once during the testing protocol. He found a

high coefficient (.90) between RPE and HR when only one reading was taken at the termination of the work task.

Stamford's successful results would suggest that the present study should also have resulted in high correlations. However, two major differences exist, these are:

1. The subjects of Stamford's study included 14 female undergraduate students with a mean age of 18.7 years, as opposed to men and women with a mean age of 65.96 years. This factor of age is discussed later.
2. The subjects of Stamford's study were much more familiar with the RPE-Scale. They were each involved in 12 tests during which RPE was measured on average 4 times per test. This contrasts considerably with the present study where RPE was measured only once for each subject at the termination of the work task.

In numerous studies, Borg (1962), Borg and Linderholm (1967), Skinner et al. (1969), Bar Or et al. (1972), Gamberale (1972), Skinner et al. (1973), Arstila and Wendelin (1974) and others, the RPE-Scale was

administered repeatedly during the testing, thus enabling the subjects to become proficient in its use. Therefore, in the present study, the low correlation coefficients could possibly be attributed to the fact that the subjects were too unfamiliar with the scale to accurately perceive their exertion.

Another factor which may have affected the correlation values in the present study is the age of the subjects. The few studies to have examined RPE and HR in older people found that this relationship changed with age. Borg and Linderholm (1967) and Bar Or et al. (1972) found that older people rated exertion higher in relation to HR than younger people. This clearly reflects the decrease of maximal HR with age and may explain the low correlations of the present study, considering that all the subjects were of an older age category.

Performance Test Differences. In recent years various studies have been conducted in an attempt to understand the physiological parameters in the subjective perception of exertion. Such studies include Borg (1962), Borg and Noble (1974), Ekblom and Goldbarg

(1971), Henriksson (1972), Noble and Metz (1973), Pandolf and Noble (1972, 1973), and Pandolf and Burse (1975). According to Pandolf (1977:371), many psychophysiological studies conclude that, "...the overall perception of exertion during physical work represents a gestalt or integration of various logical sensations and feelings."

The subjective perception of exertion associated with a work task is complex in nature and consists of the interplay among many contributing factors (Borg, 1962). Some of these factors are sensations from the organs of circulation and respiration, and from the muscles, skin and joints. It would seem that when particular sensations become pronounced they would dominate the perception.

In the present study, although there was no significant difference between the correlation values of the two performance tests, it was noted that slightly higher RPE values were elicited at the completion of the 2 minute on-the-spot walk even though, according to HR, the metabolic responses for both activities were equivalent. An explanation for this might be the two

factor theory proposed by Ekblom and Goldbarg (1971) to explain differences in perceived exertion between exercise tasks which were metabolically equivalent. The first factor is a local factor which involves the feeling of strain in the working muscles, while the second factor is a central factor which involves perception of ventilatory and circulatory stress.

The present study would appear to support the local factor theory, in that numerous subjects during and after completion of the 2 minute on-the-spot walk (raising legs to hip level) remarked on discomfort and fatigue of the quadriceps muscles.

Sex Differences. The findings of this study indicate a sex difference similar to that reported by Borg and Linderholm (1970), where females had on average, a slightly higher HR than males at equal ratings of perceived exertion (Tables 2 and 3). The findings also illustrate a significant difference ($p=.05$) in the correlation values between male and female participants, demonstrating that a stronger relationship exists between RPE and HR for women. This differs from the findings of Arstila et al. (1977) where a stronger

relationship existed between RPE and HR for men when investigating over 400 men and women aged 30-60 years, performing progressive bicycle ergometer work.

CHAPTER 5

Conclusions and Implications

Conclusions

The conclusions of this study are listed in order of the three hypotheses presented in the Statement of the Problem in Chapter 1. Also included are implications for future research into the use of the RPE-Scale in performance testing of the older populace.

Hypothesis No. 1. The analysis revealed significant correlations between RPE and HR for females over the age of 50 years in both the 600 meter walk ($r=.48$, 54 subjects, $p=.0003$) and the 2 minute on-the-spot walk ($r=.43$, 51 subjects, $p=.002$). For males over the age of 50 years a significant correlation was found only in the 2 minute on-the-spot walk ($r=.25$, 62 subjects, $p=.05$).

Hypothesis No. 2. The analysis indicated that there was no significant difference in the correlation coefficients between RPE and HR regarding the different performance tests i.e. the 600 meter walk and the 2 minute on-the-spot walk.

Hypothesis No. 3. The analysis illustrated a significant difference in the correlation coefficients ($p=.05$) between RPE and HR regarding male and female participants. The correlation values suggest that a stronger relationship exists between RPE and HR for women.

Implications

Although there is a considerable amount of research confirming high correlations between RPE and HR under various testing conditions, investigations directed towards older subjects are very limited. The longevity of human life, coupled with an increased interest in health and fitness, would suggest that there is a need for further study concerning safety in performance testing and exercise for the older population.

The low correlation values found between RPE and HR, could illustrate the difficulties encountered, firstly, when RPE is not used in a performance test situation where progressively increasing workloads are administered, and secondly, in a situation where sub-

jects have not had previous experience in the use of the RPE-Scale through repeated measures. Further investigation involving performance tests with stepwise increases in workloads and repeated measures of RPE should be undertaken to see whether improvement in the RPE and HR relationship occurs.

In the two performance tests, the similar correlation values between RPE and HR may suggest that the RPE-Scale, along with HR, could be used to measure a variety of subjective intensities in a number of testing situations. However, when the low correlation values in this study are taken into consideration, a further implication might be that a modified or more sensitive scale could prove to be more functional. Perhaps the RPE-Scale is not the perfect scale to use under every kind of situation when measuring subjective intensity. Possibly, different scales should be constructed depending on the purpose of the study. In order to determine whether a better relationship between RPE and HR can exist with the older population, further research should be directed towards the use of other scales for rating perceived exertion in perform-

ance tests of a similar nature to those used in the present study.

Sex differences in perception of effort have been discussed in various studies, however, these investigations have omitted the older population. In the present study the differences found between the sexes indicate that in a sample population over 50 years of age, a stronger relationship exists between RPE and HR, for women. In order to discover why these differences occurred, further examination into the effect of age on sex differences in perception is needed.

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APPENDIX A

The 15-Graded RPE-Scale

6	
7	Very, very light
8	
9	Very light
10	
11	Fairly light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Very, very hard
20	

Instruction of the Use of the RPE-Scale

You should now be holding a scale which contains numbers from 6 to 20. We use this scale so that you may translate into numbers your feelings of exertion while exercising. The range of numbers should represent a range of feelings from "No exertion at all" (number 6) to "Maximal exertion" (number 20). In order to help you select a number which corresponds to your subjective feelings every other number has an attached verbal expression (for example, 7 is associated with feelings of Very, Very Light Exertion while 19 is associated with feelings of Very, Very Hard Exertion). Your goal is to rate your feelings which are caused by the work and not the work itself. These feelings should be general, that is about the body as a whole. We will not ask you to specify the feeling but to select a number which most accurately corresponds to your perception of your total body feeling. Keep in mind that there are no right or wrong numbers. Use any number that you think is appropriate.

APPENDIX B

The 21-Graded RPE-Scale

The RPE Scale for Ratings of Perceived Exertion

1

2

3 Extremely light

4

5 Very light

6

7 Light

8

9 Fairly light

10

11 Neither light nor laborious

12

13 Fairly laborious

14

15 Laborious

16

17 Very laborious

18

19 Extremely laborious

20

21

APPENDIX C

The Physical Activity Readiness Questinnaire (PAR-Q)

Health and Welfare Canada Santé et Bien-être social Canada

CANADIAN HOME FITNESS TEST
LE PHYSITEST CANADIEN

Postal Code – Code Postale (1–6) | SIN No. – Nº d'assurance sociale (7–15)

NAME *(Please Print)* – NOM *(Majuscules S.V.P.)*

Family Name – Nom de famille (16–32) | Initials – Initiales (33–35)

Mailing Address – Adresse postale

No. (36–39) | Street – Rue (40–55)

Apt. (56–59) | City – Ville (60–75)

Province (1–20)

Sex – Sexe (21): [1] M [2] F

Age (22–23)

Height – Taille *(Inches – Pounces)* (24–25)

Weight – Poids *(Pounds – Livres)* (26–28)

Marital Status – État Matrimonial (29): [1] Married – Marié(e) [2] Single – Célibataire [3] Separated – Séparé(e) [4] Divorced – Divorcé(e) [5] Widowed – Veuf *(veuve)* [6] Other – Autre

How fit do you think you are – Quelle est, selon vous, votre condition physique actuelle?

☐ Undesirable Personal Fitness Level – Forme physique indésirable
☐ Minimum Personal Fitness Level – Forme physique minima
☐ Recommended Personal Fitness Level – Forme physique souhaitable

Physical Activity Readiness Questionaire*

(PAR-Q)

For most people, physical activity should not pose any problem or hazard. PAR-Q has been designed to identify the small number of adults for whom physical activity might be inappropriate or those who should have medical advice concerning the type of activity most suitable for them.

Questionnaire sur l'aptitude à l'activité physique*

(Q-AAP)

Pour la plupart des gens, l'activité physique ne pose aucun problème et ne présente aucun danger. Le Q-MP a été conçu afin de déceler les quelques adultes pour qui l'activité physique serait à déconseiller, ou qui devraient suivre un programme d'activité prescrit par leur médecin.

	YES (√) OUI	
Has your doctor ever said you have heart trouble?	31 ☐	Votre médecin vous a-t-il déjà informé que vous aviez un trouble cardiaque?
Do you frequently suffer from pains in your heart or chest?	32 ☐	Souffrez-vous fréquemment de douleurs à la poitrine ou de points au coeur?
Do you often feel faint or have spells of service dizziness?	33 ☐	Etes-vous souvent pris d'étourdissement ou de faiblesse?
Has a doctor ever said your blood pressure was too high?	34 ☐	Votre médecin vous a-t-il déja dit que votre pression artérielle était trop élevée?
Has your doctor ever told you that you have a bone or joint problem such as arthritis that has been aggravated by exercise, or might be made worse with exercise?	35 ☐	Votre médecin vous a-t-il déjà informé que vous souffriez de troubles osseux ou articulaires, comme l'arthrite, qui ont été ou pourraient être aggravés par l'exercice?
If there a good physical reason not mentioned here why you should not follow an activity program evenif you wanted to?	36 ☐	Existe-t-il une raison d'ordre physique, non mentionnée dans le présent questionnaire, pour que vous ne suiviez pas le programme d'exercices physiques, même si vous le désirez?
Are you over age 69 and not accustomed to vigorous exercise?	37 ☐	Avez-vous plus de 69 ans et perdu l'habitude de pratiquer des exercices vigoureux?

DATE _____ SIGNATURE _____

* Reference: PAR-Q Validation Report
British Columbia Department of Health
June 1975 (Modified Version)

* Source: Rapport de validite du Q-AAP
Ministère de la Santé de la Colombie Britannique
Juin 1975 (version modifiée)

NOTE: We would appreciate your assistance in answering the questions on the reverse side.

N.B.: Nous vous serions obligé si vous répondiez de votre mieux aux questions suivantes (voir verso).

FAS 31 (Sept. 1975)

APPENDIX D

Reliability Testing of Heart Rate Monitoring Devices for Post 50 "3-S" Project

Introduction

For the stamina component of the Post 50 "3-S" Project it was necessary to select an appropriate and accurate instrument for measuring heart rate. Reliability tests were conducted on three heart rate monitoring instruments: Insta-Pulse; Exersentry; and Tektronix 414 (finger pulse).

Method

Six male participants of a local fitness class volunteered to serve as subjects. Their ages ranged from 19-32 years (mean 23.5 yr.). The work task involved treadmill walking/running. The workload was adjusted by progressively increasing speed and/or gradient of the treadmill to elicit a varied range of heart rates from resting to 80-90% of maximum heart rate. Three measurements of heart rate were simultaneously recorded from each instrument and an ECG, every 5 minutes at 0, 5 and 10 seconds.

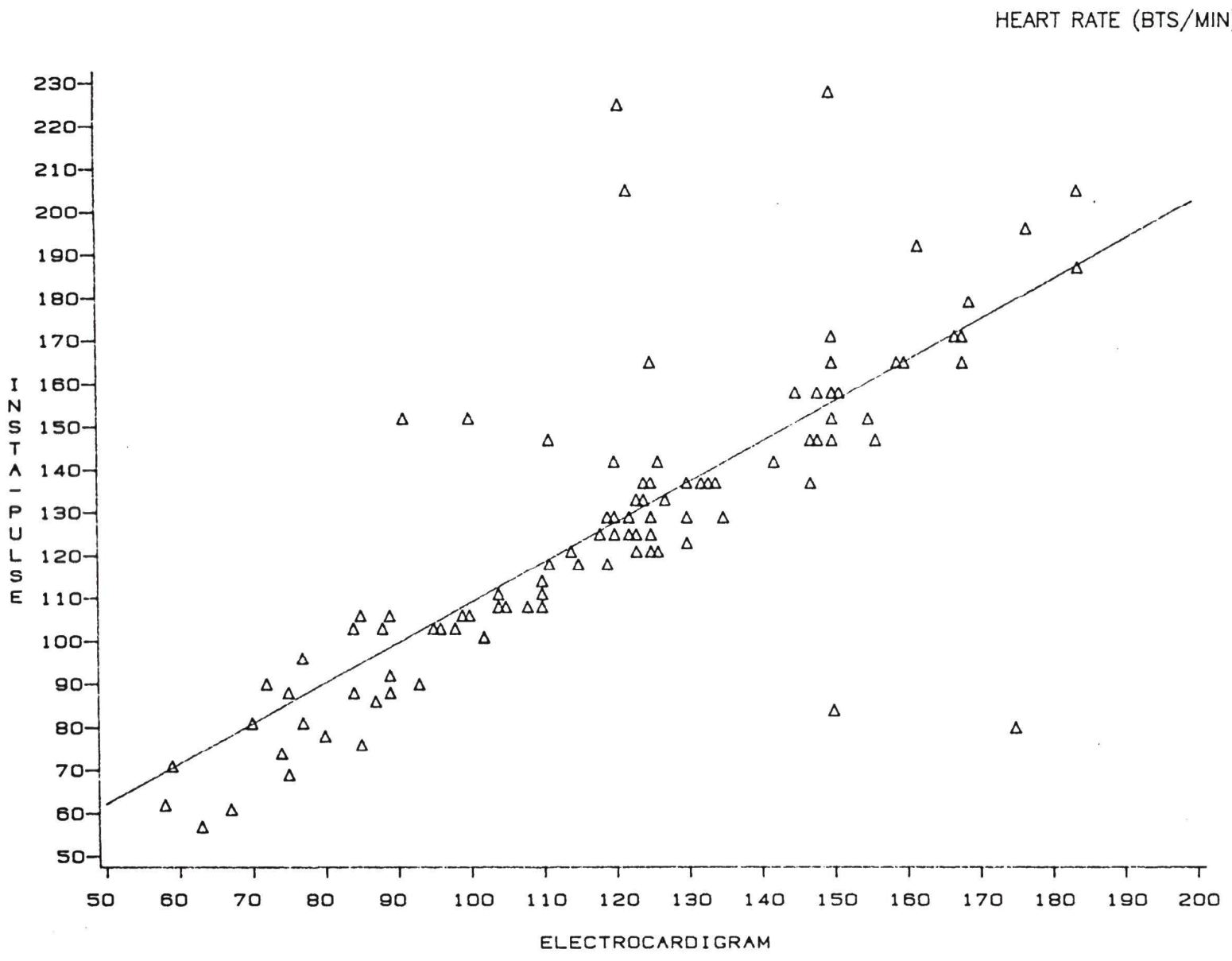
Results

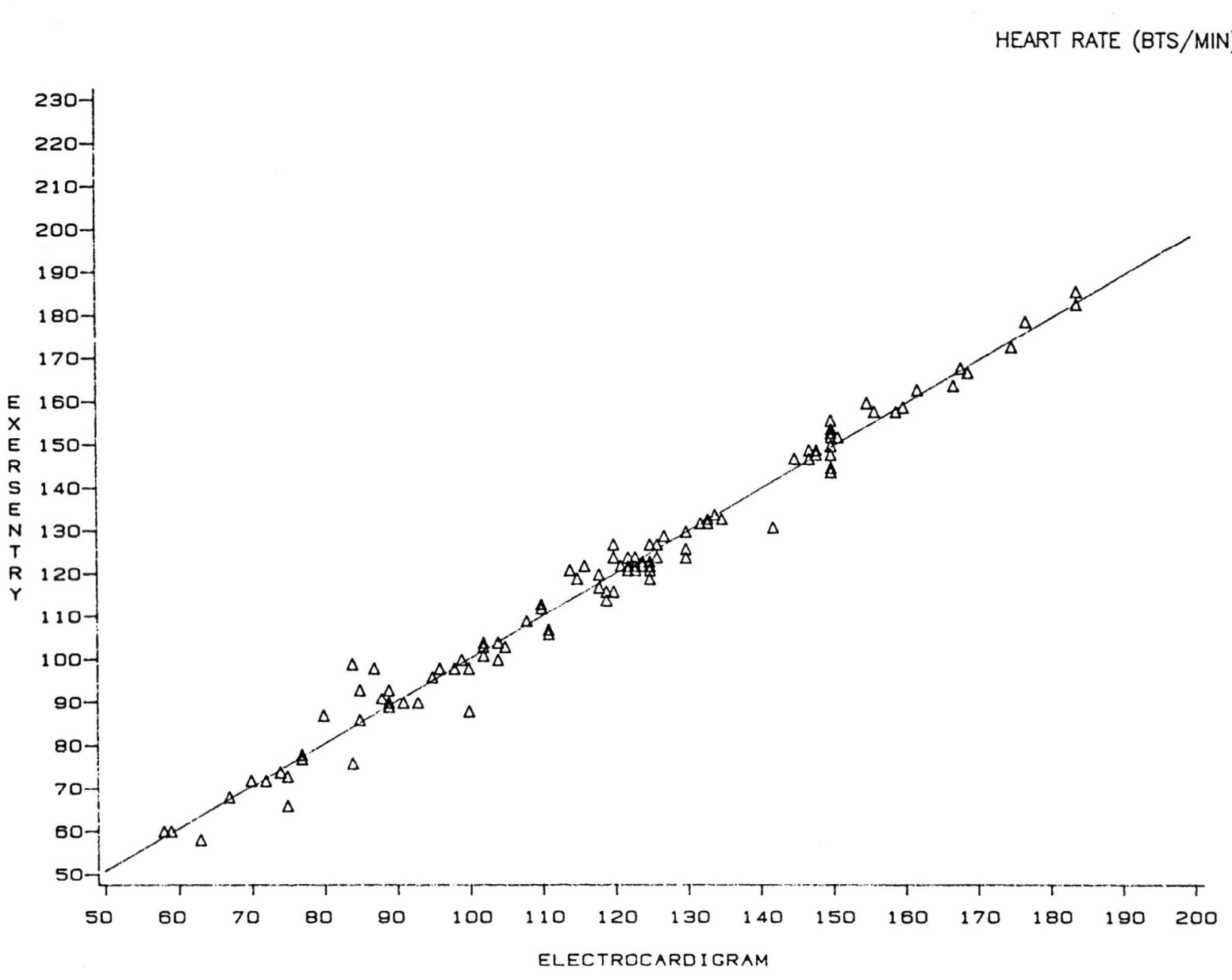
Table 1

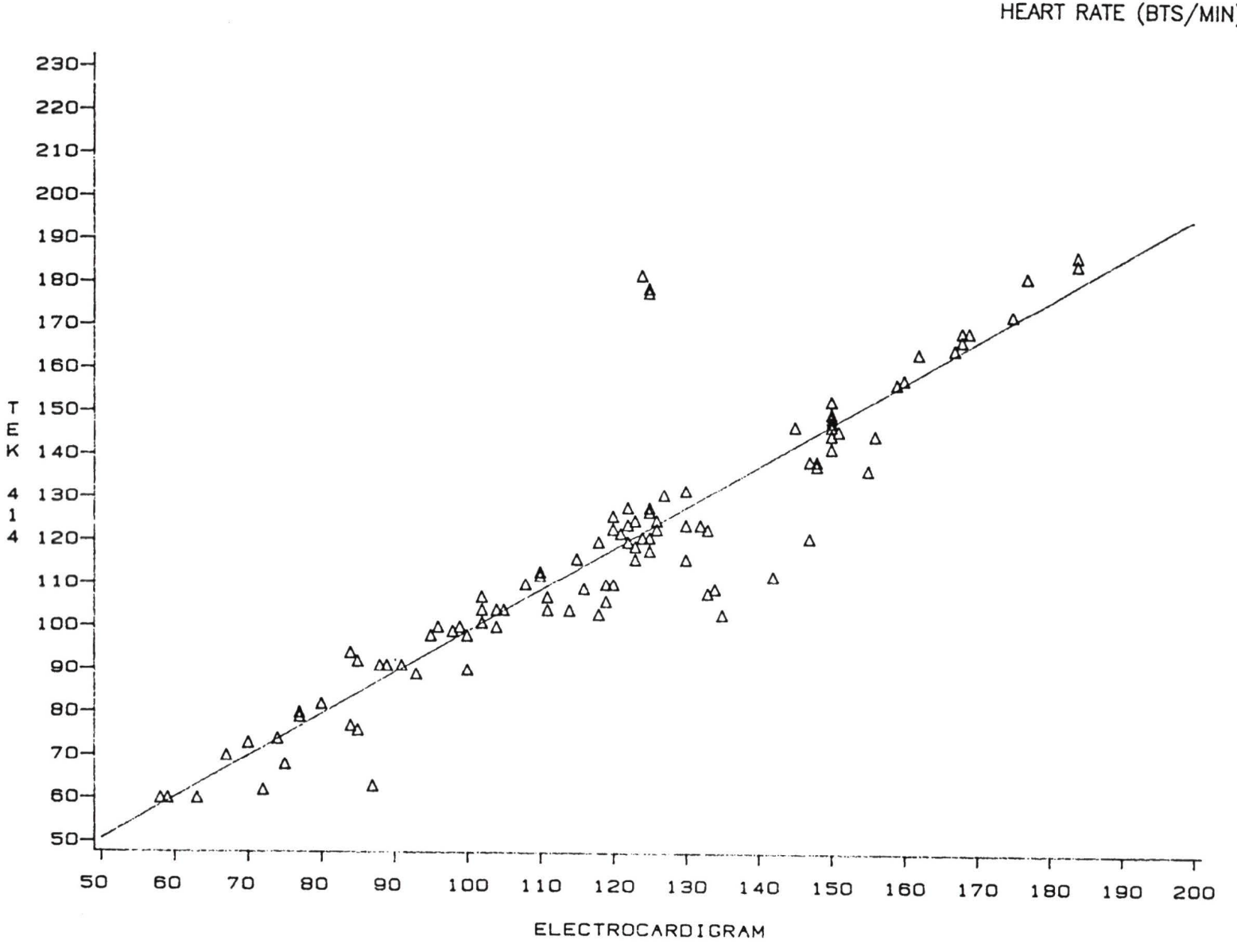
Correlation Values Between ECG and HR Monitoring Devices

	Insta-Pulse	Exersentry	Finger Pulse
ECG	.50*	.99*	.92*

* denotes p<.001


HEART RATE (BTS/MIN)
INSTA-PULSE
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
ELECTROCARDIGRAM


HEART RATE (BTS/MIN)
EXERSENTRY
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
ELECTROCARDIGRAM


HEART RATE (BTS/MIN)
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
T
E
K
4
1
4
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
ELECTROCARDIGRAM

Discussion

Insta-Pulse

The Insta-Pulse measures the extremely small biochemically generated electrocardiographic signals which cause the heart muscle to contract. The moment that the Insta-Pulse is grasped the instrument begins adapting to the ECG signal. Time from one contraction to the next is measured and the beats/minute figure calculated with each succeeding beat.

1. Testing characteristics:
   - clear visual readout.
   - erratic readings caused by: slight upper torso movement, an excessively tight grip, an improper grasp, foreign matter (dirt) on hands.
2. Ease of operation:
   - convenient, light weight and fast.
   - subject must be stationary.
   - proper grip is necessary.
   - not suitable for continuous monitoring.

Exersentry

The Exersentry works on the same principle as the ECG and Insta-Pulse by detecting the electrical signal of the heart. The 'R' wave is the strongest electrical signal produced by the beating heart which the Exersentry picks up through its soft, plastic electrodes. Every 4 beats the heart rate is recomputed and displayed in beats/minute.

1. Testing characteristics:
   - clear visual readout.
   - readings not affected by body movements, therefore appropriate for continuous monitoring during exercise.
2. Ease of operation:
   - inconvenient and awkward to place on participant.
   - must be worn under clothing with electrodes next to skin.
3. Safety:
   - has an alarm system which gives warning of exceeding heart rate.

Tektronix 414 Finger Pulse

The Finger Pulse is an opto-electrical device that detects changes in blood flow to the extremeties with each beat of the heart. The device consists of two photo-cells, a light emitting diode (LED) which continuously sends light out, and a phototransistor which is sensitive to change in light conduction.

1. Testing characteristics:
   - clear visual readout.
   - subject must be stationary because excessive movement causes erratic readings.
   - device is inappropriate for people with poor blood circulation to the hands.
   - excess light from the surrounding environment can interfere with readings.
2. Ease of operation:
   - size and weight of portable ECG unit makes it cumbersome and awkward for field testing.
   - settings on instrument panel are sensitive and need to be frequently re-adjusted.

Conclusions

In conclusion, the findings of this study indicate that the Exersentry is the most reliable of the three instruments tested. It provides continuous monitoring along with a built in safety alarm which can be set to signal at a predetermined max HR. Various modifications of the Exersentry can be made to accommodate ease of operation.

APPENDIX E

Senior Citizens Clubs

Victoria

Oak Bay Seniors' Activity Centre
1442 Monterey 595-7946

James Bay New Horizons Society
234 Menzies 386-3035

Silver Threads Service
Victoria - 4 Centennial Square 388-4268
Saanich - 286 Hampton 382-3151
Esquimalt - 527 Fraser 386-6108
Sidney - 10030 Resthaven 656-5537

Port Alberni

Echo Sunshine Club
Recreation Centre 723-2181

VITA

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Title of Thesis/Dissertation

THE RELATIONSHIP BETWEEN PERCEIVED EXERTION AND HEART RATE OF THE OLDER POPULATION DURING TWO DIFFERENT WALKING ACTIVITIES

Author [redacted]

Signature [redacted]

Gordon Dale Miller

Name

August 7, 1984

Date