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PHYSICAL CONDITIONING OF CHD AND HEALTHY FEMALES

A PROGRAM OF PHYSICAL CONDITIONING FOR HEALTHY MIDDLE-AGED FEMALES AND FEMALES WITH CORONARY HEART DISEASE

By

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ABSTRACT

The effects of a 12-week physical conditioning program on cardiorespiratory responses and the subjective assessment of work intensity (RPE) during exercise in healthy, middle-aged females and females with coronary heart disease (CHD) were studied. A physical conditioning program was developed for healthy, middle-aged females and females with CHD using an exercise prescription based on current practice in middle-aged males with and without CHD. The program included cycle ergometer exercise prescribed at 65-75% of maximal $\dot{V}_{O_2}$ for 30-45 minutes 3 times per week.

Six cardiac females (aged 40 to 57 years) and 9 healthy females (aged 44 to 52 years) started the program. The cardiac females had a significantly lower maximal work capacity, $\dot{V}_{O_2}$ and $\dot{V}_{CO_2}$ ($p<0.05$) than the healthy females. Measures of other variables were similar in the two groups. Following physical conditioning the healthy females demonstrated a significant increase in maximal PO(27.6%), $\dot{V}_{O_2}$ (15.9%), $\dot{V}_E$ (23.9%) and $\dot{V}_{CO_2}$ (17.8%); a significant decrease in HR (10.5%), SBP (7.1%), RPP (17.5%), $\dot{V}_{CO_2}$ (12.0%) and RPE (33.1%) at a standard submaximal PO; and a significant decrease in steady state $\dot{V}_{O_2}$ (6.7%), $\dot{Q}_c$ (13.4%) and HR (9.4%) ($p<0.05$). No changes were observed in other variables. Since only 3 cardiac females completed the 12-week program, they were treated as case studies. These 3 cardiac females showed considerable variation in their cardiorespiratory responses to physical conditioning but each exhibited a reduction in RPE at submaximal power outputs following physical conditioning. It was concluded that the physical conditioning program: (a) improved cardiorespiratory functioning, and reduced perceived exertion, during exercise in the healthy, middle-aged females; and (b) was effective as a mode of psychophysical rehabilitation, but not necessarily as a mode of physiological rehabilitation, for the females with CHD.

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CHAPTER I

INTRODUCTION

Similarly to apparently healthy (healthy) middle-aged males (Pollock, 1973; Pollock et al., 1974; Pollock et al., 1975b; Gettman et al., 1976; Milesis et al., 1976; Davis et al., 1979), healthy, middle-aged females have demonstrated a significant increase in functional capacity and a significant decrease in submaximal exercise heart rates within 20 weeks of physical conditioning (Kilbom, 1971a and b; Kilbom and Astrand, 1971; Flint et al., 1974; Liu and Cureton, 1975; Van Handel et al., 1976; MacKeen et al., 1978). Also, subjective perceptions of improved exercise tolerance and a general sense of well-being have been reported by healthy, middle-aged females following short-term physical conditioning (Kilbom, 1971a and b; Liu and Cureton, 1975). Although only the cardiorespiratory effects of physical conditioning on males have been quantified with respect to intensity, duration and frequency of exercise, it is generally accepted that exercise prescription can be executed in the same manner for both sexes (Hellerstein et al., 1973; Balke, 1974; Wilmore, 1976; American College of Sports Medicine, 1978).

Studies of the responses of females with Coronary Heart Disease (CHD) to physical conditioning have been few in number, restricted in scope and limited by small sample sizes (Sanne, 1973; Palatsi, 1976; Oldridge et al., 1980). Female cardiac patients showed a significant increase in their symptom-limited physical work capacity (Sanne, 1973; Oldridge et al., 1980) and stated that they were better able to tolerate daily activities (Oldridge et al., 1980) following long-term physical conditioning. While it seems that females with CHD and healthy, middle-aged females may derive similar benefits from physical conditioning, the effects of equivalent physical conditioning on cardiorespiratory responses and the perception of exertion during exercise in the two groups have not been reported.

The purpose of this investigation was to compare the effects of a 12-week physical conditioning program, analagous in design to that recommended for healthy, middle-aged adults, on selected cardiorespiratory responses and the perception of exertion during exercise in females with CHD and healthy, middle-aged females.

Definitions

The following definitions of terms are for the purpose of this study.

Acute exercise. A single bout of exercise.

Angina pectoris. A "symptom of paroxysmal pain consequent to myocardial ischemia, usually of distinctive character, location and radiation and provoked by a transient stressful situation during which the oxygen requirements of the myocardium exceed the capacity of the coronary circulation to supply it" (Silber and Katz, 1975).

Attendance. The number of supervised physical conditioning sessions attended, expressed as a percentage of the number of supervised sessions offered.

Compliance. The degree to which the physical conditioning program is adhered; that is, the percentage of total exercising subjects who do not drop out of the program.

Coronary Heart Disease. A disease of the coronary vessels as manifested by myocardial infarction (MI) with or without angina pectoris (AP).

Drop-Out. Absence from supervised sessions for more than two consecutive weeks.

Functional Capacity. The oxygen uptake ($\dot{V}O_2$) at the highest power output (PO) of a progressive multistage exercise test terminated because of fatigue or clinical signs and symptoms or both fatigue and clinical signs and symptoms.

Maximal. The measurement recorded at the highest PO of a progressive multistage exercise test.

Myocardial infarction. "An area of necrosis in the myocardium due to impairment of its blood supply".

Perceived exertion. The subjective assessment of work intensity (Morgan, 1973).

Delimitations

1. The subjects of this study were females between the ages of 40 and 57 years who resided in the cities of Hamilton, Burlington and Oakville, Ontario.

Limitations

1. The population samples were limited in size and may have been biased as they were not randomly selected. Thus, the findings of the study can not be generalized beyond the participating subjects.

2. Sampling variance for age and functional capacity was not controlled by matching subjects because of limited

availability of subjects. However, statistical tests used to analyze differences between the two groups before physical conditioning included variance components.

3. The cardiac females continued to take their daily dosages of beta-blocking drugs throughout the course of the physical conditioning program. Heart rate (HR) and other cardiorespiratory responses to exercise have been found to be lower in cardiac patients after taking beta-blocking drugs than before and lower in cardiac patients on beta-blocking drug therapy than those who are not (Clausen, 1976; Hossack _et al._, 1980). Although medications taken by the cardiac females could affect the results of between-groups comparisons of cardiorespiratory responses to exercise, in order to obtain a safe and adequate exercise prescription the cardiac females were tested while on their medications.

4. Estimations of each subject's hemoglobin concentration (Hb), rather than actual measures, were used in the calculation of arterio-venous carbon dioxide content difference.

Rationale for the Study

Physical conditioning has become widely accepted as an integral part of the process to restore the physical and mental activity of patients with CHD to a level which allows them to "...regain as normal as possible a place in the community and lead an active, productive life" (World Health Organization Technical Report Series 270, 1964). Although it has been well established that physical conditioning improves cardiorespiratory functioning during exercise (Clausen, 1976; Greenberg *et al.*, 1979) and promotes perceptions of improved exercise tolerance (Kellermann, 1975) in male cardiac patients, little is known about the effects of physical conditioning on cardiorespiratory and perceptual responses during exercise in female cardiac patients (Sanne, 1973; Palatsi, 1976; Oldridge *et al.*, 1980). The exercise prescription for cardiac patients has been based upon the same principles as for healthy, middle-aged adults. Functional limitations of the patients have been determinants of whether or not the application of these principles of exercise prescription differs from that for healthy, middle-aged adults (Pollock *et al.*, 1979). This study should help to resolve the effectiveness of 12 weeks of prescribed exercise, at an intensity, duration and frequency similar to that recommended for healthy, middle-aged adults, as a mode of physiological and psychophysical rehabilitation for female cardiac patients.

CHAPTER II

REVIEW OF LITERATURE

This chapter is divided into 4 sections. Literature on physiological responses during exercise and the effects of physical conditioning in healthy, middle-aged females, and in females with CHD, is reviewed in the first and second sections, respectively. Section three summarizes reports pertaining to the design of optimal physical conditioning programs for healthy, middle-aged adults and cardiac patients. In section four, available information on the rating of perceived exertion (RPE) is presented and then literature specific to RPE and the effects of physical conditioning on RPE in middle-aged, healthy and heart diseased females is reviewed.

Physiological Responses During Exercise in Healthy, Middle-Aged Females and Effects of Physical Conditioning.

Physiological responses to acute bouts of exercise in healthy females between the ages of 35 and 60 years have been described in several reports (Drinkwater, 1973; Atomi and Miyashita, 1974; Hartung, 1974; Drinkwater *et al.*, 1975; Voigt *et al.*, 1975; Kusumi *et al.*, 1976; Bengtsson *et al.*, 1978). There have also been numerous reports of the physiological responses to chronic exercise (physical conditioning) in similar-aged, healthy females (Kilbom, 1971a and b; Kilbom and Astrand, 1971; Flint _et al._, 1974; Liu and Cureton, 1975; Van Handel _et al._, 1976; MacKeen _et al._, 1978).

Differences between the middle-aged sexes in functional capacity and cardiorespiratory adjustments to acute exercise have been observed and attributed to differences in anatomical dimensions and biological composition (Becklake _et al._, 1965; Bruce _et al._, 1973; Van Handel _et al._, 1976). Relative to their male counterparts, females were found to have a higher HR and a lower stroke volume (V_s) at a given submaximal work intensity, while their $\dot{V}_{O_2}$ and cardiac output ($\dot{Q}_c$) was either similar (Becklake _et al._, 1965) or lower (Van Handel _et al._, 1976). However, most of the evidence suggests that healthy, middle-aged females adapt to physical conditioning in a manner similar to healthy, middle-aged males (Clausen, 1976).

Acute exercise. As in healthy males (Clausen, 1976), an age-related decrease in maximal $\dot{V}_{O_2}$, HR, expired ventilation ($\dot{V}_E$) and arterial lactate concentration (H_{LA}), and increase in systolic blood pressure (SBP), has been observed consistently in healthy females (Drinkwater, 1973; Atomi and Miyashita, 1974; Hartung, 1974; Drinkwater et al., 1975; Voigt et al., 1975; Bengtsson et al., 1978). Kilbom and Astrand (1971) reported that the maximal $\dot{Q}_c$ and V_s of healthy females also decreased with advancing age. Their findings, although based on a small sample, were concordant with those from studies on healthy males reviewed by Clausen (1976).

In the one available study where $\dot{Q}_c$ in healthy, middle-aged females was determined by the direct Fick method, $\dot{Q}_c$ was shown to be directly related to $\dot{V}_{O_2}$ during progressive exercise (Kusumi et al., 1976). Becklake and colleagues (1965) looked at the influence of age on $\dot{Q}_c$ and $\dot{V}_{O_2}$ and associated cardiorespiratory responses, such as HR, V_s and arterio-venous oxygen difference ($(a-\bar{v})O_2$ difference), in healthy females at submaximal power outputs. They found no consistent age trends in any variable when decade-based groups from 20 to 70 years were compared. They did observe, however, that the regression coefficient of $\dot{Q}_c$ on $\dot{V}_{O_2}$ for women younger than 50 years of age was significantly lower than that for women 50 years of age and older. Kilbom and Astrand (1971) noted that healthy females aged 21 to 48 years had a higher $\dot{Q}_c$, $\dot{V}_{O_2}$, HR and V_s and a lower $(a-\bar{v})O_2$ difference than healthy females aged 53 to 61 years at the same absolute submaximal power outputs. At any given $\dot{V}_{O_2}$ the younger females also had a higher $\dot{Q}_c$ than the older females. While both of these investigations showed that an age change in the exercise $\dot{Q}_c$-$\dot{V}_{O_2}$ relationship is apparent in healthy females after their fifth decade of life, they disagreed with respect to the direction of the change. This contradiction in findings may possibly be attributed to different methods of estimating $\dot{Q}_c$.

Exercise following physical conditioning. All of the studies reviewed by the present investigator showed that physical conditioning significantly improved the functional capacity of healthy, middle-aged females (Kilbom 1971a and b; Kilbom and Astrand, 1971; Flint et al., 1974; Liu and Cureton, 1975; Van Handel et al., 1976; MacKeen et al., 1978). The magnitude of the improvement in functional capacity varied from study to study and appeared to be inversely related to the pre-conditioning level and age. Kilbom and Astrand observed that the increased maximal $\dot{V}_{O_2}$ of their subjects was accompanied by an equivalent increase in maximal $\dot{Q}_c$ and no change in $(a-\bar{v})O_2$ difference. The higher maximal $\dot{Q}_c$ corresponded to an elavated maximal V_s since maximal HR was similar. MacKeen and co-investigators noted a significantly higher $\dot{Q}_c$ and V_s after physical conditioning than before at 90% of maximal HR; however, they did not state whether or not maximal HR had changed. Although in most of the females studied neither maximal $\dot{V}_E$, H_{LA} nor maximal HR was altered as a result of physical conditioning, some females demonstrated a significant increase in maximal $\dot{V}_E$ (Kilbom, 1971a), H_{LA} and HR (Kilbom, 1971b) while others demonstrated a significant decrease in maximal HR (Van Handel et al., 1976).

Physical conditioning has been consistently reported to produce a significant reduction in the submaximal exercise HR of healthy, middle-aged females (Kilbom, 1971a and b; Kilbom, 1971; Flint et al., 1974; Van Handel et al., 1976). Reports of the effects of physical conditioning on other cardiorespiratory responses in healthy, middle-aged females at submaximal work intensities have been diverse. Both a significant reduction, and no change in $\dot{V}_{O_2}$, $\dot{V}_E$, carbon dioxide output ($\dot{V}_{CO_2}$) and SBP has been observed (Kilbom, 1971a and b; Kilbom and Astrand, 1971; Flint et al., 1974; Van Handel et al., 1976). These discrepancies in study findings can not be explained on the basis of differences in subject ages or program designs but it is possible that they may reflect individual variations in mechanical efficiency. In Kilbom and Astrand's investigation there was an increase in V_S and no change in $\dot{Q}_c$ or $(a-\bar{v})O_2$ difference at a given submaximal PO following physical conditioning. On the contrary, in the investigation by Van Handel and colleagues both V_s and $\dot{Q}_c$ were significantly reduced and $(a-\bar{v})O_2$ difference was significantly elevated. Kilbom and Astrand used a dye-dilution method to estimate $\dot{Q}_c$ whereas Van Handel and colleagues used a carbon dioxide (CO_2) rebreathing procedure. Since values for V_s and $(a-\bar{v})O_2$ difference were calculated in both investigations, differences in $\dot{Q}_c$ measurement techniques may account for the contradictory findings. Cunningham and Hill (1975) studied the effects of physical conditioning on HR, $\dot{Q}_c$, V_s and $(a-\bar{v})O_2$ difference in healthy, middle-aged females during submaximal exercise. However, their results are difficult to interpret as data was analyzed in relation to percentage of predicted maximal $\dot{V}_{O_2}$.

Summary. Sex has been shown to be a factor affecting the magnitude of cardiorespiratory responses in healthy, middle-aged adults to acute exercise but not to chronic exercise.

Although age trends in the maximal $\dot{V}_{O_2}$, $\dot{Q}_c$, HR, V_s, SBP, $\dot{V}_E$ and H_{LA} of healthy females have been observed, the effects of age on these and other physiological responses during acute bouts of submaximal exercise are not clear.

Physiological Responses During Exercise in Females with CHD and Effects of Physical Conditioning

While the physiological adjustments of males with CHD to acute and chronic exercise have been extensively studied and recently reviewed (Clausen, 1976; Greenberg *et al.*, 1979), studies of the physiological adjustments of females with CHD to acute (Robinson, 1967; Holmberg *et al.*, 1971; McDonough *et al.*, 1974; Wilhelmsen *et al.*, 1975; Bruce *et al.*, 1976) and/or chronic exercise (Sanne, 1973; Palatsi, 1976; Oldridge *et al.*, 1980) have been limited in number and scope.

Acute exercise. Most of the studies reporting on exercise responses in female cardiac patients have also included male cardiac patients (Robinson, 1967; Holmberg *et al.*, 1971; Sanne, 1973; McDonough *et al.*, 1974; Wilhelmsen *et al.*, 1975; Bruce *et al.*, 1976; Palatsi, 1976). The data on females in two of these studies is difficult to interpret as it has been combined with the data on males (Robinson, 1967; McDonough *et al.*, 1974) and data on only two females is presented in another study (Holmberg *et al.*, 1971). Holmberg and colleagues observed that there was little change in the V_s of either woman as exercise intensity increased; however, in one $\dot{Q}_c$ increased along with elevations in HR and SBP and in the other $\dot{Q}_c$ remained constant while HR increased and SBP decreased. Myocardial oxygen uptake ($M\dot{V}_{O_2}$), measured directly and estimated from rate-pressure product (RPP), changed in parallel with HR in both women. Although direct sex comparisons were not made in any study, it is evident that cardiac females have a lower symptom-limited maximal work capacity (WC_{S-L}) than cardiac males, but a similar maximal HR, SBP and RPP (Sanne, 1973; Wilhelmsen _et al._, 1975; Bruce _et al._, 1976). It also appears that cardiac females respond to a given absolute work intensity with a higher HR, SBP and RPP than cardiac males (Sanne, 1973; Palatsi, 1976).

Post-MI females without exertional AP were found to have a substantially higher maximal WC_{S-L}, HR, RPP and H_{LA} than post-MI females with exertional AP. At a standard submaximal PO, there was no difference in the HR or SBP of the two patient groups (Sanne, 1973). These observations concur with those from comparisons of male cardiac patients with and without AP (Clausen, 1976).

Exercise following physical conditioning. Sanne (1973) observed a significant 69% increase in maximal WC_{S-L}, with no change in maximal HR or SBP, in post-MI females following 9 months of supervised and individually-prescribed physical conditioning. No report of the effects of the program on submaximal exercise responses in these post-MI females was given. Clinical exercise data on female cardiac patients following 7, 12 and 21 months of supervised and individually-prescribed physical conditioning have been analyzed (Oldridge et al., 1980). Symptom-limited maximal work capacity was significantly increased by 16% in the group who exercised for 7 months and by 29% in the group who exercised for 21 months. The significant increase in the maximal WC_{S-L} (20%) of the 12-month group only was associated with a significant increase in maximal HR (6%). There was no change in maximal SBP and RPP nor in HR, SBP and RPP at a given submaximal PO in any of the 3 groups. With the exception of an increase in the maximal HR of the 12-month group, the direction of changes reported in this study support the findings by Sanne; yet, the improvement in maximal WC_{S-L} after 12 and 21 months of physical conditioning is not as great as that observed by Sanne after only 9 months. The subjects in the study by Oldridge and colleagues exercised at a HR which was, on the average, 78% of their maximal HR for 25-40 minutes twice per week. Sanne's subjects exercised at a HR 15 beats per minute lower than their maximal HR for 30 minutes 3 times per week. Therefore, the differences between studies in magnitude of change in maximal WC_{S-L} may have been due to differences in exercise prescription.

In Palatsi's study (1976), there were no differences in the maximal WC_{S-L}, the physical work capacity at a HR of

130 beats per minute (PWC_{130}) or the SBP and RPP at PWC_{130} of similar-aged control and exercising post-MI females initially or after 12 months. It was reported that the mode of physical conditioning was calisthenics but the intensity, duration and frequency of calisthenics was not specified. The exercising females were only supervised once a month and apparently there was no assessment made of the amount of work they accomplished at home. Thus, an inappropriate exercise prescription and poor compliance with the program could be possible reasons why the exercising patients did not demonstrate any change in performance variables following 12 months of physical conditioning.

Summary. Sex appears to have an influence on cardiorespiratory adjustments to exercise intensities and symptom-limited maximal work capacity in cardiac patients. Exertional AP has been found to limit cardiorespiratory functioning during acute exercise in post-MI patients of both sexes.

Based on the available literature, few conclusions can be drawn about the effects of physical conditioning on physiological responses during exercise in females with CHD. Studies have not only been few in number and restricted in scope but they have also been varied in methodologies.

Program Design

It has been shown repeatedly that the intensity, duration and frequency of physical conditioning must exceed a certain threshold level in order to elicit improvements in the cardiorespiratory functioning of healthy, middle-aged males. The threshold level for improvements varies with initial degree of fitness (Pollock, 1973) and generally the greater the stimuli the greater the magnitude of the improvements (Pollock, 1973; Pollock *et al.*, 1975b; Gettman *et al.*, 1976; Milesis *et al.*, 1976). Investigators have observed that healthy, middle-aged males derive physiological benefits from programs of walking, jogging, running, cycling and swimming (Pollock, 1973; Pekka *et al.*, 1974; Pollock *et al.*, 1975b; Gettman *et al.*, 1976; Milesis *et al.*, 1976; Clausen, 1976). However, studies specifically comparing the effects of various modes of physical conditioning on physiological variables in healthy, middle-aged males have been limited (Pollock *et al.*, 1975a). Pollock and others (1975a) found that, when intensity, duration and frequency were held constant, improvements in cardiorespiratory functioning were independent of mode of physical conditioning.

Endurance exercise programs and their physiological effects on middle-aged, healthy and heart diseased females and heart diseased males have not been adequately quantified.

Based on available information on males, guidelines for designing programs of physical conditioning for healthy, middle-aged adults and cardiac patients have been specified (Hellerstein _et al._, 1973; Balke, 1974; Wilmore, 1976; American College of Sports Medicine, 1978; Pollock _et al._, 1979). The mode of physical conditioning must be rhythmic in nature and involve large muscle masses. If at all possible, consideration should be given to the interests and abilities of the individual when the choice of activity is made since enjoyment may increase motivation and so help reduce the problem of non-adherence to the program. Exercise prescription must take into account health status, pre-conditioning level of cardiorespiratory fitness, needs, goals and safety.

The recommended prescription for improvement of the cardiorespiratory fitness of healthy, middle-aged adults is exercise at an intensity of 60 to 80% of initial maximal $\dot{V}_{O_2}$, for 30 to 45 minutes a day, 3 to 4 days a week. Depending upon the functional limitations of cardiac patients, the prescription may be the same or of a lower intensity, longer duration and/or higher frequency than that for their healthy counterparts (Hellerstein _et al._, 1973; Balke, 1974; Wilmore, 1976; American College of Sports Medicine, 1978).

Summary. In designing programs of physical conditioning to improve the cardiorespiratory fitness of healthy, middle-aged adults and cardiac patients, consideration must be given to their health status, initial level of fitness, needs and safety as well as the intensity, duration, frequency and mode of exercise. The intensity, duration and frequency of exercise prescribed to healthy, middle-aged adults is modified for patients with CHD according to the functional limitations imposed on them by their disease.

The Perception of Exertion and effects of Physical Conditioning

A numerical scale for rating perceived exertion (the subjective assessment of work intensity) was originally developed (Borg, 1962) and later revised (Borg, 1970) to approximate a linear relationship between HR and RPE during cycle ergometer exercise. This revised RPE-scale has been found to be not only valid (Borg, 1973; Morgan, 1973; Skinner *et al.*, 1973a; Stamford, 1976) and reliable (Skinner *et al.*, 1973a; Stamford, 1976), but also applicable during various types of exercise (Ekblom and Goldbarg, 1971; Bar-Or *et al.*, 1972; Gamberale, 1972; Noble *et al.*, 1973a; Skinner *et al.*, 1973b; Sidney and Shephard, 1977). Studies have shown that RPE and other physiological variables measured during exercise, such as $\dot{V}_{O_2}$, $\dot{V}_E$ and H_{LA}, are correlated in a linear fashion (Ekblom and Goldbarg, 1971; Gamberale, 1972; Sargeant and Davies, 1973; Skinner _et al._, 1973b; Sargeant and Davies, 1976; Sidney and Shephard, 1977). The characteristics of these relationships and the degree of the correlations are affected, however, by mode of exercise (Ekblom and Goldbarg, 1971; Sidney and Shephard, 1977) and amount of exercising muscle mass (Gamberale, 1972; Sargeant and Davies, 1973; Sargeant and Davies, 1976). Noble and colleagues (1973b) observed that RPE was linearly related to HR, $\dot{V}_E$ and $\dot{V}_{O_2}$ only for the first fifteen minutes of exercise; during the fifteen minutes thereafter RPE continued to increase while the physiological variables plateaued. It is apparent, from the literature reviewed, that factors other than physiological processes also have a role in the perception of exertion; some of which may be duration of work bout (Noble _et al._, 1973b), amount of work accomplished (Skinner _et al._, 1973a), metabolic cost (Noble _et al._, 1973b) and muscular strain (Ekblom and Goldbarg, 1971; Noble _et al._, 1973a).

Healthy, middle-aged females. Studies reporting on RPE and its relationships to physiological variables during acute exercise in healthy, middle-aged females have been conducted primarily to determine the influence of sex or age on RPE (Borg and Linderholm, 1970; Kilbom, 1971a; Bengtsson _et al._, 1978). The effects of physical conditioning on RPE in healthy, middle-aged females have also been studied (Kilbom, 1971a and b).

The relationship between HR and RPE during exercise has been shown to be similar in healthy, middle-aged females and males (Borg and Linderholm, 1970).

Investigators observed that maximal RPE was independent of age, but RPE at submaximal power outputs increased as age increased, in healthy females (Kilbom, 1971a; Bengtsson _et al._, 1978). Kilbom also observed a linear relationship and high correlation between RPE and HR during exercise in both older and younger females.

Following physical conditioning healthy, middle-aged females were found to have a similar maximal RPE and a significantly lower RPE at given submaximal power outputs (Kilbom, 1971a and b). Correlation co-efficients for their HR-RPE relationship during exercise changed little (Kilbom, 1971a).

Females with CHD. There have been reports on RPE and its relationships to physiological variables during exercise in both female and male cardiac patients (Borg and Linderholm, 1970; Sanne, 1973). In the one available study of the effects of physical conditioning on RPE in cardiac patients a report on male patients only was given (Sanne, 1973).

The HR-RPE relationship during exercise in female angina patients and similar-aged healthy females was compared (Borg and Linderholm, 1970); a comparison between cardiac females with and without AP was also made (Sanne, 1973). In both comparisons no differences were observed.

Summary. A rating scale to evaluate the perception of exertion during various types of exercise has been developed and validated. While linear relationships and high correlations between ratings of perceived exertion and HR, $\dot{V}_E$, $\dot{V}_{O_2}$ and H_{LA} during exercise have been observed, exertional perceptions can not be attributed to these physiological processes alone.

Sex has been found to have no effect on the HR-RPE relationship during exercise in healthy, middle-aged adults. Both age and physical conditioning have been shown to influence the RPE of healthy females at submaximal power outputs.

Investigators observed a similar HR-RPE relationship during exercise in female cardiac patients with and without angina and healthy, similar-aged females. There are no available reports of the effects of physical conditioning on RPE and its relationships to physiological variables during exercise in females with CHD.

CHAPTER III

PROCEDURES

This study was conducted to compare the effects of equivalent physical conditioning on selected cardio-respiratory responses and the perception of exertion during exercise in females with CHD and healthy, middle-aged females. Measures of exercise $\dot{V}_{O_2}$, $\dot{V}_E$, $\dot{V}_{CO_2}$, respiratory exchange ratio (R), HR, SBP, RPP, $\dot{Q}_c$, V_s, $(a-\bar{v})O_2$ difference and RPE were obtained before and after the physical conditioning program. Effects of the program on both the cardiac females and the healthy females were determined from analyses of differences between respective pre-conditioning and post-conditioning measures. Group comparisons were made on the basis of pre-conditioning data and the percentage of change in each measure as a result of the program.

The subject selection process, preliminary and testing procedures are described in detail in this chapter; the dependent and independent variables are operationally defined; and the statistical methods are outlined.

Subject Selection

Cardiac females. Medical records (January 1976 to February 1978) and arteriographic reports (September 1975 to December 1977) from the McMaster University Medical Centre and medical records (January 1977 to December 1977) from St. Joseph's Hospital, in Hamilton, Ontario, were reviewed to identify females with CHD in the Hamilton and Halton districts. Also, district physicians and cardiologists were asked if they had female cardiac patients. For admission into the study, patients were required to have at least 2 of the following diagnostic features of myocardial infarction: (a) central chest pain typical of AP; (b) electrocardiographic evidence of Q waves and/or significant ST-segment changes combined with T-wave inversion; and (c) transient elevations in the serum enzymes glutamine oxalacetic-acid transaminase (SGOT) and glutamine pyruvic-acid transaminase (SGPT). Patients were excluded if they were reported to have: (a) cardiac failure; (b) serious dysrhythmias; (c) ventricular aneurysms; (d) severe hypertension (a resting diastolic blood pressure of greater than or equal to 110 millimeters of mercury); (e) arteriographic evidence of greater than 3 coronary arteries occluded by more than 75%; (f) orthopaedic disabilities; or (g) severe respiratory or metabolic disorders. Other exclusion criteria included the following: (a) greater than 60 years of age; (b) more than 2 previous infarctions; (c) less than 3 months since the last infarction; (d) geographical location outside of the Hamilton and Halton districts; and (e) airway obstruction at rest (defined by Harris (1975) as a ratio of forced expiratory volume in 1 second (FEV_1) to forced vital capacity (FVC) of less than 75%). Family physicians of potential cardiac subjects were contacted and, with their consent, patients were invited to participate in the study. An organizational meeting for eligible cardiac subjects was held two weeks before the first patient testing session (see Preliminary Procedures).

The screening process identified 176 females with CHD. Only 26 of the patients were eligible for the study, and of these 26, only 6 started the study. Figure 1 shows the patient series and Table 1 gives details of the reasons for: (a) immediate exclusion; (b) secondary exclusion after physician contact; (c) invitation refusal; (d) failure to attend the organizational meeting; and (e) contraindications for testing. Thirty-one percent of the total potential cardiac subjects did not show satisfactory evidence of MI and 18% were older than 60 years. An additional major factor instrumental in reducing the total was the presence of other health complications; the most common health complications being a tendency for

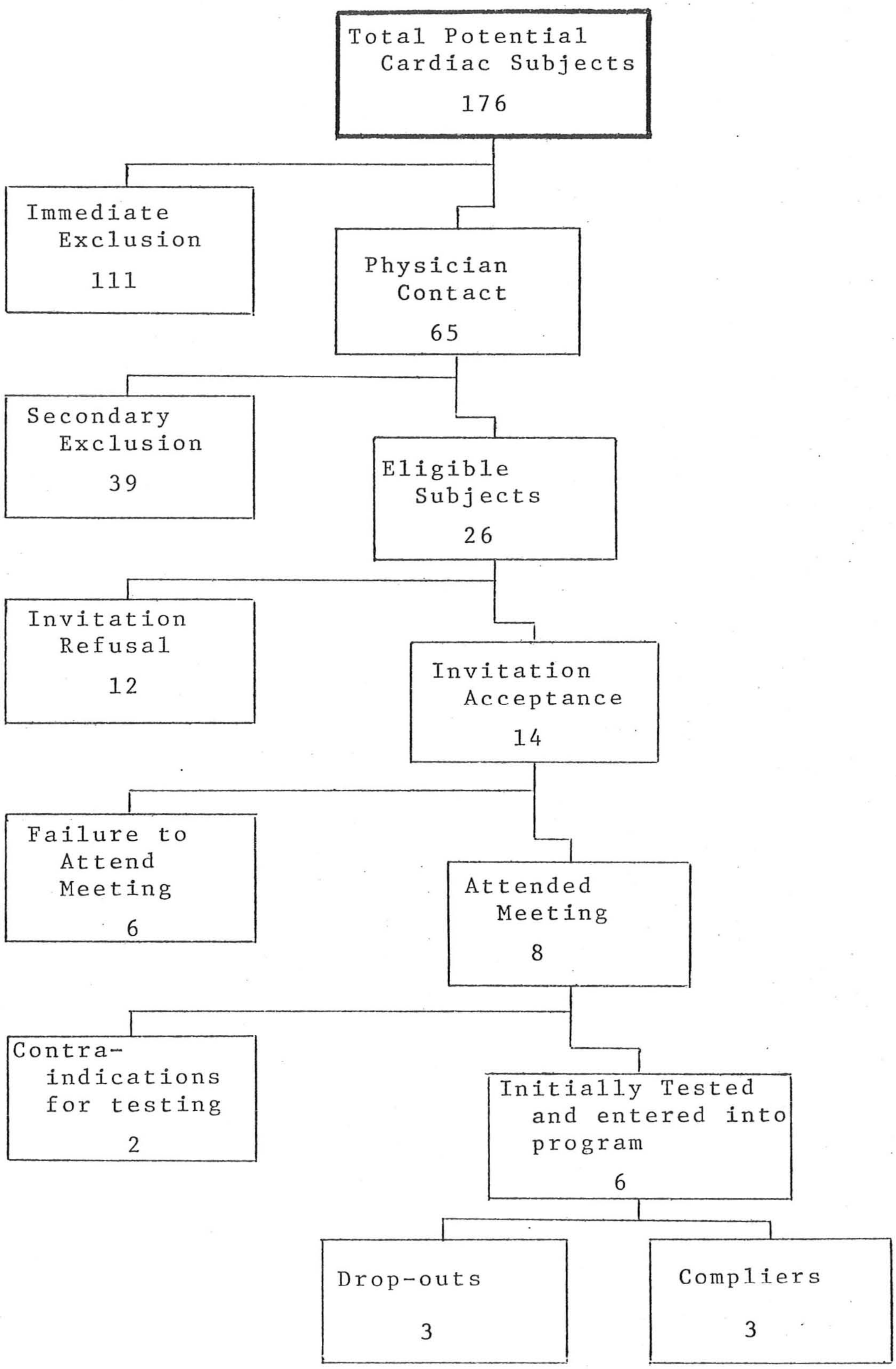


Figure 1. Patient series.

Table 1. Reasons for exclusion of patients.

Patients Identified	Total	176
		n
(a) Immediate Exclusion		
Failure to meet MI criteria		54
More than 2 MI's and/or other health complications		5
More than 60 years of age		31
Others (geographical location, participation in other programs)		21
		111
(b) Secondary Exclusion After Physician Contact		
Deaths (not recorded by hospital personnel)		8
Other health complications		13
Lack of physician support		11
Inability to contact physician or patient		7
		39
(c) Invitation Refusal		
Time conflict		3
Transportation problems		3
Others (dislike or fear of exercising, job commitment)		6
		12
(d) Failure to Attend Organizational Meeting		
Holidays		2
Transportation problems or geographical re-location		2
Unstable angina		1
Change of mind (due to program format)		1
		6
(e) Contraindications for Testing		
Unstable Angina		1
Diabetes		1
		2
	Total Excluded	170
	Resultant Total	6

heart failure and unstable AP.

Four females in the cardiac exercise group had suffered 2 myocardial infarctions and 2 females had residual AP following MI. On the average 19.2 months (range of 5 months to 34 months) had elapsed since the time of the last MI. Three of the 6 patients took beta-blocking medications daily (Table 2).

Healthy females. A request for middle-aged female volunteers, less than 60 years and free of any cardio-respiratory or metabolic disorders and orthopaedic disabilities, was placed in a McMaster University news-letter. Since an initial review of the ages of the cardiac patients revealed a majority greater than 44 years, respondents less than 44 years were excluded immediately. The remaining healthy volunteers were invited to be subjects in the study. An organizational meeting for eligible healthy subjects was held two weeks before the first healthy testing session (see Preliminary Procedures).

Nine of the 83 apparently healthy, middle-aged females who volunteered to participate in the study formed the healthy exercise group. Figure 2 depicts the healthy series and Table 3 describes the reasons for: (a) immediate exclusion; (b) invitation refusal; (c) drop-out after the organizational meeting; and (d) drop-out after the initial

Table 2. Medical history, medications and interval since last infarction of cardiac females upon entry into the physical conditioning program.

Subject	Medical History	Beta-blocking Drugs (daily dosage)	Time Since Last MI (months)
K.S.	AP; MI (November 1976)	Inderal 60 mg q.i.d.	18
J.P.	AP; MI (July 1975; August 1975); Catheterization (August 1977) showed right coronary artery with greater than 70% obstruction	Inderal 10 mg q.i.d.	34
A.L.	MI (March 1976; December 1977); Atrial fibrillation for 9 years	None	5
D.B.	MI (December 1976); Lupus Erythematosus	None	19
L.C.	MI (September 1976; November 1976)	None	18
B.C.	MI (March 1973; September 1975; Mild hypertension	Inderal 40 mg. q.i.d.	21

mg = milograms; q.i.d. = 4 times daily

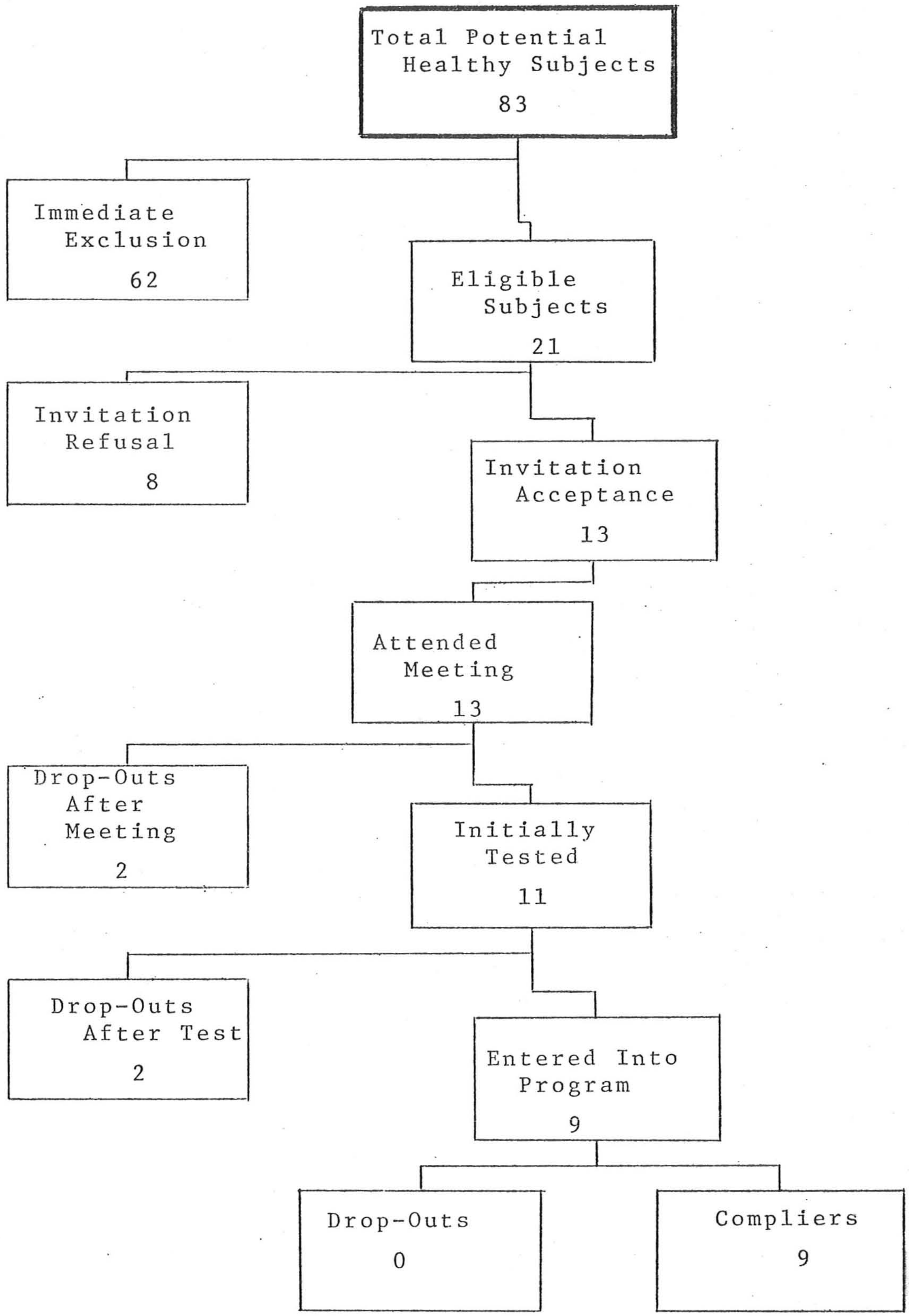


Figure 2. Healthy series.

Table 3. Reasons for exclusion of healthy females.

Volunteers	Total	83
		n
(a) Immediate Exclusion		
Age		62
(b) Invitation Refusal		
Time conflict with exercise sessions		4
Holidays		4
		8
(c) Drop-out After Organizational Meeting		
Job conflict with exercise sessions		1
Change of mind (due to program format)		1
		2
(d) Drop-out After Initial Progressive Test		
Change of mind (due to post-exercise discomfort)		1
Data not analyzed (because of subject's difficulty breathing through the mouthpiece)		1
		2
	Total Excluded	74
	Resultant Total	9

progressive test. The age criterion was instrumental in reducing the potential number of healthy subjects by 75%. Another 10% were lost when the time of the program was finalized. The percentage excluded for other reasons was minimal.

Preliminary Procedures

At the organizational meetings, the women were given: (a) detailed explanations of the rationale of the study, test protocol, program design and risks and discomforts which could potentially arise from the evaluative measures and physical conditioning sessions; (b) suggestions about suitable clothing; and (c) instructions to refrain from eating a meal, smoking, and drinking liquids with caffeine as an ingredient for at least one hour before the testing sessions but to take their daily medications as they would be on their medications throughout the program. They were shown the research laboratory and provided with an opportunity to use the testing equipment in an attempt to reduce anxiety over the procedures and to alleviate possible effects of learning on performance. Test schedules and medical referral forms (Appendix A) were distributed. Each female was required to have a physical examination and to return the medical referral form, completed by her family physician, before starting the study.

Testing Procedures

Subjects reported to the research laboratory of the Cardio-Respiratory Unit at McMaster University Medical Centre for testing once during the week preceding commencement of the physical conditioning program and once during the week following termination of the program. Each visit was scheduled at the same time of the day and involved the performance of 2 physician-supervised exercise tests, in the upright position, on an electrically-braked Elema-Schönander cycle ergometer. An informed consent form (Appendix B), approved by the McMaster University Ethics Committee, was signed by each subject immediately prior to her pre-conditioning evaluation. Medications were recorded and held constant over the post-conditioning evaluation period.

Prior to the first exercise test, height and weight was measured and a clinical examination was conducted. The clinical examination included a resting 12-lead electrocardiograph (ECG), brachial auscultation of blood pressure and spirometry (FEV_1 and FVC). The highest of 3 measures of FEV_1 and FVC, determined from a vitalometer recording and corrected for body temperature and pressure saturated with water vapour (BTPS), was expressed as a ratio (FEV_1/FVC) and multiplied by 100.

The first exercise test was a progressive multistage test at a pedalling rate of 50-60 revolutions per minute. From an initial power output of 100 kilogram-metres per minute ($kg\text{-}m \cdot min^{-1}$), the power output was increased every minute by 50 $kg\text{-}m \cdot min^{-1}$) for the patients and by 50 or 100 $kg\text{-}m \cdot min^{-1}$), depending upon body weight, for the healthy females (Jones _et al._, 1975). The test was terminated when the subject requested or when the physician judged that there were untoward signs and symptoms (Oldridge _et al._, 1978). Measurements of $\dot{V}_E$, $\dot{V}_{O_2}$, and $\dot{V}_{CO_2}$ were determined by standard methods of open circuit spirometry. Minute volume of inspired gas ($\dot{V}_I$) was measured by a Parkinson-Cowan CD4 dry gas meter. Gases expired through a low-resistance Lloyd valve were analyzed distal to a mixing chamber for fractional concentrations of oxygen (F_{EO_2}) by a Rapox meter or mass spectrometer and for fractional concentrations of carbon dioxide (F_{ECO_2}) by a Beckman infrared meter or mass spectrometer. Values for $\dot{V}_I$ and for mixed expired fractions in gas samples taken during the last 15 seconds at each power output were used in the calculation of $\dot{V}_E$, $\dot{V}_{O_2}$ and $\dot{V}_{CO_2}$ (Jones _et al._, 1975). Expired ventilation, expressed in litres per minute ($l \cdot min^{-1}$), was corrected for BTPS. Oxygen uptake and $\dot{V}_{CO_2}$ was corrected for standard temperature and pressure dry (STPD) and for body weight and expressed in millilitres per kilogram per minute ($ml \cdot kg^{-1} \cdot min^{-1}$).

Respiratory exchange ratio was calculated by dividing $\dot{V}_{CO_2}$ by $\dot{V}_{O_2}$. A continuous ECG recording from bipolar chest leads was obtained. Heart rate was determined by measuring the distance between R waves during the last 15 seconds at each power output and converting to beats per minute ($b \cdot min^{-1}$). At minute intervals, BP was measured with a mercury sphygmomanometer. Rate-pressure product was calculated as the product of HR x SBP and expressed in $b \cdot min^{-1} \cdot$ millimetres of mercury $(mmHg) \cdot 10^{-2}$. Immediately prior to each increase in PO, subjects were asked to rate their perception of exercise intensity by pointing to the appropriate number on Borg's RPE-scale which was held in front of them (Borg, 1970; Appendix C). A twelve-lead ECG was recorded immediately post-exercise and at 1, 3, 5 and 10 minutes into the recovery period. Exercise and recovery ECG responses were checked for the following abnormalities: (a) horizontal or downsloping ST-segment depression greater than or equal to 0.1 millivolts (mV) for at least 0.08 seconds; or (b) ST-segment elevation greater than or equal to 0.1 mV for 0.08 seconds (Detry et al., 1977). Arterialized-capillary blood was sampled from an earlobe puncture during the third minute of recovery and subsequently analyzed for H_{LA} using an enzymatic-fluorimetric technique (Guilbault, 1970). Values for H_{LA}, expressed in millimoles per litre ($mM \cdot l^{-1}$), were the average of 2 determinations.

A steady state test was conducted after a 40-minute rest period. Subjects pedalled at a rate of 50-60 revolutions per minute, for 5-8 minutes, at a power output corresponding to 40-70% of their initial maximum; the absolute power output for each subject being the same for pre-conditioning and post-conditioning evaluations. Relative work intensities were varied so that the regression of $\dot{Q}_c$ on $\dot{V}_{O_2}$ in each group during submaximal exercise could be determined. Methods and equipment used for measurements were the same as used in the progressive test. Heart rate was monitored continuously. Measurements of HR and mixed expired fractions were taken every 30 seconds. When a "steady state" condition (defined by a variation in HR of no more than $\pm$ 5 $b \cdot min^{-1}$ and a variation in F_{EO_2} and F_{ECO_2} of less than 0.1%) was reached, inspired gas volume and the fractional concentration of CO_2 in end-tidal gas (F_{ETCO_2}) was recorded for one full minute. Cardiac output was then obtained using an equilibration CO_2 rebreathing method which has been reported to be valid and reliable (Jones _et al._, 1975). Subjects rebreathed a concentration of CO_2 in O_2 (10% to 16%) for 10-15 seconds from a bag with an appropriate volume (1½ times tidal volume). The fractional concentration of CO_2 at the mouthpiece ($F_{\bar{v}CO_2}$) was recorded simultaneously. If a plateau in the record of $F_{\bar{v}CO_2}$ was not obtained within 8-12 seconds, the bag volume and/or concentration was changed accordingly and a second rebreathe was performed 30 seconds thereafter. Fractional concentrations of CO_2 in end-tidal gas and at the mouthpiece were measured by a Beckman infrared meter or mass spectrometer. Values for the partial pressure of CO_2 (P_{CO_2}) in arterial blood were estimated from values for P_{CO_2} in end-tidal gas. A "downstream correction" factor was applied to values for P_{CO_2} in the rebreathing bag to derive values for P_{CO_2} in mixed venous blood. Arterio-venous content difference of CO_2 was calculated and then corrected for Hb (Jones _et al._, 1975). Based on the average Hb of women previously tested in the laboratory (Personal communication from Elizabeth Head, Cardio-Respiratory Unit, McMaster University Medical Centre), Hb was estimated as being 13 grams per 100 millilitres for each subject. Arterial O_2 saturation was assumed to be 95%. Cardiac output was calculated from $\dot{V}_{CO_2}$ and arterio-venous CO_2 content difference using the Fick equation (Jones _et al._, 1975). Stroke volume was calculated from $\dot{Q}$ and HR. Arterio-venous O_2 difference was calculated from $\dot{V}_{O_2}$ and $\dot{Q}_c$. Stroke volume and, hence, $\dot{Q}_c$ is affected by body size and heart dimensions (Astrand and Rodahl, 1977). Physiologists have criticized the practice of normalizing $\dot{Q}_c$ for body surface area and have recommended that $\dot{Q}_c$ be directly related to metabolism and normalized per kilogram of body weight (Defares, 1965;

Burch and Giles, 1971). Since both $\dot{Q}_c$ and V_s normalized per kilogram body weight have been shown to be reliable indices (Faulkner et al., 1977), $\dot{Q}_c$ was expressed in $ml \cdot kg^{-1} \cdot min^{-1}$ and V_s was expressed in millilitres per kilogram ($ml \cdot kg^{-1}$) in this study. Values for $(a-\bar{v})O_2$ difference were in millilitres per 100 millilitres ($ml \cdot 100ml^{-1}$).

During both exercise tests, an eight-channel recorder (Mingograf 81, Elema-Schönander, Sweden) recorded electrical output from a potentiometer attached to the dry gas meter, ECG, O_2 analyzer and CO_2 analyzer.

The respiratory circuit and valves were checked for leaks before each testing session. Gas analyzers were calibrated before and after each test with 3 known gas mixtures previously analyzed by a Lloyd-Haldane apparatus. An additional 3 gases, in the range of 7-16% CO_2, were used to calibrate the CO_2 analyzer when a rebreathing procedure was to be performed. Mingograf recordings were constantly scrutinized during each test for abnormalities in patterns. Room temperature ranged from 22 to 25 degrees Celsius and barometric pressure ranged from 745 to 755 mmHg during the testing sessions.

The Physical Conditioning Program

The physical conditioning program consisted of

3 exercise sessions per week for 12 weeks. Each session included a 3-minute warm-up (cycle ergometer exercise), 18-24 minutes of aerobic work (intermittent cycle ergometer exercise) and 10-15 minutes of cool-down activities (walking or calisthenics). Mechanically-braked cycle ergometers were used and the pedalling rate was maintained at 50-60 revolutions per minute.

Exercise intensity was individually-determined from graphs of HR versus $\dot{V}_{O_2}$ based on the results of the pre-conditioning progressive exercise test. Throughout the program warm-up work loads corresponded to the HR at 40% of maximal $\dot{V}_{O_2}$. Initial conditioning work loads prescribed corresponded to the HR (within a range of ± 5%) at 65% of maximal $\dot{V}_{O_2}$. Following the warm-up, subjects exercised at their conditioning work loads for 3 minutes and rested for 3 minutes. Work intervals were repeated 4 times for the first week and 6 times for the next 7 weeks. The number of repetitions per session was kept low initially to prevent excessive muscle soreness. Subjects were taught how to palpate their carotid pulse and measurements of their HR, taken immediately after the warm-up and each subsequent work interval, were recorded in log books. At the end of 4 weeks, the conditioning intensity was increased to 75% of maximal $\dot{V}_{O_2}$. Thereafter, work loads were augmented only when recorded HR responses were consistently below the target

HR range at 75% of maximal $\dot{V}_{O_2}$. At the end of the eighth week the number of work intervals was increased to 8 and the duration of the rest intervals was reduced to 2 minutes.

The investigator was present at all sessions to make periodic checks of HR responses and for motivational purposes. The healthy group and one of the cardiac patients exercised in a human performance laboratory located in the Ivor Wynne Centre at McMaster University. The remainder of the patient group exercised in a rehabilitation gymnasium located in the McMaster University Medical Centre. Emergency equipment was immediately available at both exercise sites and a physician was either present or nearby when the patients were exercising.

Four of the healthy subjects went on holidays during the course of the program. They were given an alternate jog/walk prescription, with a similar intensity and an increased frequency (4 times a week), to perform in their absence from the supervised exercise sessions. Intervals of jogging and walking were each 3 minutes in duration and were repeated over a period of 30-45 minutes. The subjects were instructed to jog at a speed which would maintain their HR in its target range and to record HR responses in their log books.

Research Design

This study followed a pre-test post-test design which was expanded to permit a comparison of changes in two groups as a result of the same experimental manipulation (Kerlinger, 1973). However, since only 3 cardiac females completed the 12 weeks of physical conditioning, changes in each of these females were determined and compared to those in the healthy group using a case study approach.

Statistical Methods

The level of significance for statistical analyses of differences was set at 0.05 based on the initial size of the two groups (Colton, 1974). In many instances descriptive statistics were used to summarize differences.

Comparison of cardiac females with healthy females before physical conditioning. Group differences in variances for age and functional capacity before physical conditioning were determined by an F test (Klugh, 1970). Since the F ratio for age was significant and the groups were small and unequal in size, a modified t test (Klugh, 1970) was used to analyze pre-conditioning differences between the cardiac females and the healthy females on measures of physical characteristics, cardiorespiratory variables, H_{LA} and RPE.

Individual subject regression equations for the following relationships during progressive exercise were calculated from data at all power outputs: (a) $\dot{V}_{O_2}$ to PO; (b) $\dot{V}_E$ to $\dot{V}_{CO_2}$; (c) HR, SBP and RPP to $\dot{V}_{O_2}$; and (d) RPE to $\dot{V}_{O_2}$, $\dot{V}_E$, HR and RPP. Differences between the two groups in pre-conditioning mean slopes and intercepts of these relationships were determined by the modified t test. Group regression equations for the same relationships during progressive exercise were calculated from data on all of the subjects in the group at each PO. The significance of correlation coefficients (r) for the relationships between RPE and cardiorespiratory variables in each group was ascertained from a table of critical values (Klugh, 1970).

Although relative steady state PO varied within each group before and after physical conditioning, there was little variability in the absolute steady state PO at which group members exercised during both assessment periods. Hence, the regression of $\dot{Q}_c$ on $\dot{V}_{O_2}$ during steady state exercise in each group was not determined before or after physical conditioning. A regression equation for the relationship of $\dot{Q}_c$ (in $ml \cdot kg^{-1} \cdot min^{-1}$) to $\dot{V}_{O_2}$ (in $ml \cdot kg^{-1} \cdot min^{-1}$) in the healthy, middle-aged female subjects from a previous study where $\dot{Q}_c$ was measured using the direct Fick method

(Kusumi et al., 1976) was calculated from mean values at several work intensities. This normalized regression line ($\dot{Q}_c = 4.6(\dot{V}_{O_2}) + 72.2$), plus or minus 1 standard error of the estimate (SEE), was used as a frame of reference in a graphical comparison of the pre-conditioning $\dot{Q}_c$-$\dot{V}_{O_2}$ relationship in the cardiac and healthy female subjects of the present study.

Changes in healthy females following physical conditioning. A matched pairs t test (Klugh, 1970) was used to ascertain differences between the pre-conditioning and post-conditioning means of the healthy group for the following: (a) physical characteristics; (b) cardiorespiratory variables; (c) H_{LA}; (d) RPE; and (e) slopes and intercepts of individual regression equations. Changes in the steady state $\dot{Q}_c$-$\dot{V}_{O_2}$ relationship following physical conditioning were determined from a graphical comparison of pre-conditioning and post-conditioning plots of $\dot{Q}_c$ on $\dot{V}_{O_2}$.

The reproducibility of measurements taken in this study was not resolved but information on intra-individual variability in measurements from repeated observations on healthy, young females in the laboratory was available (Personal communication from James Kane, Cardio-Respiratory Unit, McMaster University Medical Centre). Changes in cardiorespiratory variables and H_{LA} in the healthy females were considered to have resulted from the physical conditioning program only if the following criteria were both satisfied: (a) differences between pre-conditioning and post-conditioning means were statistically significant; and (b) the percent change in means for pre-conditioning and post-conditioning variables ([post-conditioning value x 100] divided by pre-conditioning value) was greater than the percent change expected from intra-individual variability.

<u>Comparison of changes in each cardiac female following physical conditioning with changes in healthy females</u>. Percent changes in measures of cardiorespiratory variables and H_{LA} for each cardiac female following physical conditioning were compared to those expected from intra-individual variability to confirm the effects of physical conditioning. Percent changes in physiological measures and RPE for each cardiac female were then compared, in magnitude and direction, to the respective mean percent changes for the healthy group.

Graphical comparisons of pre-conditioning and post-conditioning plots of the following at each PO during progressive exercise, and of steady state $\dot{Q}_c$ on $\dot{V}_{O_2}$, in each cardiac female were made to determine changes in relationships between variables due to physical conditioning: (a) $\dot{V}_{O_2}$ on PO; (b) $\dot{V}_E$ on $\dot{V}_{CO_2}$; (c) HR, SBP and RPP on $\dot{V}_{O_2}$; and (d) RPE on $\dot{V}_{O_2}$, $\dot{V}_E$, HR and RPP.

Differences between the effects of physical conditioning on these relationships in each cardiac female and the healthy group were also determined through graphical comparisons.

CHAPTER IV

RESULTS

Entry characteristics and compliance of the subjects are delineated in the first section of this chapter. Results of pre-conditioning between-group analyses of measures for physical characteristics, for variables during the progressive exercise test and for variables during the steady state exercise test are presented in section two. Section three gives results of the analyses of differences between pre-conditioning and post-conditioning measures for all variables in the healthy group.

Entry Characteristics and Compliance

Physical characteristics of each cardiac and healthy subject upon entry into the physical conditioning program are outlined in Table 4.

There was a 50% compliance rate in the cardiac exercise group. Three of the 6 patients dropped out of the physical conditioning program within the first 5 weeks; the remaining 3 patients attended an average of 34 of the possible 36 supervised exercise sessions (Table 5).

Table 4. Physical characteristics of cardiac and healthy females upon entry into the physical conditioning program.

Subject	Age (years)	Height (centimeters)	Weight (Kilograms)	FEV1/FVC (%)
Cardiac				
K.S.	49	159.9	64.5	86
J.P.	48	157.0	64.0	85
A.L.	57	156.1	84.5	83
D.B.	58	157.2	54.0	76
L.C.	40	160.1	56.5	85
B.C.	56	163.4	82.5	87
Mean	51.3	159.0	67.7	83.7
± 1 SEM	±2.9	±1.1	±5.3	±1.6
Healthy				
B.R.	45	165.4	67.8	84
E.E.	52	158.0	62.0	92
H.K.	50	160.6	57.0	77
E.T.	47	170.0	66.6	75
P.H.	44	148.9	60.0	84
P.B.	51	162.8	58.0	90
D.C.	49	160.8	77.0	85
R.H.	44	167.0	74.0	90
A.O.	48	163.8	78.0	77
Mean	47.8	161.9	66.7	83.8
± 1 SEM	±1.0	±2.0	±2.7	±2.1

SEM = standard error of the mean

Table 5. Attendance of cardiac and healthy females to the physical conditioning program.

Subject	Number of Exercise Sessions Attended	% of Maximum Number of Exercise Sessions Attended
Cardiac		
K.S.	33	94
J.P.	34	92
A.L.	35	97
Healthy		
B.R.	36	100
E.E.	29	81
H.K.	36	100
E.T.	33	92
P.H.	31	86
P.B.	31	86
D.C.	31	86
R.H.	32	89
A.O.	28	78
Mean	31.9	88.6
± 1 SEM	±0.9	±0.8

Individual reasons for dropping out were as follows: (a) expensive, exhausting and time-consuming; (b) time-consuming because of living and working outside of the Hamilton city limits; and (c) exhausting as well as painful because of the development of arthritis.

The compliance rate of the healthy exercise group with the physical conditioning program was 100%. Attendance of the healthy females to a maximum of 36 supervised exercise sessions ranged from 78% to 100% (Table 5).

Comparison of Cardiac Females with Healthy Females Before Physical Conditioning

The two initial exercise groups were similar in their means for age, height, weight and resting spirometry (FEV_1/FVC) (Table 4).

Progressive exercise test. Prior to physical conditioning the mean maximal PO (450.0 $kg\text{-}m \cdot min^{-1}$), functional capacity (16.3 $ml \cdot kg^{-1} \cdot min^{-1}$; 1.1 $l \cdot min^{-1}$) and maximal $\dot{V}_{CO_2}$ (18.1 $ml \cdot kg^{-1} \cdot min^{-1}$; 1.2 $l \cdot min^{-1}$) of the cardiac females was significantly lower than the mean maximal PO (705.6 $kg\text{-}m \cdot min^{-1}$), functional capacity (23.3 $ml \cdot kg^{-1} \cdot min^{-1}$; 1.6 $l \cdot min^{-1}$) and maximal $\dot{V}_{CO_2}$ (27.0 $ml \cdot kg^{-1} \cdot min^{-1}$; 1.8 $l \cdot min^{-1}$) of the healthy females. Mean maximal values for all other cardiorespiratory variables, H_{LA} and RPE in the two groups were similar (Table 6). Muscular fatigue was the most common limiting factor to maximal exercise performance reported by the subjects as a whole, although 4 of the 6 cardiac subjects also complained of shortness of breath (Table 7). None of the subjects experienced exertional chest pain or demonstrated significant ST-segment changes in their exercise or post-exercise electrocardiogram.

No differences between the two groups in either pre-conditioning mean slopes or intercepts for the following relationships during progressive exercise were observed: (a) $\dot{V}_{O_2}$ to PO; (b) $\dot{V}_E$ to $\dot{V}_{CO_2}$; and (c) HR, SBP and RPP to $\dot{V}_{O_2}$ (Table 8). Since the cardiac females had a significantly reduced maximal $\dot{V}_{O_2}$ and PO in comparison to the healthy females, it appears that they were working at a higher percentage of their functional capacity than the healthy females at any given submaximal PO.

Ratings of perceived exertion were linearly related to (as determined from scattergrams), and significantly correlated with, $\dot{V}_{O_2}$, $\dot{V}_E$, HR and RPP in both groups during progressive exercise. Correlation coefficients for these relationships were similar in the healthy group (0.80 (RPE-$\dot{V}_{O_2}$), 0.78 (RPE-$\dot{V}_E$), 0.71 (RPE-HR) and 0.75 (RPE-RPP). However, in the cardiac group the degree of association between RPE and $\dot{V}_E$ ($r = 0.80$) was much higher than that between RPE and $\dot{V}_{O_2}$ ($r = 0.62$), HR ($r = 0.56$) and RPP

$\dot{V}_{CO_2}$ (ml·kg^{-1}·min^{-1})	18.1 ± 1.9	27.0 ± 1.7 †	31.8 ± 1.7*	+ 17.8	K.S.	+ 60.8
$\dot{V}_{CO_2}$ (l·min^{-1})	1.2 ± 0.1	1.8 ± 0.2 †	2.1 ± 0.1*		J.P.	+ 26.0
					A.L.	+ 5.9
R	1.12 ± 0.04	1.16 ± 0.05	1.17 ± 0.03	+ 0.9	K.S.	+ 21.6
					J.P.	+ 19.0
					A.L.	- 2.8
H_{LA} (mM·l^{-1})	6.1 ± 0.9 □	7.7 ± 0.8 ▲	8.8 ± 0.9 ▲	+ 14.3	K.S.	+ 23.0
					J.P.	+ 10.9
					A.L.	- 24.2
RPE	18.0 ± 0.4	17.4 ± 0.3	18.3 ± 0.5	+ 5.2	K.S.	+ 5.6
					J.P.	- 10.5
					A.L.	0.0

Values are means ± 1 SEM
Percent changes in normalized values for $\dot{V}_{O_2}$ and $\dot{V}_E$ are given only

† indicates significant difference ($p < 0.05$) between pre-conditioning means for cardiac and healthy groups as determined by a modified t test
* indicates significant difference ($p < 0.05$) between pre-conditioning and post-conditioning means for healthy group as determined by a matched pairs t test
□ n = 5 due to methodological errors
▲ n = 7 due to methodological errors

Table 7. Reasons given by cardiac and healthy females for discontinuing the progressive exercise test before and after physical conditioning.

Subject	Before	After
Cardiac		
K.S.	muscular fatigue; S.O.B.	general fatigue
J.P.	muscular fatigue	muscular fatigue
A.L.	muscular fatigue	S.O.B.
D.B.	muscular fatigue; S.O.B.	----------
L.C.	muscular fatigue; S.O.B.	----------
B.C.	muscular fatigue; S.O.B.	----------
Healthy		
B.R.	muscular fatigue	S.O.B.
E.E.	muscular fatigue	dizziness
H.K.	muscular fatigue	S.O.B.
E.T.	general fatigue	muscular fatigue; S.O.B.
P.H.	muscular fatigue	muscular fatigue; S.O.B.
P.B.	muscular fatigue	chest tightness; S.O.B.
D.C.	S.O.B.	muscular fatigue
R.H.	general fatigue; S.O.B.	dry throat
A.O.	general fatigue	S.O.B.

S.O.B. = shortness of breath

(r = 0.69). There were no differences between the cardiac females and the healthy females in pre-conditioning mean slopes or intercepts for any of these relationships (Table 9).

Steady state exercise test. Group means for the relative intensity of steady state exercise before physical conditioning were similar (cardiac = 53.0% maximal PO and healthy = 55.6% maximal PO) while the mean absolute work intensity for the cardiac females (241.7 kg-m·min^{-1}) was significantly lower than that for the healthy females (394.4 kg-m·min^{-1}). Pre-conditioning group mean values for cardiorespiratory variables measured during steady state exercise were not significantly different (Table 10). Therefore, lower values observed in the cardiac group reflect the lower absolute steady state PO.

The majority of healthy females had an elevated $\dot{Q}_c$-$\dot{V}_{O_2}$ relationship in comparison to the reference group (from Kusumi et al., 1976) whereas 2 cardiac females had an elevated, 2 had a similar and 2 had a reduced $\dot{Q}_c$-$\dot{V}_{O_2}$ relationship (Figure 3).

Changes in the Healthy Females Following Physical Conditioning

The mean body weight and resting FEV_1/FVC of the healthy group did not change over the 12 weeks of physical conditioning (Table 4).

Table 8. Slopes and intercepts of relationships between oxygen uptake and power output and between cardiorespiratory variables during progressive exercise in cardiac females before physical conditioning and in healthy females before and after physical conditioning.

Relationship		Cardiac Before	Healthy Before	Healthy After
$\dot{V}_{O_2}$-PO	Slope	0.03 ± 0.004	0.03 ± 0.003	0.03 ± 0.002
	Intercept ($ml \cdot kg^{-1} \cdot min^{-1}$)	3.1 ± 1.0	3.8 ± 0.5	4.6 ± 0.7
$\dot{V}_E$-$\dot{V}_{CO_2}$	Slope	2.2 ± 0.4	2.0 ± 0.1	2.1 ± 0.9
	Intercept ($l \cdot min^{-1}$)	2.0 ± 0.7	1.1 ± 0.9	0.1 ± 0.8
HR-$\dot{V}_{O_2}$	Slope	3.0 ± 1.2	4.1 ± 0.4	3.8 ± 0.2
	Intercept ($b \cdot min^{-1}$)	87.4 ± 18.9	69.7 ± 3.6	64.9 ± 5.5
SBP-$\dot{V}_{O_2}$	Slope	5.5 ± 2.0	3.0 ± 0.3	2.2 ± 0.2
	Intercept (mmHg)	87.9 ± 20.3	117.7 ± 5.9	122.5 ± 5.9
RPP-$\dot{V}_{O_2}$	Slope	12.6 ± 2.5	10.5 ± 0.8	9.3 ± 0.5
	Intercept ($b \cdot min^{-1} \cdot mmHg \cdot 10^{-2}$)	41.4 ± 31.7	58.0 ± 8.2	56.0 ± 11.8

Values are means ± 1 SEM of individual regression equations

Table 9. Slopes and intercepts of relationships between ratings of perceived exertion and cardiorespiratory variables during progressive exercise in cardiac females before physical conditioning and in healthy females before and after physical conditioning.

	Relationship	Cardiac	Healthy	
		Before	Before	After
RPE-$\dot{V}_{O_2}$	Slope	0.82 ± 0.15	0.59 ± 0.04	0.59 ± 0.07
	Intercept	4.7 ± 1.4	2.9 ± 0.79	1.2 ± 1.2
RPE-$\dot{V}_E$	Slope	0.30 ± 0.30	0.22 ± 0.03	0.25 ± 0.03
	Intercept	5.7 ± 0.67	3.8 ± 0.86	4.4 ± 0.76
RPE-HR	Slope	0.15 ± 0.01	0.15 ± 0.02	0.15 ± 0.01
	Intercept	-5.0 ± 2.1	-7.8 ± 3.2	-7.9 ± 1.2
RPE-RPP	Slope	0.07 ± 0.01	0.06 ± 0.007	0.07 ± 0.005
	Intercept	1.0 ± 1.8	-0.91 ± 0.19	-2.0 ± 0.74

Values are means ± 1 SEM of individual regression equations

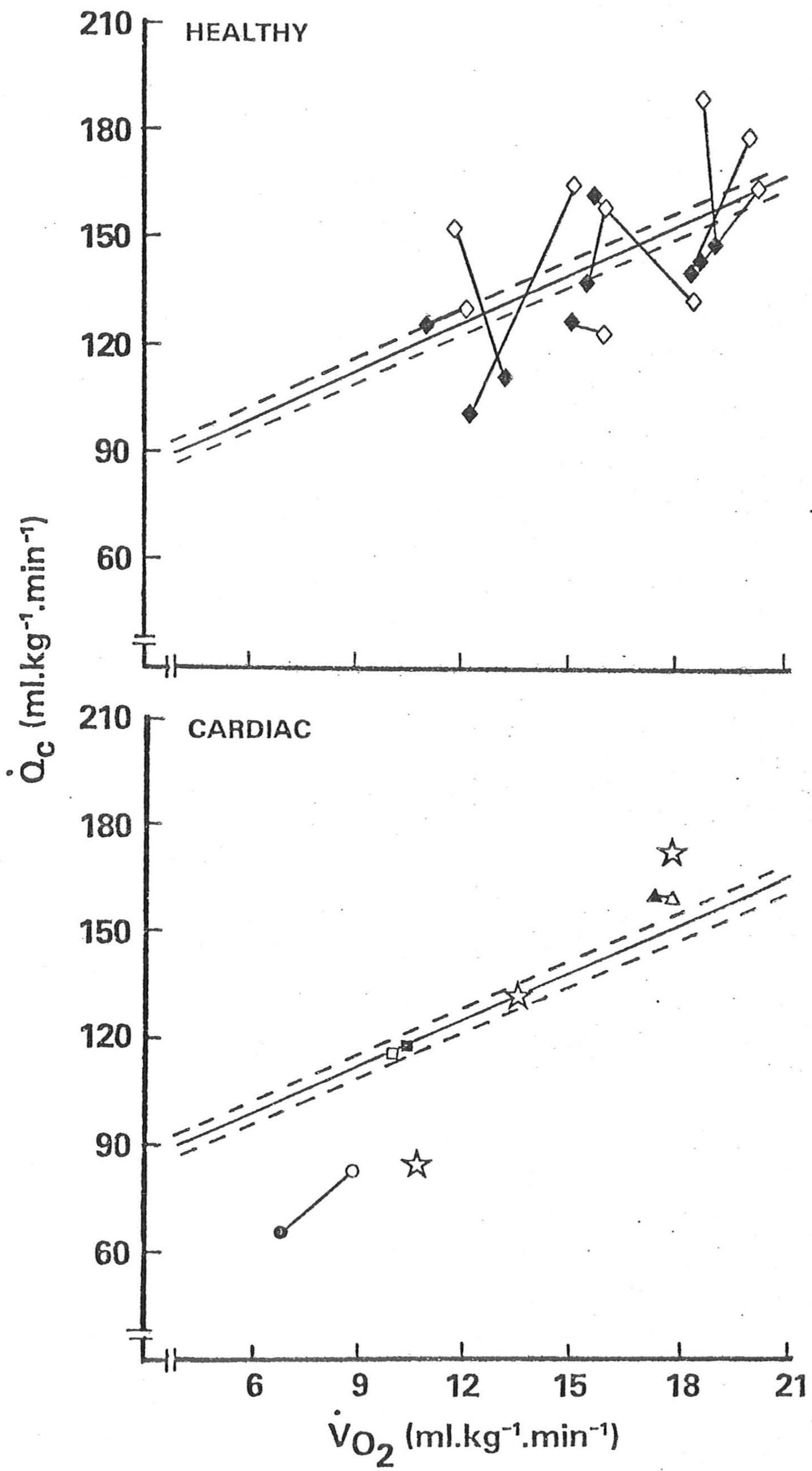
R	1.05 ± 0.4	0.99 ± 0.05	0.90 ± 0.02	- 9.1	K.S.	- 16.7
					J.P.	- 6.1
					A.L.	- 23.1

Values are means ± 1 SEM

Percent changes in normalized values for $\dot{V}_{O_2}$, $\dot{Q}_c$ and V_s are given only

†indicates significant difference ($p<0.05$) between pre-conditioning means for cardiac and healthy groups as determined by a modified t test

*indicates significant difference ($p<0.05$) between pre-conditioning and post-conditioning means for healthy group as determined by a matched pairs t test


210
HEALTHY
180
150
120
90
60
$\dot{Q}_c$ (ml.kg^{-1}.min^{-1})
210
CARDIAC
180
150
120
90
60
6
9
12
15
18
21
$\dot{V}O_2$ (ml.kg^{-1}.min^{-1})

Progressive exercise test. A significant increase in the mean maximal PO of the healthy females following physical conditioning (from 705.6 $kg\text{-}m\cdot min^{-1}$ to 900 $kg\text{-}m\cdot min^{-1}$) was accompanied by significant increases in mean maximal $\dot{V}_{O_2}$ (from 23.3 $ml\cdot kg^{-1}\cdot min^{-1}$; 1.6 $l\cdot min^{-1}$ to 27.0 $ml\cdot kg^{-1}\cdot min^{-1}$; 1.8 $l\cdot min^{-1}$), $\dot{V}_E$ (from 57.7 $l\cdot min^{-1}$ to 71.5 $l\cdot min^{-1}$) and $\dot{V}_{CO_2}$ (from 27.0 $ml\cdot kg^{-1}\cdot min^{-1}$; 1.8 $l\cdot min^{-1}$ to 31.8 $ml\cdot kg^{-1}\cdot min^{-1}$; 2.1 $l\cdot min^{-1}$). These significant increases were all of a magnitude greater than that expected from intra-individual variability (Table 11). Pre-conditioning and post-conditioning mean maximal values for other cardiorespiratory variables and H_{LA} were similar (Table 6). The most common subjective reason given by the healthy females for discontinuing the progressive test after physical conditioning was shortness of breath whereas before it was muscular fatigue (Table 7). Exercise and post-exercise ECG responses of each healthy female were within normal limits during both assessment periods.

There were no differences in healthy pre-conditioning and post-conditioning mean slopes or mean intercepts for the following relationships during progressive exercise: (a) $\dot{V}_{O_2}$ to PO; (b) $\dot{V}_E$ to $\dot{V}_{CO_2}$; and (c) HR, SBP and RPP to $\dot{V}_{O_2}$ (Table 8).

Both before and after physical conditioning,

Table 11. Intra-individual variability in data collected in the exercise laboratory at McMaster University Medical Centre.

Variable	Percent Change
PO ($kg\text{-}m \cdot min^{-1}$)	± 3.0
$\dot{V}_{O_2}$ ($ml \cdot kg^{-1} \cdot min^{-1}$)	± 3.8
HR ($b \cdot min^{-1}$)	± 5.0
SBP (mmHg)	±10.9*
$\dot{V}_E$ ($l \cdot min^{-1}$)	± 8.0
$\dot{V}_{CO_2}$ ($ml \cdot kg^{-1} \cdot min^{-1}$)	± 4.2□
$\dot{Q}_c$ ($ml \cdot kg^{-1} \cdot min^{-1}$)	± 5.7▲
H_{LA} ($mM \cdot l^{-1}$)	± 5.0

Percent changes were derived by dividing standard deviations by means and multiplying by 100

*intra-individual variability in RPP($b \cdot min^{-1} \cdot mmHg \cdot 10^{-2}$) is considered to be equivalent

□intra-individual variability in $\dot{R}$ is considered to be equivalent

▲intra-individual variability in V_s($ml \cdot kg^{-1}$) and $(a\text{-}\bar{v})O_2$ difference ($ml \cdot 100\ ml^{-1}$) is considered to be equivalent significant correlations between RPE and $\dot{V}_{O_2}$, $\dot{V}_E$, HR and RPP during progressive exercise were observed in the healthy group. Pre-conditioning and post-conditioning correlation coefficients for the relationships of RPE to HR and RPP were similar. However, post-conditioning correlation coefficients for the relationships of RPE to $\dot{V}_{O_2}$ (0.90) and $\dot{V}_E$ (0.87) were higher than the respective pre-conditioning correlation coefficients (0.80 and 0.78). Although RPE was more closely associated with $\dot{V}_{O_2}$ and $\dot{V}_E$ in the healthy group after physical conditioning than before, increases in maximal $\dot{V}_{O_2}$ and $\dot{V}_E$ were not accompanied by an increase in maximal RPE (Table 6). Mean slopes and intercepts for the relationships of RPE to cardiorespiratory variables in the healthy females during progressive exercise were unchanged following physical conditioning (Table 9).

<u>Steady state exercise test</u>. At the same steady state PO following physical conditioning the mean $\dot{Q}_c$ of the healthy group was significantly decreased (from 155.3 $ml \cdot kg^{-1} \cdot min^{-1}$; 10.4 $l \cdot min^{-1}$ to 134.5 $ml \cdot kg^{-1} \cdot min^{-1}$; 9.0 $l \cdot min^{-1}$) concomitantly with a significant decrease in mean $\dot{V}_{O_2}$ (from 16.5 $ml \cdot kg^{-1} \cdot min^{-1}$; 1.1 $l \cdot min^{-1}$ to 15.4 $ml \cdot kg^{-1} \cdot min^{-1}$; 1.0 $l \cdot min^{-1}$). The $\dot{Q}_c$-$\dot{V}_{O_2}$ relationship was lower in the majority of the healthy females after physical conditioning than before (Figure 3). There was

no change in mean $(a-\bar{v})O_2$ difference (Table 10). The lower mean $\dot{Q}_c$ was associated with a significantly lower mean HR (from 141.7 $b \cdot min^{-1}$ to 128.4 $b \cdot min^{-1}$) and a similar mean V_s (Table 10). Mean R was not altered (Table 10). All significant decreases were of a greater magnitude than those expected from intra-individual variability (Table 11).

CHAPTER V

DISCUSSION

Patient selection and compliance with the physical conditioning program was a major problem in the present study. The difficulties encountered in acquiring a sample of females with CHD and possible reasons for differences in healthy and patient compliance rates are discussed in this chapter. Data collected during acute exercise are then discussed in terms of the limitations of the cardiac females since the feasibility of an exercise prescription for patients is dependent upon their limitations. In the last section of this chapter effects of the physical conditioning program on the healthy females are presented.

Subject Selection and Compliance

In physical conditioning studies where cardiac patients of both sexes have been selected on the basis of criteria similar to those used in this study the initial ratio of females to males has been approximately 1 to 10 (Sanne, 1973; Wilhelmsen *et al.*, 1975; Palatsi, 1976). The smaller proportion of females to males may reflect: (a) sex differences in the incidence of MI, since MI has been reported to occur 6 to 8 times more frequently in middle-aged males than in middle-aged females (Kannel and Feinleib, 1972; Bengtsson, 1973; Elmfeldt et al., 1975; Gordon et al., 1978); and (b) unwillingness to undergo physical conditioning on the part of middle-aged female patients. The present investigator not only had difficulty finding post-MI females less than 60 years of age, but also had difficulty finding post-MI females without other health complications. Thus, the paucity of investigations on the responses of post-MI females to physical conditioning in comparison to the number on post-MI males could be due to problems in acquiring a sample which is both large enough and safe to study. Unfortunately, many potential cardiac subjects had to be excluded from the present study because they lived a great distance from the testing and program facilities. Another aspect of the patient series, which may or may not be unique, is that several family physicians refused the investigator permission to invite their patients to be participants because they believed exercise would be of no value to their patients.

There is little available information specific to the compliance and non-compliance (drop-out) of cardiac females with exercise rehabilitation programs. Bruce and colleagues (1976) reported that 42% of the female patients who enrolled in Cardiopulmonary Research Institute (CAPRI) community programs in Seattle, Washington, were still active in the programs after 1 year and less than 30% were active after 3 years. Forty-four percent dropped out for reasons categorized as unavoidable (work conflicts, financial considerations, geographical re-location); 21% for psycho-social reasons (lack of interest and motivation, personal problems); 15% because of medical problems; and 20% for reasons unknown. In reports on the Göteborg study (Sanne, 1973; Wilhelmsen _et al._, 1975), it was stated that 17 out of 151 post-MI patients randomly allocated to a physical conditioning group were females and that 6 of these 17 females completed 9 months of physical conditioning. There was no mention of the number of female patients who actually started the program or the factors responsible for female drop-out. Lowenthal and McAllister (1976) found that 16% of the males and females with either evidence of CHD or at a high risk for coronary events dropped out of a 12-week physical rehabilitation program for non-medical reasons. In the present study 3 of the 6 patients complied with the physical conditioning program; 2 of the 3 patients who dropped out did so for non-medical reasons. A comparison between the compliance rate of female patients in this study (50%) and other studies would be invalid because of differences in the following: (a) methods and criteria used for patient selection; (b) criteria used for drop-out; (c) program design and objectives; and, perhaps, (d) attitudes and expectations of participants (Oldridge, 1979).

Oldridge (1979) recently reviewed several studies and found that the compliance rates of apparently healthy, middle-aged males with exercise programs were generally higher than those of male post-MI patients. He postulated that differences in the compliance of healthy and post-MI subjects might be due to differences in motives for initiating and continuing an exercise prescription. In the present study the compliance rate of the healthy females with the physical conditioning program was double that of the cardiac females; none of the healthy females dropped out. A comparison of responses to a pre-conditioning questionnaire showed that there was little difference between the two groups in motives for entering into the program or in elements, such as subjective perceptions of health and illness and perceived benefits and support of family, which may have affected these motives. Sixty-seven percent of the cardiac group stated that their motive was to feel better or more physically fit and 33% stated that it was to prevent illness and disease. Corresponding figures for the healthy group were 56% and 44%. The majority of subjects in each group reported that: (a) they perceived their level of physical fitness as being low to moderate; (b) their families believed exercise had an important role in the maintenance of good health; and (c) their families were supportive of their participation in the program.

Sanne (1973) has suggested that, among other factors, drop-out from physical training programs is dependent upon distance to the training facility, travelling expenses and suitability of training time. All but one healthy subject worked on the university campus where lunch-hour exercise sessions were held and she was within walking distance of the campus. Each cardiac subject had to travel quite far to the training facility but exercise sessions were held at times selected by the subject. In view of observations from the Göteborg study (Sanne, 1973), and reasons given for dropping out in this study (Chapter IV), it appears that differences between the cardiac and healthy groups in compliance were related to differences in ease of facility accessibility and financial costs.

Each organizational meeting, held prior to the commencement of the study, also served as a recruitment meeting and was of a type which has been found to have a positive effect on compliance with exercise programs (Heinzelmann, 1973). The healthy subjects were sampled from a group of self-selected volunteers who had attended a meeting. The cardiac subjects were sampled from a group of patients who, having been previously found through a screening process to satisfy specific requirements (Chapter III), attended a meeting and, subsequently, volunteered for the study. Remington and co-workers (1978) observed that self-selected male volunteers for a CHD prevention program involving long-term physical conditioning had certain behaviours and characteristics which were distinguishable from those of non-volunteers. One such distinction was that volunteers tended to be more habitually active in their leisure time. The initial cardiac and healthy exercise groups in this study were both composed of volunteers and had similar leisure-time physical activity habits as determined from the questionnaire comparison. However, since the method used to select the cardiac subjects differed somewhat from that used to select the healthy subjects and 2 of the 3 drop-outs reported that the exercise sessions were exhausting, a volunteer bias in subject selection (Remington _et al._, 1978; Sackett, 1979) may have influenced compliance with the exercise program. Although the relative intensity of physical conditioning was the same for the cardiac and healthy subjects, it is also possible that compliance was affected by the physical demands of the exercise prescription (Oldridge, 1979).

Acute Exercise

Initial values for the maximal $\dot{V}_{O_2}$, HR, $\dot{V}_E$ and H_{LA} of the healthy group were at the low end of the range reported for similar-aged healthy females in previous cycle ergometer exercise studies (Astrand, 1960; Kilbom, 1971a and b; Kilbom and Astrand, 1971; Atomi and Miyashita, 1974; Hartung, 1974; Bengtsson _et al._, 1978). Values for these physiological variables in healthy, middle-aged females have been found to be dependent upon habitual level of physical activity (Profant _et al._, 1972; Atomi and Miyashita, 1974; Drinkwater _et al._, 1975). Since 6 of the 9 healthy subjects were largely inactive in their leisure-time habits, the relatively poor maximal performance of the healthy females in the present study presumably reflected their sedentary life style.

In comparison to the healthy females, the cardiac females had a markedly decreased exercise tolerance, functional capacity and CO_2 production upon entry into the study. Maximal HR was 20 $b \cdot min^{-1}$ lower in the patient group than in the healthy group; the HR difference was not statistically significant, however, as it resulted primarily from substantially lower heart rates in 2 of the 6 patients. These two patients were taking daily doses of beta-blocking drugs which have been shown to decrease HR, SBP (RPP) and $\dot{Q}_c$ during exercise (Clausen, 1976; Hassock _et al._, 1980). The mechanism behind such drug-induced reductions is an inhibition of the responses of cardiac beta-receptors to sympathetic stimulation. Both of the patients on drug therapy had a lower maximal RPP than the other members of the patient group but the maximal RPP of the whole patient group did not differ from that of the healthy group.

Differences between the cardiac females and the healthy females in maximal cardiorespiratory variables were not attributable to differences in age or physical activity status. Rate-pressure product, and HR, has been found to be highly correlated with $M\dot{V}_{O_2}$ (Holmberg _et al._, 1971; Kitamura _et al._, 1972). Since the maximal RPP of the patient group was similar to that of the healthy group, the lower maximal work capacity of the patient group was probably not due to a lower maximal myocardial O_2 consumption. Furthermore, there was no evidence that the exercise performance of the cardiac females was limited by myocardial ischemia; that is, there were no complaints of angina and no significant ST-segment changes in exercise or post-exercise ECG responses (Linhart et al., 1974; Borer et al., 1975; Sketch et al., 1975; Detry et al., 1977; Lindsey and Cohn, 1978). All of the cardiac females and the majority of the healthy females reported that they terminated the progressive test because of muscular fatigue. It is possible that group members experienced fatigue because they were unaccustomed to muscular work. A low $\dot{Q}_c$, reduced perfusion of exercising muscles and poor peripheral O_2 extraction could explain why the cardiac females had a maximal H_{LA} similar to that of the healthy females at a much lower maximal $\dot{V}O_2$. The observation that there were no significant differences in the maximal HR, O_2 pulse ($\dot{V}_{O_2}$/HR; a relative measure of V_s) or mean blood pressure (diastolic pressure + 1/3 pulse pressure) of the two groups suggests that there was no difference in maximal $\dot{Q}_c$. The cardiac females had a reduced maximal $\dot{V}_{CO_2}$, relative to the healthy group, at the same maximal $\dot{V}_E$. This may be indicative of a reduced muscle blood flow as healthy, middle-aged males have been found to have an increased $\dot{V}_E$ in the presence of a reduced $\dot{V}_{CO_2}$ following occlusion of the arterial supply to the exercising muscles (Sargeant et al., 1978). Without actual measures, it can not be concluded whether the lower functional capacity of the cardiac females was associated with a lower $\dot{Q}_c$, muscle blood flow, $(a-\bar{v})O_2$ difference or some other factor such as a lower capacity for oxidative phosphorylation.

The finding that RPE was linearly related to $\dot{V}_{O_2}$, HR and $\dot{V}_E$ in the two groups during acute, progressive exercise corroborates findings on healthy, middle-aged females (Kilbom, 1971a) and males (Bar-Or et al., 1972; Sargeant and Davies, 1973) and elderly individuals (Sidney and Shephard, 1977). While the relationship of RPE to RPP has not been previously studied, this investigation showed that it was also linear in both the healthy and heart diseased females. There was no difference between groups in RPE at any given $\dot{V}_{O_2}$, $\dot{V}_E$, HR and RPP or at their maximum PO which would seem to suggest that the perceived exertion of the subjects was a function of the relative degree of stress on their cardiorespiratory system. However, unlike in the healthy females, RPE in the cardiac females was much more closely associated with $\dot{V}_E$ than with any of the other cardiorespiratory variables. Four of the 6 patients experienced dyspnea while exercising. Thus, it may be that perceived exertion in the patients was influenced by sensations of distress arising from the work of breathing rather than by changes in $\dot{V}_E$ per se. Since leg discomfort was a common reason for stopping exercise in both groups, the exertional perceptions of the women may have also been affected by local factors such as a "feeling of strain in the working muscles" (Ekblom and

Goldbarg, 1971) or an accumulation of substances which "...might conceivably interfere with enzyme activity" (Simonsson, 1971).

At a significantly lower absolute PO, the cardiac females had a steady state $\dot{V}_{O_2}$ (12.8 $ml \cdot kg^{-1} \cdot min^{-1}$) which was similar to that (16.5 $ml \cdot kg^{-1} \cdot min^{-1}$) of the healthy females. Respectively, these values for $\dot{V}_{O_2}$ represented 78.8% and 71.2% of maximal $\dot{V}_{O_2}$. Clausen (1976) recently reviewed several studies and found that, compared to their healthy counterparts, the majority of male cardiac patients had a reduced V_s and an elevated HR at exercise intensities requiring greater than 60% of maximal $\dot{V}_{O_2}$. Stroke volume decreased markedly in the male patients as exercise intensities increased and, depending upon the magnitude of the relative elevation in HR, $\dot{Q}_c$ either decreased or remained constant. These manifestations of impaired left-ventricular functioning demonstrated by male patients at high work loads were not exhibited by the female patients in this study as the steady state HR, V_s and $\dot{Q}_c$ of the female patients did not differ from that of the healthy females. The observation of a similar $(a-\bar{v})O_2$ difference in the two groups suggests that peripheral O_2 extraction was also similar.

Effects of Physical Conditioning on the Healthy Females

The healthy females typically demonstrated an improvement in maximal work capacity and $\dot{V}_{O_2}$ as a result of physical conditioning. The 16% improvement in maximal $\dot{V}_{O_2}$ approximated that reported by Van Handel and colleagues (1976) but was greater than that reported in other studies of similar-aged females where the intensity, duration and frequency of exercise was similar (Kilbom, 1971a; Kilbom and Astrand, 1971). A lower pre-conditioning functional capacity or longer period of physical conditioning or, more likely, the interactive effect of these two factors may account for the relatively greater gain in functional capacity of the healthy subjects in this study.

Since maximal RPP (HR and SBP) was unchanged in the healthy females following physical conditioning, the higher functional capacity did not appear to be associated with augmented work of the myocardium. It has been reported that the increase in the maximal $\dot{V}_{O_2}$ of middle-aged female subjects following participation in a physical conditioning program is related to an increase in maximal V_s (Kilbom and Astrand, 1971; MacKeen _et al._, 1978). Maximal V_s was not measured in the present study. However, the observation of a similar maximal O_2 pulse before and after the program suggests that there was no change in maximal V_s with physical conditioning.

The significant increase in the maximal $\dot{V}_E$ of the healthy females following physical conditioning was due to the significant increase in maximal $\dot{V}_{O_2}$ and concomitant increase in maximal $\dot{V}_{CO_2}$ as neither maximal H_{LA} nor maximal R was altered. All of these findings agree with those of Kilbom (1971a).

A comparison of pre-conditioning and post-conditioning reasons for terminating exercise given by the healthy females showed that there was a shift in the subjective limiting factors to maximal work performance from local (in the muscles) to cardiorespiratory factors. Maximal RPE was no different after physical conditioning than before despite increases in cardiorespiratory responses. This finding supports other studies on healthy, middle-aged females (Kilbom, 1971a and b) and implies that the women perceived themselves as being able to tolerate a greater degree of cardiorespiratory stress following physical conditioning.

There was no evidence of change in cardiorespiratory variables or RPE in the healthy group at any absolute submaximal work intensity during the progressive test when pre-conditioning and post-conditioning regression lines were compared. Since the raw data indicated that there were changes at several power outputs, differences between pre-conditioning and post-conditioning measures at a submaximal PO (400 $kg\text{-}m \cdot min^{-1}$) which was no greater than 80% of maximum for any healthy female were statistically analyzed using a matched pairs t test. Reductions (from a mean ($\bar{X}$) ± 1 SEM to a $\bar{X}$ ± 1 SEM) in HR (133.2 ± 4.3 $b \cdot min^{-1}$ to 119.2 ± 3.2 $b \cdot min^{-1}$), SBP (165.6 ± 7.0 mmHg to 153.9 ± 7.0 mmHg), RPP (221.0 ± 12.3 $b \cdot min^{-1} \cdot mmHg \cdot 10^{-2}$ to 183.4 ± 9.2 $b \cdot min^{-1} \cdot mmHg \cdot 10^{-2}$), $\dot{V}_{CO_2}$ (14.2 ± 0.6 $ml \cdot kg^{-1} \cdot min^{-1}$ to 12.5 ± 0.6 $ml \cdot kg^{-1} \cdot min^{-1}$) and RPE (11.7 ± 0.9 to 9.0 ± 0.6) were significant but reductions in $\dot{V}_{O_2}$ (15.8 ± 0.8 $ml \cdot kg^{-1} \cdot min^{-1}$ to 14.3 ± 0.5 $ml \cdot kg^{-1} \cdot min^{-1}$) and $\dot{V}_E$ (27.9 ± 1.0 $l \cdot min^{-1}$ to 25.5 ± 0.9 $l \cdot min^{-1}$) were not. The reduction in SBP (7.1%) was less than that expected from intra-individual variability (Table 11) and, hence, not attributed to the physical conditioning program.

Studies have shown consistently that healthy, middle-aged females demonstrate a decrease in HR with no change in $\dot{V}_{O_2}$ or $\dot{V}_E$ at a given submaximal PO following physical conditioning (Kilbom, 1971a and b; Kilbom and Astrand, 1971; Flint _et al._, 1974; Van Handel _et al._, 1976). The 10.5% drop in HR noted in this investigation was within the range (8.1% to 12.0%) previously reported and primarily responsible for the drop in RPP (17.5%). This lower HR and RPP in the healthy females during submaximal exercise presumably reflects decreased myocardial requirements at the same absolute total body $\dot{V}_{O_2}$. The middle-aged women in Kilbom and Astrand's study exhibited a significant reduction in mean blood pressure (MBP), but no change in $\dot{Q}_c$, at submaximal work intensities following physical conditioning. Their reduced myocardial work was ascribed to a lower peripheral resistance. The decreased submaximal HR in the healthy females of this investigation was not associated with a decreased mean pressure. However, it is impossible to determine from the available data if the post-conditioning bradycardia during the progressive test resulted from changes accompanying reduced vasoconstriction or an augmentation in V_s or other factors.

A significant decrease in the submaximal RPE of the healthy subjects following physical conditioning is in agreement with previous reports on healthy, middle-aged females (Kilbom, 1971a and b). This observation implies that the women would perceive activities of daily living as being less tiring. The reduced exertional perceptions of the healthy females may have been related to the reduced myocardial work (HR and RPP) at submaximal work intensitites. There was no indication of an increase in mechanical efficiency and inferences about adaptations in the exercising muscles can not be made from the data collected during the progressive test. However, since the majority of the healthy females attained a higher maximal PO after physical conditioning than before without experiencing leg discomfort, the lower submaximal RPE after physical conditioning may have been a function of the relatively lesser strain on the exercising muscles.

The same absolute steady state PO represented a lower relative work intensity for the healthy group after physical conditioning (43.4% of maximum) than before (55.6% of maximum). At this PO after physical conditioning the healthy group, unlike females in previous studies (Kilbom and Astrand, 1971; Van Handel et al., 1976), had a significantly decreased $\dot{V}_{O_2}$ which was associated with a significantly decreased HR (and $\dot{Q}_c$), an unchanged V_s and an unchanged $(a-\bar{v})O_2$ difference. Oxygen uptake was decreased by 6.7% (1.1 $ml \cdot kg^{-1} \cdot min^{-1}$; 0.1 $l \cdot min^{-1}$) while $\dot{Q}_c$ was decreased by 13.4% (20.8 $ml \cdot kg^{-1} \cdot min^{-1}$; 1.4 $l \cdot min^{-1}$). The difference in the magnitude of these reductions, and the observation that $\dot{Q}_c/\dot{V}O_2$ was reduced in 5 of the 9 healthy females by an average of 19.2%, would seem to suggest that the lower $\dot{V}_{O_2}$ and $\dot{Q}_c$ reflected both an improvement in mechanical efficiency and physiological adaptations. Within the limits of this study, it is impossible to draw conclusions as to the mechanism for these adaptations.

CHAPTER VI

CASE STUDIES

As stated in Chapter III, changes in physiological variables measured during exercise in the 3 cardiac subjects (K.S., J.P. and A.L.) who completed the 12-week program were compared to those expected from intra-individual variability to confirm the effects of physical conditioning. Since inter-individual variability in pre-conditioning data for all of the cardiac females tended to be greater than that for the healthy females and values for intra-individual variability used in this study were determined from observations on healthy females, changes in the 3 cardiac subjects were considered to be due to the program if they were at least 5% greater than changes expected from intra-individual variability. Relationships between variables in these cardiac subjects during progressive exercise before and after physical conditioning are depicted in Figures 4 to 6 (K.S.), 7 to 9 (J.P.) and 10 to 12 (A.L.).

In this chapter, changes in each cardiac female following physical conditioning are identified and discussed using a case study format. The findings for the cardiac females are also discussed in terms of the question posed in the Introduction; that is, the feasibility of the 12-week program as a mode of physiological and psychophysical rehabilitation.

Cardiac Subject K.S.

This cardiac subject was 49 years old, weighed 64.5 kilograms (kg), was 159.9 centimeters (cm) tall and had a resting FEV_1/FVC (86%) which was within normal limits upon entry into the study (Table 4). She had suffered an MI 18 months previously, had residual AP and was taking 60 mg of Inderal q.i.d. (Table 2).

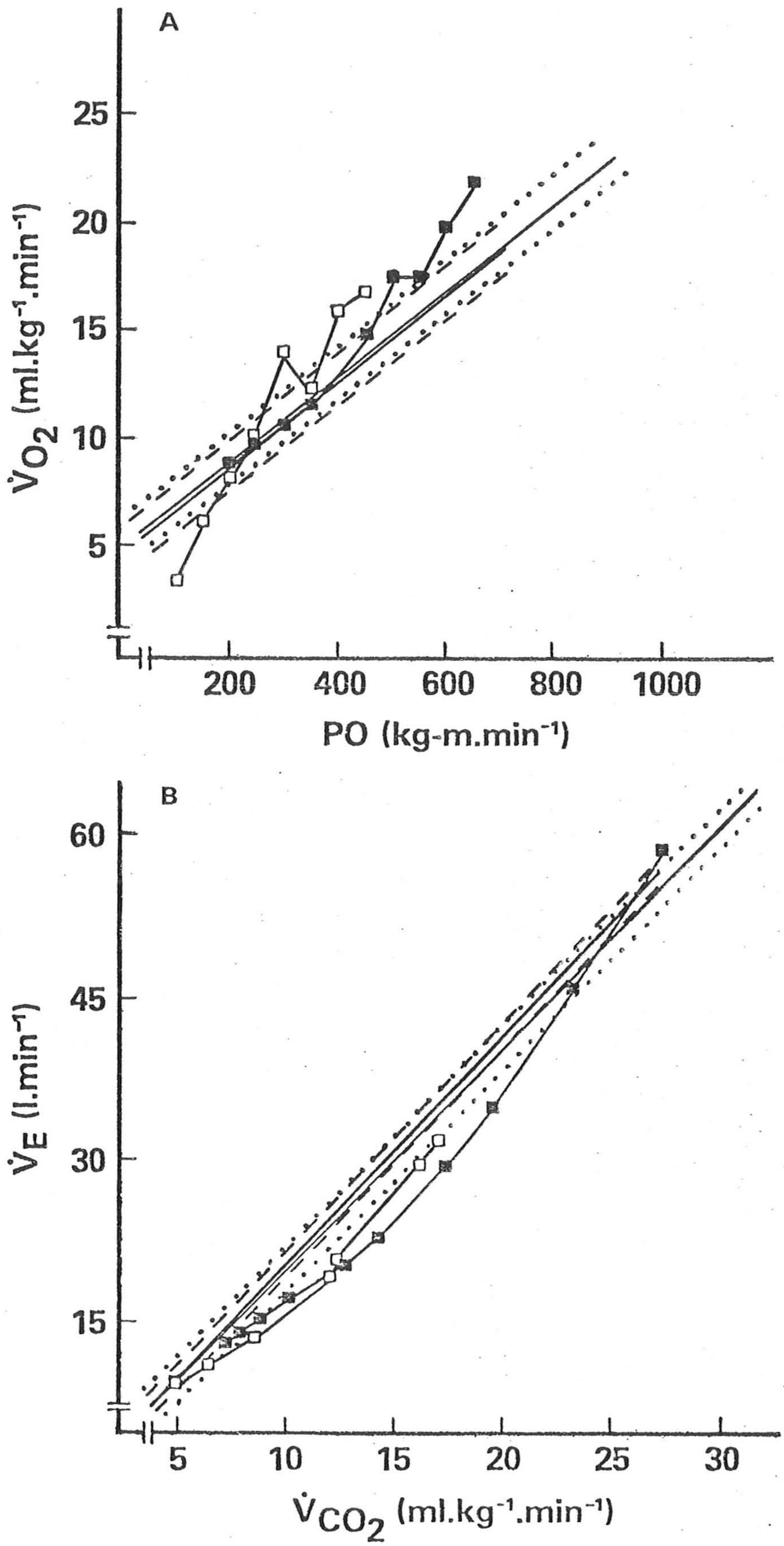
Results. She attended 94% of the possible exercise sessions (Table 5) with no change in weight or resting FEV_1/FVC (Table 4).

Following physical conditioning K.S. demonstrated an increased maximal PO, $\dot{V}_{O_2}$, $\dot{V}_E$, $\dot{V}_{CO_2}$, R, H_{LA}, HR, SBP and RPP (Tables 6 and 11; Figures 4-5). Her maximal RPE was essentially unchanged (Table 6; Figure 6). She stopped the progressive test after physical conditioning because of general fatigue whereas before she stopped because of muscular fatigue and shortness of breath (Table 7). There was no evidence of abnormality in her exercise or post-exercise electrocardiogram during either assessment period.

Oxygen uptake, $\dot{V}_{CO_2}$ and $\dot{V}_E$ in K.S. was not determined at the first two power outputs during the progressive test after physical conditioning because she had problems breathing into the mouthpiece but at subsequent submaximal power outputs $\dot{V}_{O_2}$, $\dot{V}_{CO_2}$, and $\dot{V}_E$ was generally lower than before physical conditioning (Figure 4). At any given submaximal $\dot{V}_{O_2}$ following physical conditioning HR was decreased and SBP was markedly increased; hence, RPP was increased (Figure 5). The relationships between RPE and $\dot{V}_{O_2}$, $\dot{V}_E$, HR and RPP during progressive exercise were lowered following the 12-week program (Figure 6).

During submaximal steady state exercise at the same absolute PO, there was no change in the $\dot{V}_{O_2}$, $\dot{Q}_c$ or $(a-\bar{v})O_2$ difference of this subject following physical conditioning (Tables 10 and 11; Figure 3). However, HR and R was decreased and V_s was increased (Tables 10 and 11).

Discussion. This cardiac female showed a greater improvement in maximal work capacity (44.4%), $\dot{V}_{O_2}$ (32.1%), $\dot{V}_E$ (83.8%) and $\dot{V}_{CO_2}$ (60.8%) than the healthy group following physical conditioning (Table 6). Unlike the healthy group, she also exhibited increases in maximal R (21.6%), H_{LA} (23.0%), HR (10.9%), SBP (28.6%) and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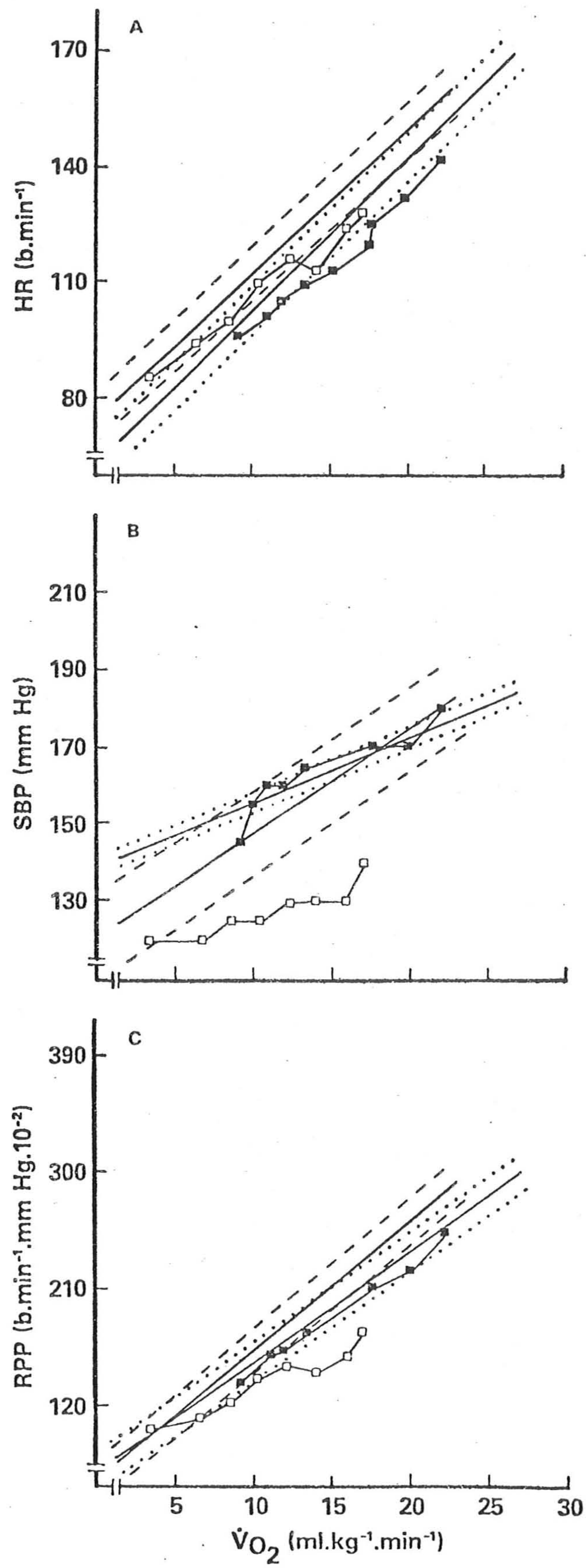
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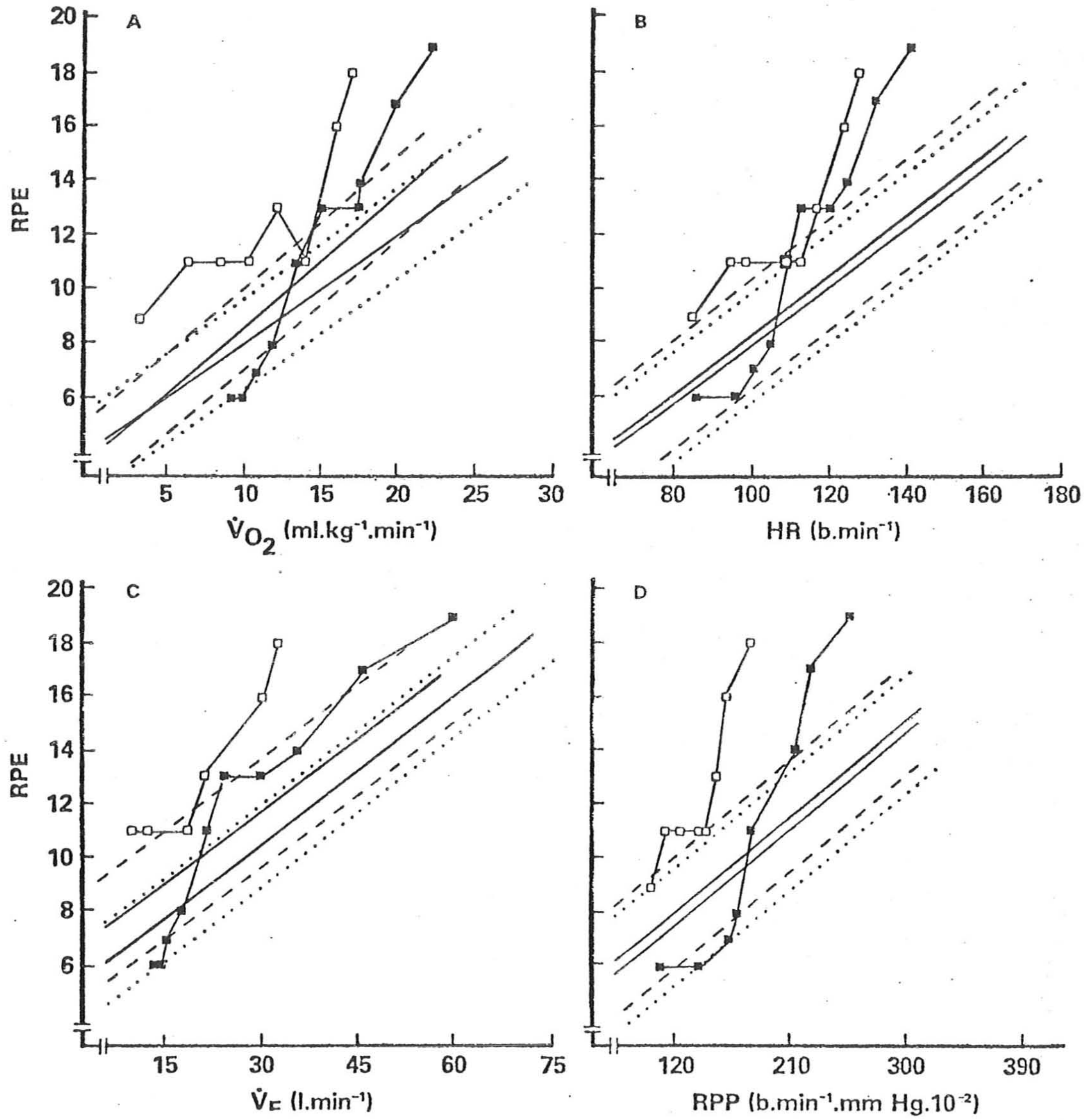

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RPP (b.min^{-1}.mm Hg.10^{-2})

RPP (42.6%). The higher maximal HR, SBP and RPP suggests an augmentation in myocardial work. A 20% increase in both maximal O_2 pulse and maximal MBP suggests that $\dot{Q}_c$ was increased as well. In view of the magnitude of the increases in maximal $\dot{V}_E$, $\dot{V}_{CO_2}$, R and H_{LA} and the change in her subjective reason for stopping exercise with physical conditioning, it appears that, because of leg discomfort caused by cycling, K.S. terminated the pre-conditioning progressive test before her O_2 transport system was fully taxed. Differences between K.S. and the healthy group in the magnitude of changes following physical conditioning were presumably related to the relatively poor initial maximal performance of K.S..

Since K.S. tended to have a lower $\dot{V}_{O_2}$ (by a $\bar{X}$ of 1.6 $ml \cdot kg^{-1} \cdot min^{-1}$; 0.2 $l \cdot min^{-1}$) at submaximal power outputs after physical conditioning than before, reductions in her submaximal $\dot{V}_E$ (by a $\bar{X}$ of 5.4 $l \cdot min^{-1}$), $\dot{V}_{CO_2}$ (by a $\bar{X}$ of 2.4 $ml \cdot kg^{-1} \cdot min^{-1}$; 0.2 $l \cdot min^{-1}$) and HR (by a $\bar{X}$ of 10.6 $b \cdot min^{-1}$) may have reflected an improvement in mechanical efficiency. The decrease in her submaximal RPE (by a $\bar{X}$ of 4 units) indicates that, similarly to the healthy females, she perceived the same absolute work intensity as being less stressful. Whether the lower perceived exertion was a function of reductions in $\dot{V}_{O_2}$, $\dot{V}_{CO_2}$, $\dot{V}_E$

and HR per se, the decreased degree of stress on the cardiorespiratory system or decreased muscular strain due to an improved mechanical efficiency is difficult to ascertain.

The reduction in the HR (12.1%) of K.S. at her steady state PO following physical conditioning was greater than that observed in the healthy group but $\dot{Q}_c$ was unchanged (Table 10). Hence, unlike in the healthy group, V_s was increased (by 15.1%) in K.S. (Table 10). From the available data, it can not be determined whether the increase in V_s was due to intrinsic changes in the myocardium or represented a change secondary to the reduction in HR. As has been observed in healthy, young and middle-aged males (Davis _et al._, 1979; Taylor and Jones, 1979), R was decreased in this cardiac female during steady state exercise following physical conditioning. Davis and colleagues attributed the fall in R to a shift in the major fuel source from carbohydrates to free fatty acids (FFA). Taylor and Jones found no change in the blood FFA levels of their subjects during exercise with physical conditioning. The extent of changes observed in cardiorespiratory responses of their subjects was not as great as the differences between responses of untrained and trained subjects observed in another study (Cobb and Johnson, 1963) where trained subjects had higher blood

FFA levels during exercise than untrained subjects. The 16.7% decrease in the R of K.S. was larger than that reported by Taylor and Jones; thus, it is possible that there was a change in her FFA turnover rate. There have been reports that physical conditioning causes an increase in the number and size of muscle cell mitochondria (Holloszy, 1973), the activity of oxidative enzymes (Varnauskas *et al.*, 1970; Saltin *et al.*, 1976) and the capillary density of muscle tissue (Brodal *et al.*, 1977). Therefore, the decreased R of K.S. may have been related to an improvement in her muscle oxidative capacity. The present investigator does not know of a study which has compared the magnitude of changes in cardiorespiratory responses during exercise following physical conditioning in cardiac patients on beta-blocking drug therapy to those in cardiac patients not on therapy. However, since exercise HR, $\dot{V}_{CO_2}$ and R has been found to be significantly lower in cardiac patients after taking beta-blocking drugs than before (Hassock *et al.*, 1980), reductions in the HR and R of K.S. may possibly have reflected an interactive effect of physical conditioning and beta-receptor blockade.

Cardiac Subject J.P.

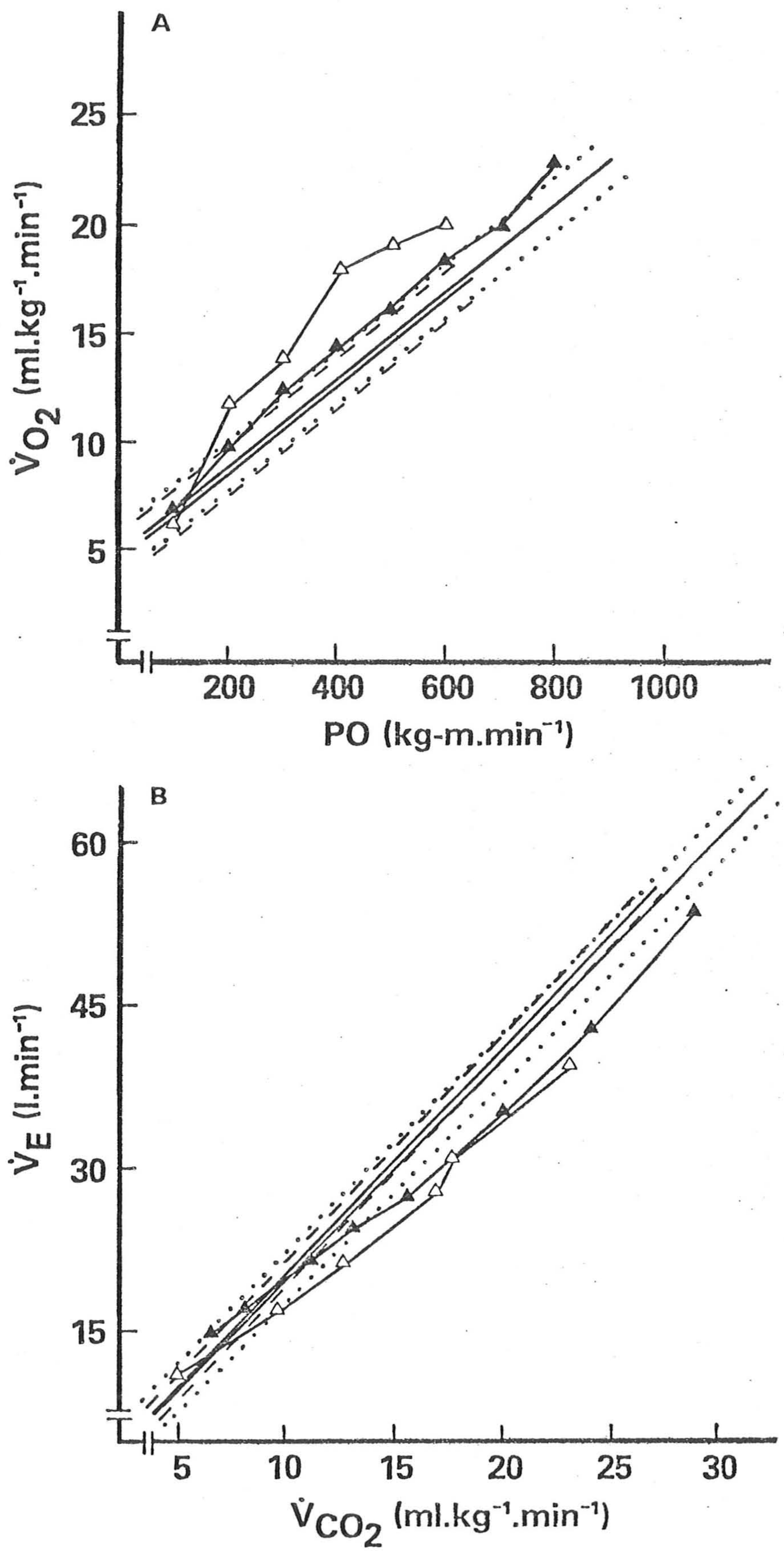
This cardiac subject was 48 years old, weighed

64.0 kg, was 157.0 cm tall and had a normal resting FEV_1/FVC (85%) when she began the study (Table 4). Her medical history showed previous myocardial infarctions in July and August of 1975 with residual AP (Table 2). She took 10 mg of Inderal q.i.d. throughout the course of the study.

Results. She attended the supervised exercise sessions regularly (92% of possible maximum) (Table 5). Her weight and resting FEV_1/FVC increased slightly over the duration of the program (Table 4).

This cardiac subject had an increased maximal PO, $\dot{V}_E$, $\dot{V}_{CO_2}$, R and H_{LA}, a decreased maximal RPE and an unchanged maximal $\dot{V}_{O_2}$, HR, SBP and RPP following physical conditioning (Tables 6 and 11; Figures 7-9). Both before and after physical conditioning she terminated the progressive test because of muscular fatigue (Table 7) and her exercise and post-exercise electrocardiogram was within normal limits.

At given submaximal power outputs following physical conditioning there was a decrease in the $\dot{V}_{O_2}$, but little or no change in the $\dot{V}_E$, $\dot{V}_{CO_2}$, HR, SBP and RPP, of J.P. (Figures 7 and 8). Her RPE was lower at pre-conditioning submaximal levels of $\dot{V}_{O_2}$, $\dot{V}_E$, HR and RPP (Figure 9).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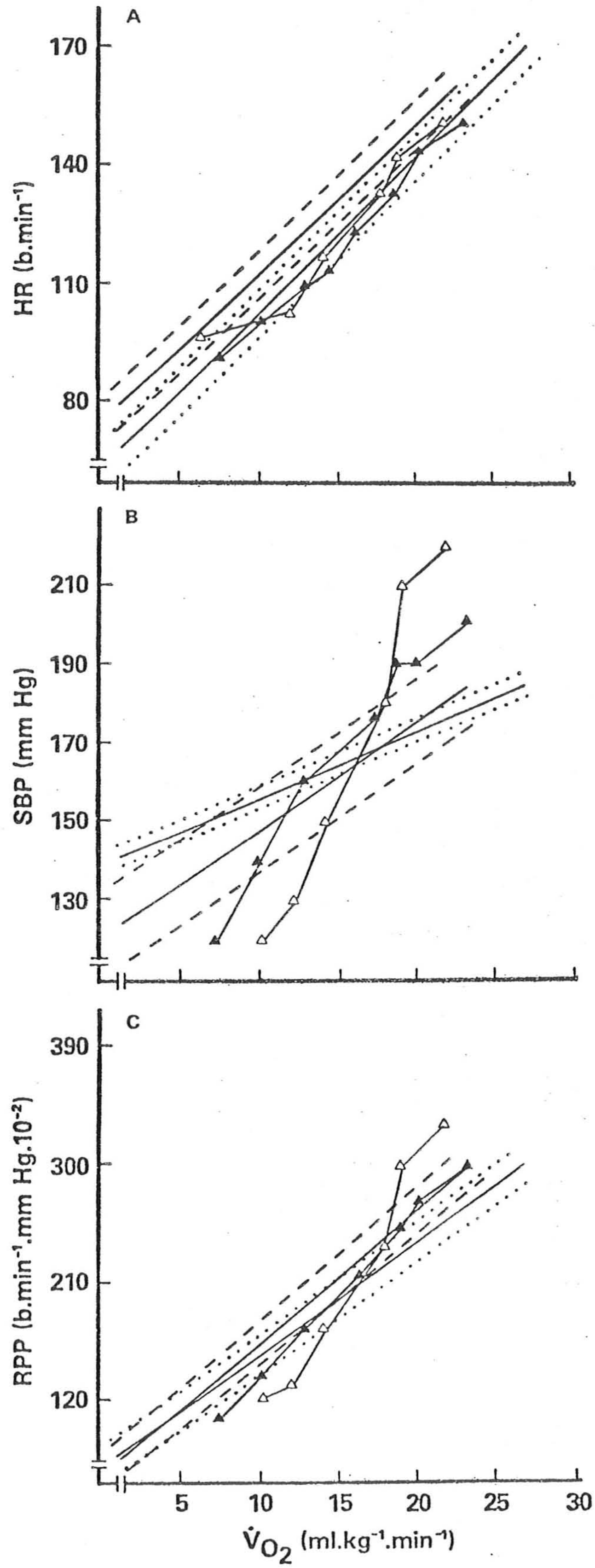

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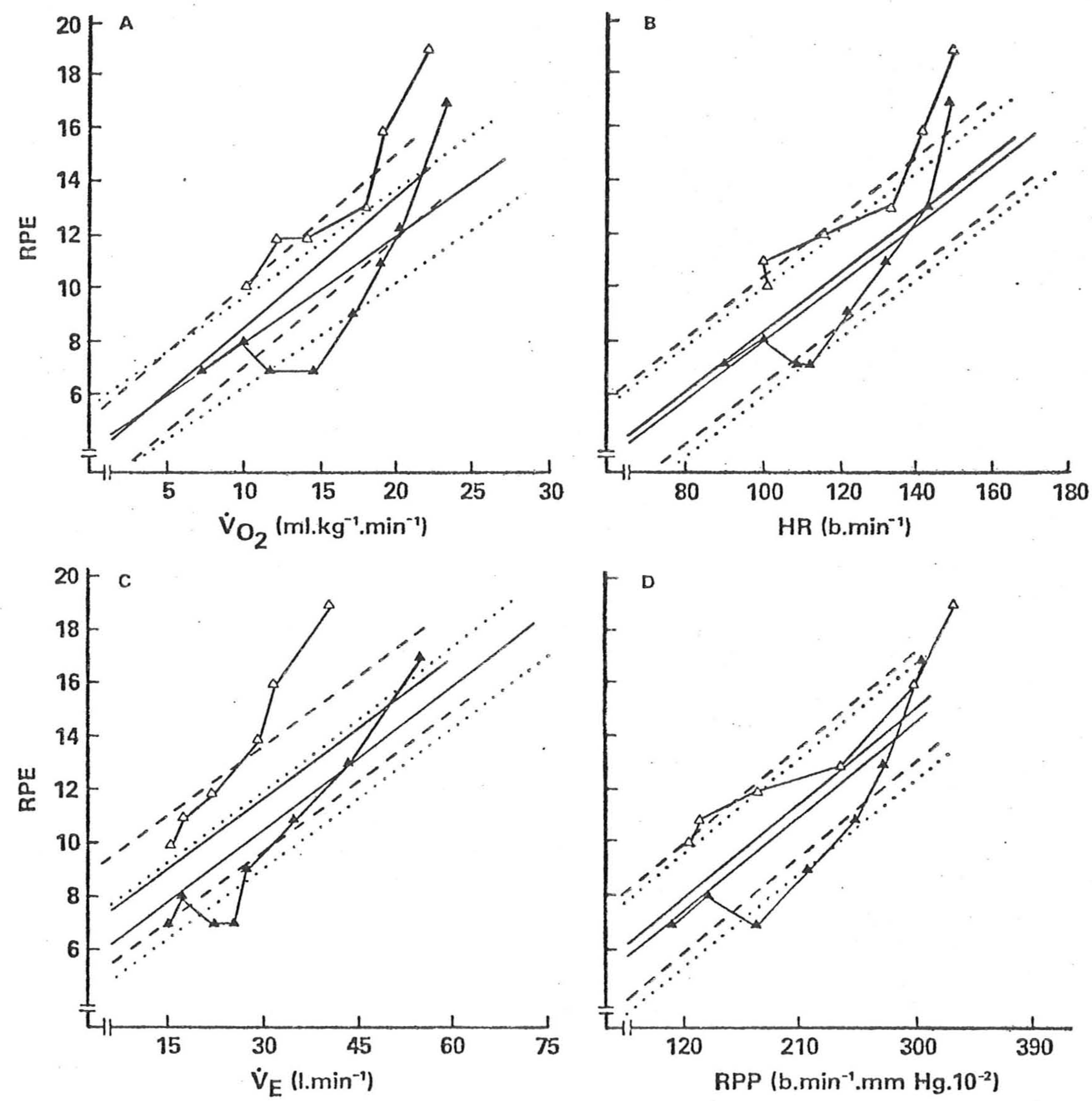

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$\dot{V}_E$ (l.min^{-1})
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RPP (b.min^{-1}.mm Hg.10^{-2})

Changes in the $\dot{V}_{O_2}$, $\dot{Q}_c$, HR, V_s, $(a-\bar{v})O_2$ difference and R of J.P. during submaximal steady state exercise at the same absolute PO following physical conditioning were all within the range of intra-individual variability (Tables 10 and 11; Figure 3).

Discussion. Following physical conditioning this cardiac female exhibited greater gains in maximal PO (33.3%), $\dot{V}_E$ (35.7%) and $\dot{V}_{CO_2}$ (26.0%) than the healthy group with no change in maximal $\dot{V}_{O_2}$, an increase in maximal H_{LA} (10.9%) and a decrease in maximal RPE (10.5%) (Table 6). The increase in maximal $\dot{V}_E$ appeared to be associated with the increase in work intensity and in CO_2 production from anaerobic-glycolytic metabolism. In direct contrast to the healthy females, J.P. showed a decrease in $\dot{V}_{O_2}$ (by an average of 2.3 $ml \cdot kg^{-1} \cdot min^{-1}$; 0.2 $l \cdot min^{-1}$) and no change in HR, SBP, RPP or $\dot{V}_{CO_2}$ at pre-conditioning submaximal power outputs during the progressive test following physical conditioning. It is difficult to ascertain whether or not this reduced submaximal $\dot{V}_{O_2}$ is indicative of an improved mechanical efficiency as it was not accompanied by reductions in other cardiorespiratory variables. However, if J.P. did have a greater cycling efficiency after the 12 weeks of exercise then this, and a decreased feeling of muscular strain, could be offered as an explanation for her improved maximal work performance and lower RPE. Kellerman (1975) reported that several investigators have observed a decrease in anxiety and depression in cardiac patients following participation in an exercise rehabilitation program. Since RPE has been shown to be dependent upon a subject's level of anxiety and state of depression (Morgan, 1973), the reduced exertional perceptions in J.P. also may have been related to a change in her psychological state with physical conditioning.

Physical conditioning had no apparent effect on the cardiorespiratory functioning of J.P. during steady state exercise at a given submaximal PO.

Cardiac Subject A.L.

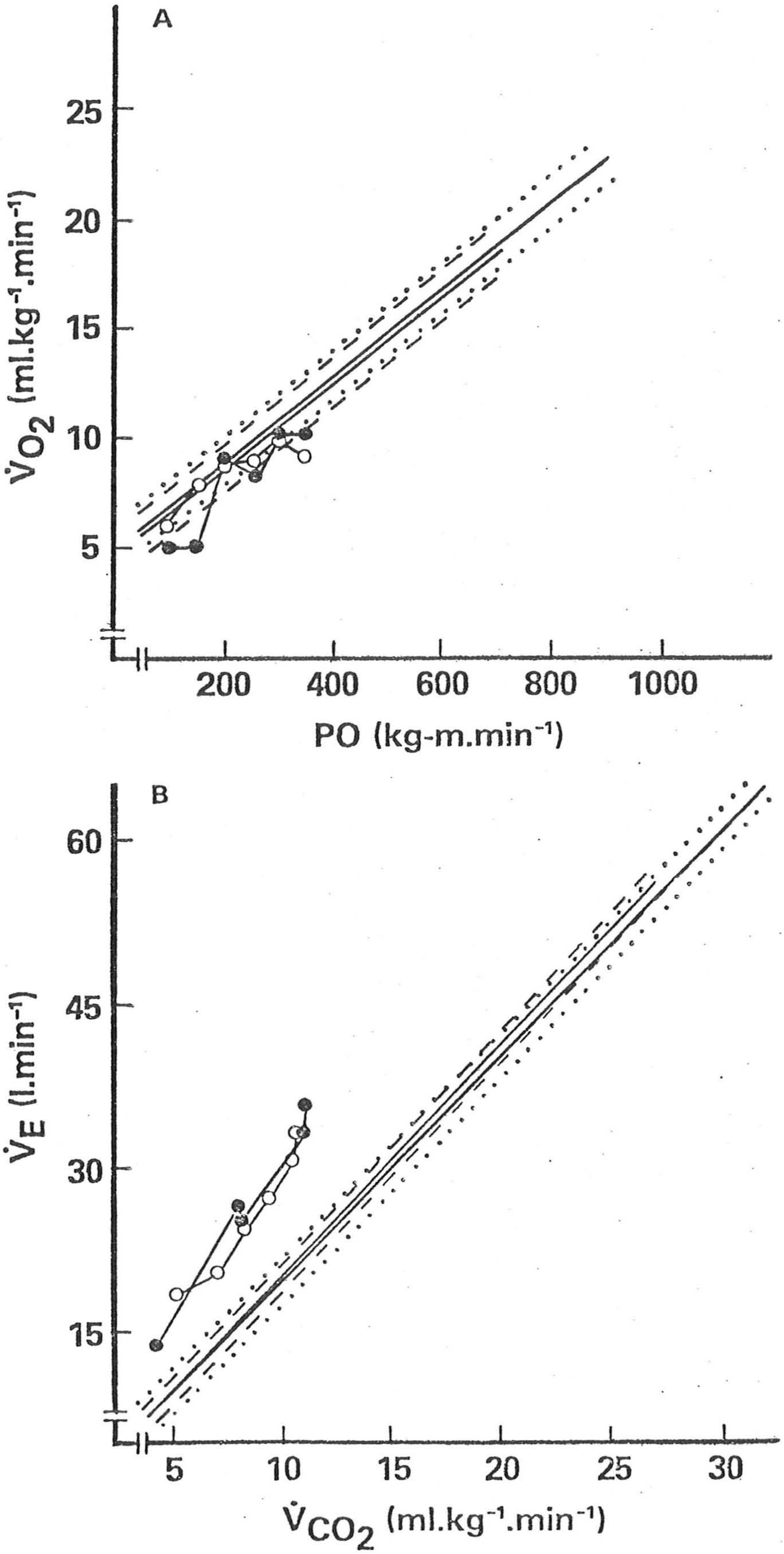
Upon entry into the study, A.L. was older (57 years), heavier (84.5 kg) and shorter (156.1 cm) than the other two cardiac subjects. Her resting FEV_1/FVC (83%) did not differ from that of her counterparts and was essentially normal (Table 4). As well as having had suffered two myocardial infarctions previously, she had had atrial fibrillation for 9 years (Table 2).

Results. This cardiac subject attended 97% of the possible exercise sessions with no change in weight or resting FEV_1/FVC (Table 4).

Following physical conditioning A.L. showed no change in maximal PO, $\dot{V}_{CO_2}$, HR, R and RPE, an increase in maximal $\dot{V}_{O_2}$, $\dot{V}_E$, SBP and RPP and a decrease in maximal H_{LA} (Tables 6 and 11; Figures 10-12). Her subjective reason for stopping the progressive test after physical conditioning was shortness of breath while before it was muscular fatigue (Table 7). She did not exhibit ST-segment changes in her exercise or post-exercise ECG responses either before or after physical conditioning.

There was no consistent change in the $\dot{V}_{O_2}$, $\dot{V}_E$ and $\dot{V}_{CO_2}$ of A.L. at submaximal power outputs during the progressive test with physical conditioning (Figure 10). Although her submaximal HR response was erratic before and after physical conditioning, her post-conditioning submaximal SBP and RPP was generally higher than her pre-conditioning response (Figure 11). The relationships of submaximal RPE to $\dot{V}_{O_2}$, $\dot{V}_E$, HR and RPP in A.L. tended to be decreased following physical conditioning (Figure 12).

This cardiac subject demonstrated a substantial decrease in $\dot{V}_{O_2}$, $\dot{Q}_c$, V_s and R, but no change in HR or $(a-\bar{v})O_2$ difference, during submaximal exercise at her steady state PO following physical conditioning (Tables 10 and 11; Figure 3).



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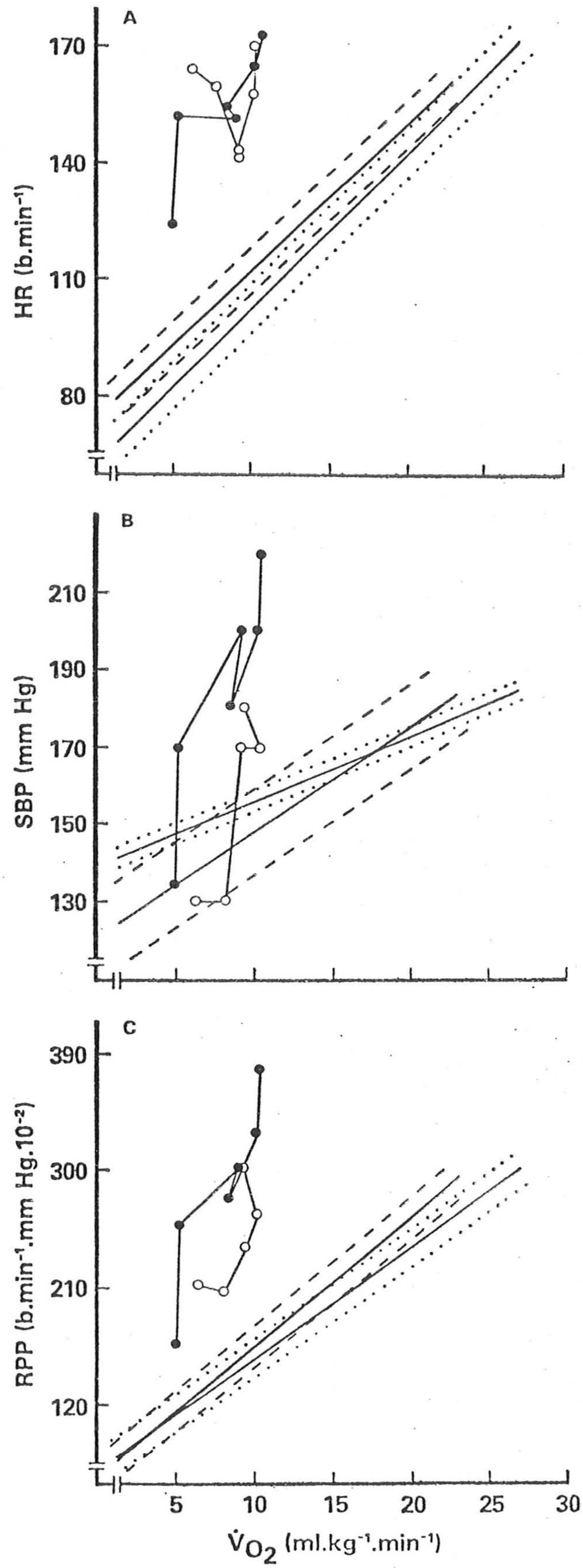
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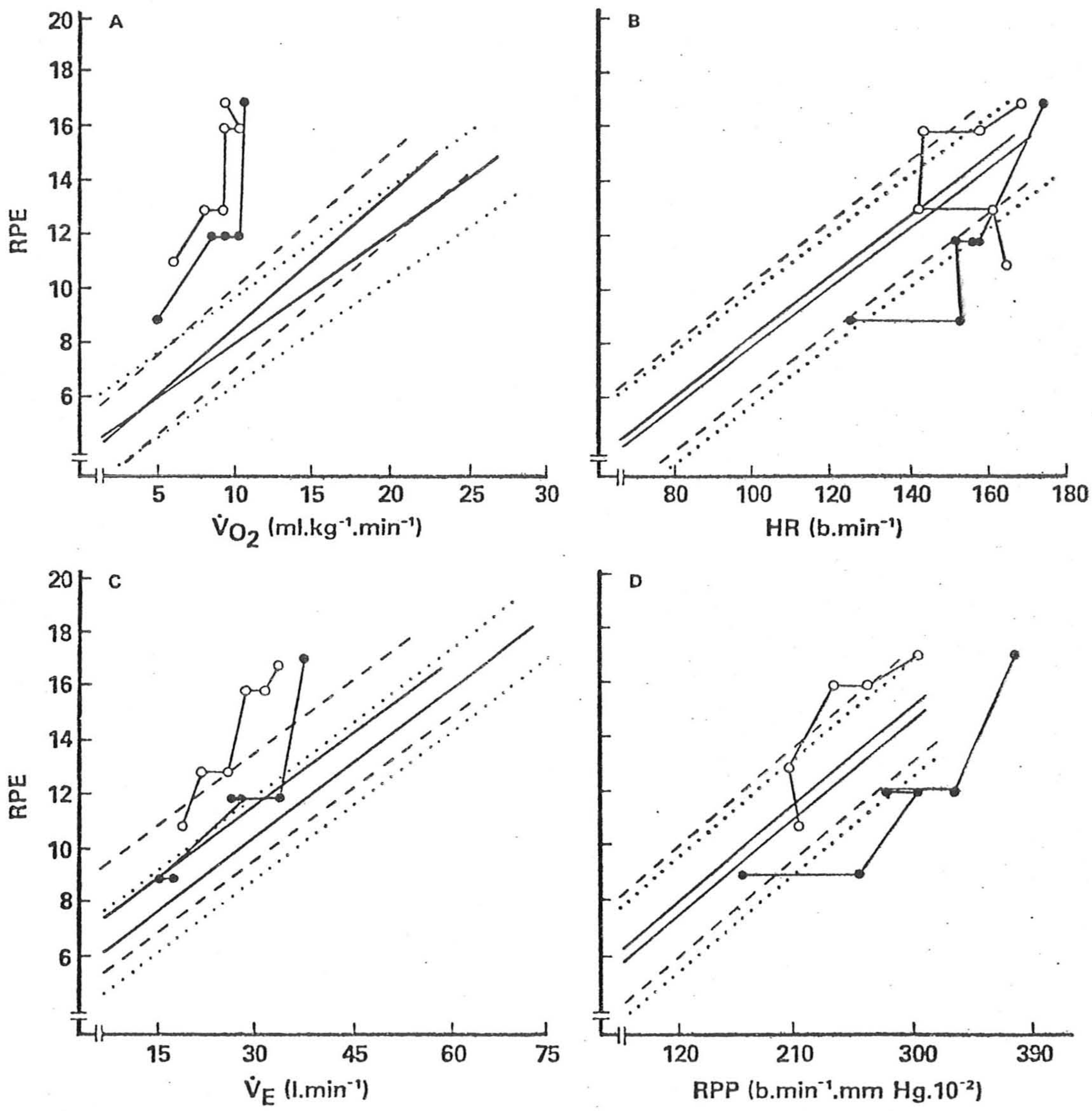
A
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RPE
$\dot{V}O_2$ (ml.kg⁻¹.min⁻¹)
HR (b.min⁻¹)
$\dot{V}_E$ (l.min⁻¹)
RPP (b.min⁻¹.mm Hg.10⁻²)

Discussion. Despite her lower initial values, increases in the maximal $\dot{V}_{O_2}$ (9.5%) and $\dot{V}_E$ (14.1%) of A.L. following physical conditioning were not as great as those observed in the healthy females (Table 6). This cardiac female also differed from the healthy females in that her maximal work capacity and $\dot{V}_{CO_2}$ did not change, her maximal SBP and RPP increased (by 22.2% and 25.8%, respectively) and her maximal H_{LA} decreased (by 24.2%) over the duration of the physical conditioning program (Table 6).

Since SBP and RPP was higher in A.L. at each PO following physical conditioning (by a $\bar{X}$ of 25.0 mmHg and 55.3 $b \cdot min^{-1} \cdot mmHg \cdot 10^{-2}$), it would appear that the pressure-work of the heart was greater throughout the progressive test. There was no indication of an increase in maximal V_s when pre-conditioning and post-conditioning values for maximal O_2 pulse were compared. Maximal MBP was increased, however, by 27.8%. This observation of a greater mean pressure following physical conditioning may imply that there was an increase in $\dot{Q}_c$ and, subsequently, an increase in muscle blood flow. Both an augmented O_2 delivery to the exercising muscles and a more complete extraction of O_2 from blood perfusing the exercising muscles could explain why A.L. had a reduced H_{LA} and was no longer limited by muscular fatigue following physical conditioning. Within the limits of this study, it is impossible to determine if the improvement in the functional capacity of A.L. was related to an increase in muscle blood flow, $(a-\bar{v})O_2$ difference, V_s or some other factor such as an enhanced capacity for oxidative phosphorylation in the exercising muscles.

Similarly to the healthy females this cardiac female demonstrated no change in maximal RPE and a reduction in RPE at submaximal power outputs (by a $\bar{X}$ of 3 units) during the progressive test following physical conditioning. The reduction in submaximal RPE was accompanied by increases in submaximal SBP and RPP. These observations suggest that A.L. perceived herself as being better able to tolerate the same submaximal work intensities following physical conditioning irrespective of the work of the heart. She commented that she could climb a flight of stairs without having to stop and rest following participation in the program. Hence, there was presumably a carry-over effect of physical conditioning on her exertional perceptions of daily living activities. Since A.L. appeared to have a lower H_{LA} during exercise at submaximal power outputs following physical conditioning and RPE has been reported to be highly correlated with H_{LA} (Ekblom and Goldbarg, 1971; Gamberale, 1972), possibly her submaximal RPE was influenced by the same factors responsible for the decrease in her submaximal H_{LA}.

This cardiac female showed larger reductions in $\dot{V}_{O_2}$ and $\dot{Q}_c$ and a smaller reduction in HR during submaximal exercise at her steady state PO (150 kg-m$\cdot$min^{-1}) following physical conditioning than the healthy females showed at their steady state PO (Table 10). Unlike her healthy counterparts, A.L. also demonstrated decreases in V_s and R. The reductions in $\dot{Q}_c$ and R corresponded to the reduction in $\dot{V}_{O_2}$; thus, changes in the cardiorespiratory functioning of A.L. during submaximal steady state exercise following physical conditioning may have reflected an improvement in mechanical efficiency. A plausible explanation for this improvement in mechanical efficiency is that A.L. learned to eliminate unnecessary movements and to apply only the necessary amount of power at her steady state PO through training at the same PO.

General Discussion

Cardiac females K.S. and A.L. differed from the healthy females in their cardiorespiratory adjustments to progressive exercise before physical conditioning and had a markedly impaired functional capacity. Following physical conditioning K.S. demonstrated a more "normal" response to progressive exercise and a substantial improvement in functional parameters. On the other hand, A.L. still differed greatly from the healthy females in her adjustments to progressive exercise following physical conditioning and showed a small change in functional capacity. Cardiac female J.P. was indistinguishable from the healthy females in her cardio-respiratory responses to exercise prior to physical conditioning. However, unlike the healthy females, she exhibited little change in her exercise performance with physical conditioning. The physical conditioning program employed in the present study evidently served as a mode of physiological rehabilitation, on the parameters measured, for only one cardiac female. Further study, using different applications of the principles of exercise prescription, is necessary in order to clarify whether the design of the program was inappropriate to produce physiological changes or whether physical conditioning per se is ineffective in improving the cardio-respiratory fitness of females with CHD.

All 3 of the cardiac females perceived that their exercise tolerance was greater after the 12 weeks of physical conditioning than before. Thus, it appears that the program afforded psychophysical changes in the female patients which would help them to "...lead an active, productive life" (World Health Organization Technical Report Series 270, 1964).

CHAPTER VII

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

The purpose of this investigation was to compare the effects of a 12-week physical conditioning program on selected cardiorespiratory responses and the perception of exertion during exercise in females with CHD and healthy, middle-aged females. The design of the program was analagous to that recommended for healthy, middle-aged adults; intermittent cycle ergometer exercise at 65-75% of maximal $\dot{V}_{O_2}$ for 30-45 minutes 3 times per week.

Both before and after the 12 weeks of physical conditioning progressive multistage and steady state cycle ergometer exercise tests were conducted. Measures of RPE and the following cardiorespiratory variables were obtained: $\dot{V}_{O_2}$, $\dot{V}_E$, $\dot{V}_{CO_2}$, R, HR, SBP, RPP, $\dot{Q}_c$, V_s and $(a-\bar{v})O_2$ difference.

Several problems were encountered in the subject selection process. Six out of 26 eligible cardiac subjects, aged 40 to 57 years, and 9 out of 21 eligible healthy subjects, aged 44 to 52 years, started the study.

A modified t test was used to determine pre-conditioning differences between the two groups in measures of physical characteristics, cardiorespiratory variables and RPE. The cardiac females had a significantly lower maximal PO, $\dot{V}_{O_2}$ and $\dot{V}_{CO_2}$ than the healthy females. Initial values for other variables were similar in the two groups. Correlation coefficients for the relationship of RPE to $\dot{V}_{O_2}$, $\dot{V}_E$, HR and RPP in both groups during progressive exercise before physical conditioning were significantly different from zero as determined from a table of critical values for r.

All 9 of the healthy females complied with the physical conditioning program but 3 of the 6 cardiac females dropped out. A matched pairs t test was used to ascertain differences between pre-conditioning and post-conditioning measures for the healthy group. The analyses showed that, following physical conditioning, the healthy females had: (a) a significantly increased maximal $\dot{V}_{O_2}$, $\dot{V}_E$ and $\dot{V}_{CO_2}$; (b) a significantly decreased $\dot{V}_{CO_2}$, HR, SBP, RPP and RPE at a given submaximal PO during the progressive test; and (c) a significantly decreased $\dot{V}_{O_2}$, $\dot{Q}_c$ and HR at the same submaximal steady state PO. Ratings of perceived exertion were significantly correlated to $\dot{V}_{O_2}$, $\dot{V}_E$, HR and RPP in the healthy group during progressive exercise after physical conditioning. Post-conditioning correlation coefficients for the relationship of RPE to $\dot{V}_{O_2}$ and $\dot{V}_E$ were higher than respective pre-conditioning correlation coefficients. Pre-conditioning and post-conditioning correlation coefficients for the relationships of RPE to HR and RPP were similar. Due to the high drop-out rate in the cardiac group, a between-groups comparison of changes following physical conditioning was not made. The 3 cardiac females who completed the program were treated as case studies. Descriptive statistics showed that the 3 cardiac females had a lower RPE at a given submaximal PO during the progressive test following the 12-week program but were heterogeneous in their cardiorespiratory response to physical conditioning.

Conclusions

The following conclusions are within the scope of the study.

1. Twelve weeks of prescribed physical conditioning improved cardiorespiratory functioning, and lowered perceived exertion, in healthy, middle-aged females during exercise.

2. A 12-week program of physical conditioning, with an intensity, duration and frequency of exercise similar to that recommended for healthy, middle-aged adults, did not improve

cardiorespiratory functioning during exercise in all of the cardiac females. However, it reduced perceived exertion during exercise in all of the cardiac females.

3. While both females with CHD and healthy, middle-aged females demonstrated an increased functional capacity following 12 weeks of prescribed physical conditioning, changes in cardiorespiratory responses during exercise associated with the increased functional capacity were not always similar in the two groups.

Recommendations for Future Investigations

On the basis of problems encountered in, and the results of, the present investigation, it is recommended that future investigations of this type:

1. have a larger sample size;

2. include steady state exercise tests at several power outputs;

3. include measurement of physiological variables which may help to identify if the limitations to exercise and adaptations to physical

conditioning are central or peripheral in nature; and

4. look at the effects of a longer period of physical conditioning, with a lower initial intensity of exercise, on physiological responses and the perception of exertion during exercise.

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APPENDIX A

MEDICAL REFERRAL FORM

MEDICAL REFERRAL FORM FOR PARTICIPATION IN EXERCISE TESTS AND A PHYSICAL TRAINING PROGRAM

Patient's Name ______________________________ Date ____________________
Last First Initial

Address __________________________ Age __________ Phone No. ____________

I consider the above individual as:
________ Healthy
________ Cardiac Patient
________ Prone to Coronary Heart Disease
________ Other (Explain) ____________

DIAGNOSTIC DATA ETIOLOGIC	PRESENT PHYSICAL ACTIVITY LEVEL	ECG	RHYTHM
_____ No heart disease	_____ Very active	_____ Normal	_____ Sinus
_____ Rheumatic heart disease			
_____ Congenital heart disease	_____ Average	_____ Infarct	_____ Atrial Fib.
_____ Congestive heart failure			
_____ Hypertension	_____ Limited	_____ Abnormal	_____ Other
_____ Angina Pectoris			
_____ Ventricular aneurysm	_____ Very Limited		
_____ Other			

RESULTS OF ANGIOGRAPHY ____

SPECIFIC CARDIAC DIAGNOSIS ____

ADDITIONAL ABNORMALITIES ____

PRESENT MEDICATION __________________________ DOSAGE ________________

Please fill in the information below if it is available:

1. ECG, 12 lead (enclose copy) ______________________________
2. Blood pressure systolic __________mmHg diastolic __________mmHg
3. Glucose __________mg.%
4. Cholesterol __________mg.% Lipoprotein Electrophoresis __________

   Triclyceride __________mg.%
5. Graded Exercise Test Results (if available, enclose)
6. Does your patient smoke as well? __________

The above listed person is capable of performing graded exercise tests and participating in a supervised physical training program of moderate intensity.

YES ☐ NO ☐

Signed ______________________________ M.D.

Address ______________________________

Phone No. __________

APPENDIX B

INFORMED CONSENT FORM

INFORMED CONSENT FOR RESEARCH INVOLVING EXERCISE TESTS AND A PHYSICAL CONDITIONING PROGRAM

Purpose of Research

To determine the effects of a 12-week physical conditioning program on specific exercise responses of females with Coronary Heart Disease and on healthy middle-aged females.

Explanation of the Exercise Tests

Initially you will perform a maximal and a submaximal exercise test on a cycle ergometer. The first test will begin at a level that you can easily accomplish and after each minute this level will be increased by a small amount. We may stop the test when you feel fatigued, breathless or have chest pain. We do not want you to exercise at a level which is abnormally uncomfortable for you so we will be asking you to rate your degree of exertion at each work load according to a scale. A sample of blood will be taken from your earlobe 3 minutes after the test is over.

The second test will begin approximately 30 minutes after the first. It will involve exercising at a work load which is 40-70% of your previously determined maximum for 5-8 minutes. After completion of the fifth minute you will breathe a concentration of carbon dioxide from a special rebreathing bag for 10-15 seconds.

Both tests will be repeated after the physical conditioning program and all results will be kept confidential.

Risks and Discomforts

Certain events may occur during the tests such as abnormal blood pressure responses, fainting and disorders of heart beat. Very rarely do heart attacks occur (less than 1% of middle-aged persons being tested). Every effort to minimize these occurrences will be made by preliminary examination and constant monitoring of the heart rate and blood pressure responses during the tests. Emergency equipment, a physician and other trained personnel will be available to deal with unusual situations which may arise.

Reasons for the Tests

Based on your cardiorespiratory responses to the initial multistage maximal test you will be prescribed a work load on the cycle ergometer and a target heart rate which will correspond to 65-75% of your functional capacity. These will serve as guidelines for the intensity at which you will work during the physical conditioning sessions. The repetition of this test following the program will be to evaluate your progress.

The submaximal test will provide us with a clearer picture of your adaptation to exercise at a level corresponding to your daily activities.

Explanation of the Physical Conditioning Program

Exercise sessions will be held 3 times per week and will include 5-10 minutes of warm-up activities, 25-35 minutes of cycling and 15-20 minutes of cool-down activities and/or games. Each session will not last longer than 1 hour.

The cycling work will be intermittent in nature. You will pedal for a length of time and then rest for a length of time. The number of times which you will repeat the work bouts will range from 5-8. You will be taught how to monitor your own heart rate and be given a range in which it should remain while exercising. Periodically the exercise leader will check your accuracy at determining your heart rate.

Risks and Discomforts

The same risks exist as for the exercise test only to a lesser degree. The continuous checking of the heart rate responses will be in an effort to minimize these. Emergency equipment and qualified personnel will be available at all sessions to deal with unusual situations which may arise.

Muscle fatigue and soreness may result for the first few sessions but you should be capable of completing a session with a minimal amount of discomfort by the end of the second week.

Benefits to be Expected

No assurance can be given that the physical conditioning program will increase your functional capacity although widespread experience indicates that this improvement is usually achieved. We do expect changes in your adaptation to exercise which is at a similar intensity to your daily life activities.

An explanation of what these changes mean may help you to evaluate your capabilities and limitations with respect to recreational activities.

Inquiries

If there are any questions or doubts about the procedures used in the exercise tests or the physical conditioning program, please ask for further explanations.

Freedom of Consent

You are free to volunteer to participate in this study and may withdraw at any time without penalty.

I have read this form carefully and I understand the purpose of the study, the testing procedures and the physical conditioning program.

I am aware of the risks involved from participating in the exercise tests and the physical conditioning program, as well as the benefits to be gained, and that I will not be compensated financially for my time and trouble.

I consent to participate in this research study with the understanding that I am free to withdraw from it at any time if I should desire.

________________ (Date)

____________________________ (Signature)

____________________________ (Witness)

APPENDIX C

RPE-SCALE

BORG'S RPE-SCALE FOR RATINGS OF PERCEIVED EXERTION

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

APPENDIX D

RAW DATA

VARIABLES AND UNITS OF MEASUREMENT

HR	$b \cdot min^{-1}$
SBP	mmHg
DBP	mmHg
FEV_1	litres
FVC	litres
Wt	kg
PO	$kg\text{-}m \cdot min^{-1}$
RPP	$b \cdot min^{-1} \cdot mmHg \cdot 10^{-2}$
$\dot{V}_E$	$1 \cdot min^{-1}$
$\dot{V}_{O_2}$	$ml \cdot kg^{-1} \cdot min^{-1}$
$\dot{V}_{CO_2}$	$ml \cdot kg^{-1} \cdot min^{-1}$
R	--
RPE	--
H_{LA}	$mM \cdot 1^{-1}$
V_s	$ml \cdot kg^{-1}$
$\dot{Q}_c$	$ml \cdot kg^{-1} \cdot min^{-1}$
$(a\text{-}\bar{v})O_2$ difference	$ml \cdot 100\ ml^{-1}$

PRE-CONDITIONING PROGRESSIVE TEST: HEALTHY SUBJECTS

SUBJECT: B.R. BTPS - 1.075 STPD - 0.874

Resting

HR	77	FEV_1	3.08
SBP	115	FVC	3.52
DBP	80	Wt	67.8

PO	100	200	300	400	500	600	700
HR	102	113	119	130	135	147	156
SBP	120	135	130	145	160	150	160
DBP	80	90	90	85	90	85	90
RPP	122.4	152.6	154.7	188.5	216.0	220.5	249.6
$\dot{V}_E$	12.8	16.3	18.8	23.8	32.9	42.1	48.8
$\dot{V}_{O_2}$	6.3	9.5	11.3	13.7	16.4	19.1	19.5
$\dot{V}_{CO_2}$	5.1	7.6	9.5	12.7	17.8	22.7	25.2
R	0.81	0.80	0.84	0.93	1.09	1.19	1.29
RPE	7	8	9	10	12	15	17

Maximal H_{LA} - 6.4

SUBJECT: E.E. BTPS - 1.075 STPD - 0.867

Resting

HR 68
SBP 110
DBP 70

FEV_1 2.44
FVC 2.64
Wt 62.0

PO	100	150	200	250	300	350	400
HR	90	93	101	106	112	121	129
SBP	120	130	135	150	150	155	160
DBP	80	80	80	80	80	90	90
RPP	108.0	120.9	136.4	159.0	168.0	187.6	206.4
$\dot{V}_E$	11.5	15.1	17.0	18.9	24.3	25.2	29.1
$\dot{V}O_2$	5.6	8.4	9.6	11.2	14.5	14.0	16.2
$\dot{V}CO_2$	4.9	7.3	8.4	9.8	12.7	13.5	15.5
R	0.81	0.87	0.88	0.88	0.88	0.96	0.96
RPE	7	9	12	13	14	14	15

PO	450	500	550	600
HR	136	144	150	165
SBP	160	180	180	190
DBP	90	90	90	90
RPP	217.6	259.2	270.0	313.5
$\dot{V}_E$	29.1	33.7	36.0	33.9
$\dot{V}O_2$	16.7	17.8	18.9	20.5
$\dot{V}CO_2$	15.5	18.4	20.1	20.3
R	0.93	1.03	1.06	0.99
RPE	15	15	17	19

No maximal H_{LA}

SUBJECT: H.K. BTPS - 1.075 STPD - 0.874

Resting

HR 81
SBP 170
DBP 95

FEV_1 2.56
FVC 3.30
Wt 57.0

PO	100	200	300	400	500
HR	96	106	122	135	149
SBP	175	175	185	200	220
DBP	95	95	95	95	90
RPP	168.0	185.5	225.7	270.0	327.8
$\dot{V}_E$	15.6	20.5	26.1	32.0	46.3
$\dot{V}_{O_2}$	5.8	9.9	13.1	13.9	20.4
$\dot{V}_{CO_2}$	5.6	8.4	11.8	15.4	21.8
R	0.97	0.85	0.90	1.11	1.07
RPE	7	7	9	14	14

Maximal H_{LA} - 5.7

SUBJECT: E.T. BTPS - 1.080 STPD - 0.876

Resting

HR	104	FEV_1	2.85
SBP	110	FVC	3.80
DBP	70	Wt	66.6

PO	100	200	300	400	500	600	700
HR	108	106	110	129	146	156	167
SBP	130	145	150	150	160	160	-
DBP	80	80	85	85	80	80	-
RPP	140.4	153.7	165.0	193.5	233.6	249.6	-
$\dot{V}_E$	16.5	16.1	20.2	28.0	40.3	49.8	63.2
$\dot{V}_{O_2}$	6.2	8.1	11.6	15.2	17.8	20.7	24.0
$\dot{V}_{CO_2}$	6.3	6.9	9.6	13.7	19.1	23.1	28.5
R	1.02	0.85	0.83	0.90	1.07	1.12	1.19
RPE	7	7	9	9	11	13	17

PO	800
HR	171
SBP	180
DBP	85
RPP	307.8
$\dot{V}_E$	75.7
$\dot{V}_{O_2}$	26.6
$\dot{V}_{CO_2}$	33.2
R	1.25
RPE	19

Maximal H_{LA} - 8.6

SUBJECT: P.H. BTPS - 1.075 STPD - 0.867

Resting

HR 90
SBP 115
DBP 80

FEV_1 2.25
FVC 2.66
Wt 60.0

PO	100	150	200	250	300	350	400
HR	102	-	109	108	118	125	128
SBP	140	-	140	150	150	155	170
DBP	80	-	80	80	80	80	85
RPP	142.8	-	152.6	162.0	177.0	193.8	217.6
$\dot{V}_E$	12.3	-	16.7	15.0	16.9	24.2	27.4
$\dot{V}_{O_2}$	7.1	-	12.0	12.3	14.0	16.1	18.8
$\dot{V}_{CO_2}$	6.0	-	9.2	8.9	10.7	14.3	16.6
R	0.85	-	0.77	0.72	0.76	0.89	0.88
RPE	6	-	6	7	8	10	12

PO	450	500	550	600	650
HR	-	147	158	164	174
SBP	-	160	185	190	200
DBP	-	90	80	85	90
RPP	-	235.2	292.3	311.6	348.0
$\dot{V}_E$	28.7	30.7	35.7	40.2	46.6
$\dot{V}_{O_2}$	18.8	29.7	22.1	24.6	27.9
$\dot{V}_{CO_2}$	18.2	19.0	21.7	24.3	27.3
R	0.97	0.96	0.98	0.99	0.98
RPE	13	15	17	17	18

No Maximal H_{LA}

SUBJECT: P.B. BTPS - 1.085 STPD - 0.879

Resting

HR 76
SBP 125
DBP 80

FEV_1 3.07
FVC 3.40
Wt 58.0

PO	100	200	300	400	500	600
HR	96	111	132	160	174	190
SBP	145	155	150	160	170	170
DBP	90	90	90	90	100	100
RPP	139.2	172.1	198.0	256.0	295.8	323.0
$\dot{V}_E$	12.1	16.3	20.8	28.5	36.6	61.1
$\dot{V}O_2$	6.3	9.7	11.3	14.8	16.1	21.2
$\dot{V}CO_2$	4.8	7.8	10.7	15.2	18.1	27.2
R	0.76	0.80	0.95	1.03	1.12	1.28
RPE	7	7	9	9	11	13

Maximal H_{LA} - 7.3

SUBJECT: D.C. BTPS - 1.091 STPD - 0.886

Resting

HR	56		FEV_1	2.96
SBP	115		FVC	3.48
DBP	80		Wt	77.0

PO	100	200	300	400	500	600
HR	83	98	120	132	133	155
SBP	135	135	160	200	-	180
DBP	80	80	90	100	-	90
RPP	112.1	132.3	192.0	264.0	-	279.0
$\dot{V}_E$	14.4	14.2	25.0	30.4	44.3	56.8
$\dot{V}_{O_2}$	5.5	7.6	14.1	16.0	20.6	24.1
$\dot{V}_{CO_2}$	4.6	6.1	11.6	14.2	21.0	24.6
R	0.84	0.80	0.82	0.89	1.02	1.02
RPE	11	12	13	16	18	19

Maximal H_{LA} - 11.6

SUBJECT: R.H. BTPS - 1.091 STPD - 0.886

Resting

HR	104	FEV_1	2.83
SBP	110	FVC	3.13
DBP	70	Wt	74.0

PO	100	200	300	400	500	600	700
HR	109	122	130	143	155	155	167
SBP	140	150	155	160	180	190	190
DBP	80	80	80	80	80	80	80
RPP	152.6	183.0	201.5	228.8	279.0	294.5	317.3
$\dot{V}_E$	18.3	22.9	21.1	29.8	31.1	42.8	45.6
$\dot{V}_{O_2}$	7.9	10.9	12.0	15.2	15.4	21.0	20.3
$\dot{V}_{CO_2}$	7.8	9.9	9.5	13.4	14.3	20.3	22.0
R	0.99	0.91	0.79	0.88	0.93	0.97	1.08
RPE	7	7	9	11	13	14	14

PO	800	900	1000
HR	176	186	192
SBP	-	205	205
DBP	-	80	80
RPP	-	381.3	393.6
$\dot{V}_E$	57.0	79.8	91.6
$\dot{V}_{O_2}$	23.1	27.7	26.5
$\dot{V}_{CO_2}$	27.6	35.0	36.2
R	1.19	1.26	1.37
RPE	16	17	19

Maximal H_{LA} - 9.0

SUBJECT: A.O. BTPS - 1.080 STPD - 0.876

Resting

HR	85	FEV_1	2.65
SBP	110	FVC	3.44
DBP	90	Wt	78.0

PO	100	200	300	400	500	600	700
HR	124	-	111	113	119	124	134
SBP	120	140	145	145	145	160	160
DBP	80	90	85	85	85	90	90
RPP	148.8	-	161	163.9	172.6	198.4	214.4
$\dot{V}_E$	12.7	22.1	20.4	22.5	31.5	37.0	39.0
$\dot{V}_{O_2}$	6.6	13.6	11.6	12.8	16.4	18.4	18.6
$\dot{V}_{CO_2}$	5.2	10.4	9.6	10.8	15.1	17.7	19.1
R	0.79	0.76	0.83	0.84	0.92	0.96	1.03
RPE	7	9	9	9	10	10	13

PO	800	900
HR	138	146
SBP	170	165
DBP	95	95
RPP	234.6	240.9
$\dot{V}_E$	51.2	58.9
$\dot{V}_{O_2}$	21.9	22.9
$\dot{V}_{CO_2}$	24.0	27.3
R	1.10	1.19
RPE	15	19

Maximal H_{LA} - 5.3

PRE-CONDITIONING STEADY STATE TEST: HEALTHY SUBJECTS

Subject	PO	$\dot{V}O_2$	HR	V_s	$\dot{Q}_c$	$(a-\bar{v})O_2$ difference	R
B.R.	500	18.7	156	1.21	189.5	9.9	1.13
E.E.	350	15.1	133	1.24	164.6	9.2	1.02
H.K.	200	12.1	108	1.22	131.9	9.2	0.87
E.T.	450	20.3	155	1.14	178.1	11.4	1.04
P.H.	350	18.5	144	0.93	133.5	13.9	0.70
P.B.	350	16.0	170	0.93	158.6	10.1	1.04
D.C.	350	11.7	111	1.30	153.0	7.7	1.18
R.H.	550	20.2	170	0.96	163.9	12.3	0.95
A.O.	450	15.9	128	0.98	124.4	12.8	0.94

POST-CONDITIONING PROGRESSIVE TEST: HEALTHY SUBJECTS

SUBJECT: B.R. BTPS - 1.080 STPD - 0.879

Resting

HR	91	FEV_1	3.05
SBP	110	FVC	3.45
DBP	70	Wt	67.5

PO	100	200	300	400	500	600	700
HR	96	116	121	133	142	148	155
SBP	130	130	130	130	140	145	-
DBP	80	80	90	90	90	90	-
RPP	124.8	150.8	157.3	172.9	198.8	214.6	-
$\dot{V}_E$	15.0	18.4	21.5	26.1	31.4	38.8	46.0
$\dot{V}_{O_2}$	8.1	10.5	11.8	14.8	16.6	20.2	22.5
$\dot{V}_{CO_2}$	6.1	8.2	9.8	12.4	15.6	19.4	23.3
R	0.75	0.78	0.83	0.84	0.94	0.96	1.04
RPE	6	6	6	6	7	8	10

PO	800	900
HR	160	167
SBP	150	160
DBP	80	90
RPP	240.0	267.2
$\dot{V}_E$	48.1	51.4
$\dot{V}_{O_2}$	22.5	19.5
$\dot{V}_{CO_2}$	24.0	23.6
R	1.07	1.21
RPE	12	15

Maximal H_{LA} - 8.9

SUBJECT: E.E. BTPS - 1.080 STPD - 0.874

Resting

HR	82	FEV_1	2.37
SBP	120	FVC	2.45
DBP	90	Wt	62.0

PO	150	200	250	300	350	400	450
HR	91	96	99	106	110	118	121
SBP	130	130	130	140	135	135	-
DBP	80	90	90	85	80	80	-
RPP	118.3	124.8	128.7	148.4	148.5	159.3	-
$\dot{V}_E$	14.0	17.3	18.0	20.8	24.0	27.1	31.8
$\dot{V}_{O_2}$	6.7	9.7	10.0	11.7	12.8	14.0	16.1
$\dot{V}_{CO_2}$	5.9	8.0	8.7	9.6	11.9	13.6	16.2
R	0.89	0.83	0.87	0.82	0.93	0.97	1.01
RPE	6	8	8	9	10	11	12

PO	500	550	600	650	700	750	800
HR	122	136	142	146	155	169	177
SBP	160	160	165	160	170	170	170
DBP	90	95	95	95	90	100	100
RPP	195.2	217.6	234.3	233.6	263.5	287.3	300.9
$\dot{V}_E$	25.3	46.1	44.8	43.3	47.4	62.1	72.1
$\dot{V}_{O_2}$	11.5	21.0	20.9	20.7	22.0	24.2	25.0
$\dot{V}_{CO_2}$	12.4	22.6	21.8	21.5	24.1	30.0	32.9
R	1.08	1.08	1.04	1.04	1.10	1.24	1.32
RPE	13	14	14	15	16	18	19

No maximal H_{LA}

SUBJECT: H.K. BTPS - 1.080 STPD - 0.879

Resting

HR	79	FEV_1	1.45
SBP	170	FVC	2.30
DBP	90	Wt	61.0

PO	100	200	300	400	500	600	700
HR	91	98	110	117	130	150	167
SBP	170	180	180	200	200	210	215
DBP	100	95	90	90	90	90	95
RPP	154.7	176.4	198.0	234.0	260.0	315.0	359.1
$\dot{V}_E$	16.9	19.4	24.3	30.7	39.6	47.9	63.1
$\dot{V}_{O_2}$	7.7	9.6	12.6	15.3	18.0	20.8	24.4
$\dot{V}_{CO_2}$	6.4	7.7	10.2	13.4	17.4	21.8	27.7
R	0.83	0.80	0.81	0.88	0.97	1.05	1.14
RPE	6	6	6	7	11	15	17

Maximal H_{LA} - 7.9

SUBJECT: E.T. BTPS - 1.085 STPD - 0.888

Resting

HR	66
SBP	120
DBP	90

FEV_1	3.40
FVC	4.35
Wt	65.5

PO	100	200	300	400	500	600	700
HR	93	96	110	120	129	140	146
SBP	150	140	170	160	170	-	180
DBP	90	90	90	90	90	-	90
RPP	139.5	134.4	187.0	192.0	219.3	-	262.8
$\dot{V}_E$	17.0	16.7	20.3	25.9	34.1	37.4	46.0
$\dot{V}O_2$	8.3	9.8	12.9	15.4	19.4	20.9	23.1
$\dot{V}CO_2$	7.9	8.4	10.5	13.4	18.2	19.8	24.7
R	0.95	0.86	0.81	0.87	0.94	0.95	1.07
RPE	6	7	7	10	12	13	13

PO	800	900	1000
HR	158	165	169
SBP	180	180	185
DBP	90	100	100
RPP	284.4	297.0	312.7
$\dot{V}_E$	54.9	65.4	79.3
$\dot{V}O_2$	26.2	28.5	30.1
$\dot{V}CO_2$	28.6	32.4	37.3
R	1.09	1.14	1.24
RPE	15	16	19

Maximal H_{LA} - 10.2

SUBJECT: P.H. BTPS - 1.080 STPD - 0.879

Resting

HR	71	FEV_1	2.25
SBP	120	FVC	2.35
DBP	80	Wt	60.0

PO	100	150	200	250	300	350	400
HR	103	-	114	111	116	115	121
SBP	150	-	150	150	150	160	160
DBP	80	-	80	80	80	80	80
RPP	154.5	-	171.0	166.5	174.0	184.0	193.6
$\dot{V}_E$	12.5	-	16.3	19.6	20.8	21.2	24.2
$\dot{V}O_2$	7.3	-	10.4	12.5	14.5	14.7	16.3
$\dot{V}CO_2$	6.3	-	8.6	10.4	11.5	12.4	14.1
R	0.86	-	0.83	0.83	0.79	0.84	0.87
RPE	7	-	7	8	8	9	9

PO	450	500	550	600	650	700	750
HR	125	130	135	143	150	161	167
SBP	160	-	160	170	180	170	175
DBP	80	-	90	80	80	90	85
RPP	200.0	-	216.0	243.1	270.0	273.7	292.3
$\dot{V}_E$	28.0	27.8	32.0	35.1	37.5	47.7	51.9
$\dot{V}O_2$	18.8	18.1	20.3	22.1	23.5	28.6	28.5
$\dot{V}CO_2$	16.7	16.8	19.6	22.1	23.6	29.1	31.7
R	0.89	0.93	0.97	1.00	1.00	1.02	1.11
RPE	10	11	12	14	14	15	15

...cont'd.

SUBJECT: P.H.

PO	800
HR	170
SBP	190
DBP	80
RPP	323.0
$\dot{V}_E$	62.5
$\dot{V}_{O_2}$	32.8
$\dot{V}_{CO_2}$	35.7
R	1.09
RPE	19

No Maximal H_{LA}

SUBJECT: P.B. BTPS - 1.080 STPD - 0.883

Resting

HR	78	FEV_1	3.08
SBP	100	FVC	3.58
DBP	75	Wt	61.0

PO	100	200	300	400	500	600	700
HR	96	107	113	127	152	165	179
SBP	120	135	135	150	160	-	-
DBP	80	80	80	85	90	-	-
RPP	115.2	144.5	152.6	190.5	243.2	-	-
$\dot{V}_E$	13.0	17.3	20.9	22.4	30.9	37.2	42.7
$\dot{V}_{O_2}$	7.7	11.0	13.2	14.6	19.0	22.1	25.1
$\dot{V}_{CO_2}$	5.1	8.7	11.3	13.0	18.2	22.1	26.6
R	0.66	0.79	0.86	0.89	0.96	1.00	1.06
RPE	7	7	9	9	10	11	12

PO	800	900	1000
HR	188	193	198
SBP	170	180	180
DBP	90	90	90
RPP	319.6	347.4	356.4
$\dot{V}_E$	57.9	72.4	86.7
$\dot{V}_{O_2}$	29.8	30.8	33.5
$\dot{V}_{CO_2}$	33.4	35.9	36.6
R	1.12	1.17	1.09
RPE	12	15	19

Maximal H_{LA} - 11.3

SUBJECT: D.C. BTPS - 1.085 STPD - 0.888

Resting

HR	60	FEV_1	3.00
SBP	105	FVC	3.64
DBP	75	Wt	77.0

PO	100	200	300	400	500	600	700
HR	83	92	103	116	126	138	150
SBP	130	160	160	160	160	180	180
DBP	90	90	90	90	90	100	100
RPP	107.9	147.2	164.8	185.6	201.6	248.4	270.0
$\dot{V}_E$	15.0	-	20.1	26.4	27.5	40.6	45.6
$\dot{V}_{O_2}$	5.7	-	10.4	12.8	11.9	16.8	19.7
$\dot{V}_{CO_2}$	5.2	-	8.8	12.3	12.7	18.6	21.3
R	0.91	-	0.85	0.96	1.07	1.11	1.08
RPE	8	9	10	12	12	16	17

PO	800	900
HR	158	165
SBP	190	190
DBP	100	100
RPP	300.2	313.5
$\dot{V}_E$	59.6	89.8
$\dot{V}_{O_2}$	22.8	26.6
$\dot{V}_{CO_2}$	26.9	33.4
R	1.18	1.26
RPE	18	20

Maximal H_{LA} - 8.1

SUBJECT: R.H. BTPS - 1.085 STPD - 0.888

Resting

HR	94
SBP	125
DBP	65

FEV_1	2.37
FVC	2.45
Wt	73.5

PO	100	200	300	400	500	600	700
HR	115	118	123	123	138	146	155
SBP	140	140	155	155	160	-	165
DBP	80	80	80	95	70	-	75
RPP	161.0	165.2	190.7	190.7	220.8	-	255.8
$\dot{V}_E$	16.3	16.7	20.7	22.3	29.3	32.6	37.8
$\dot{V}_{O_2}$	5.7	7.1	9.7	11.9	15.3	17.0	18.0
$\dot{V}_{CO_2}$	5.8	5.9	8.4	8.0	13.1	15.2	17.3
R	1.02	0.83	0.87	0.67	0.86	0.89	0.96
RPE	7	7	9	9	11	12	13

PO	800	900	1000	1100
HR	167	172	179	183
SBP	175	180	185	185
DBP	80	70	70	70
RPP	292.3	309.6	331.2	338.6
$\dot{V}_E$	55.6	61.3	69.7	87.4
$\dot{V}_{O_2}$	23.5	24.2	25.9	29.0
$\dot{V}_{CO_2}$	24.7	26.9	29.5	34.1
R	1.05	1.11	1.14	1.18
RPE	15	16	16	18

Maximal H_{LA} - 10.8

SUBJECT: A.O. BTPS - 1.085 STPD - 0.881

Resting

HR	73	FEV_1	2.65
SBP	110	FVC	3.50
DBP	80	Wt	75.0

PO	100	200	300	400	500	600	700
HR	-	89	88	98	103	112	122
SBP	120	130	130	135	130	130	150
DBP	80	80	80	80	80	80	80
RPP	-	-	114.4	132.3	133.9	145.6	183.0
$\dot{V}_E$	-	-	23.1	25.1	26.3	34.5	41.2
$\dot{V}O_2$	-	-	13.7	14.0	15.0	18.9	20.2
$\dot{V}CO_2$	-	-	10.7	11.8	12.5	16.8	20.5
R	-	-	0.78	0.84	0.83	0.89	1.01
RPE	7	7	7	8	13	15	15

PO	800	900
HR	132	139
SBP	150	160
DBP	90	80
RPP	198.0	222.4
$\dot{V}_E$	45.6	51.3
$\dot{V}O_2$	22.2	22.4
$\dot{V}CO_2$	23.2	25.3
R	1.05	1.13
RPE	17	19

Maximal HLA - 4.6

POST-CONDITIONING STEADY STATE TEST: HEALTHY SUBJECTS

Subject	PO	$\dot{V}_{O_2}$	HR	V_s	$\dot{Q}_c$	$(a-\bar{v})O_2$ difference	R
B.R.	500	18.9	150	0.99	149.0	12.7	0.93
E.E.	350	12.2	125	0.89	111.0	11.0	0.87
H.K.	200	11.0	92	1.37	125.7	8.7	0.94
E.T.	450	18.4	129	1.09	141.1	13.0	0.85
P.H.	350	15.7	129	1.26	163.2	9.6	0.82
P.B.	350	15.4	138	0.99	137.5	11.2	0.95
D.C.	350	13.1	125	0.89	111.0	11.8	0.89
R.H.	550	18.5	155	0.93	143.8	12.9	0.92
A.O.	450	15.0	113	1.10	127.7	11.7	0.95

PRE-CONDITIONING PROGRESSIVE TEST: CARDIAC SUBJECTS

SUBJECT: K.S. BTPS - 1.085 STPD - 0.888

Resting

HR 70
SBP 115
DBP 80

FEV_1 2.70
FVC 3.13
Wt 64.5

PO	100	150	200	250	300	350	400
HR	85	94	99	109	113	117	124
SBP	120	120	125	125	130	130	130
DBP	80	80	85	85	85	85	85
RPP	102.0	112.8	123.8	136.3	146.9	152.1	161.2
$\dot{V}_E$	7.1	9.5	11.3	13.5	19.5	20.5	29.7
$\dot{V}_{O_2}$	3.3	6.4	8.4	10.3	13.8	12.4	15.8
$\dot{V}_{CO_2}$	2.6	4.9	6.6	8.6	12.1	12.2	16.4
R	0.79	0.77	0.79	0.83	0.88	0.98	1.04
RPE	9	11	11	11	11	13	16

PO	450
HR	128
SBP	140
DBP	90
RPP	179.2
$\dot{V}_E$	32.1
$\dot{V}_{O_2}$	16.8
$\dot{V}_{CO_2}$	17.1
R	1.02
RPE	18

Maximal H_{LA} - 6.1

SUBJECT: J.P. BTPS - 1.075 STPD - 0.867

Resting

HR 55
SBP 110
DBP 75

FEV_1 2.28
FVC 2.68
Wt 64.0

PO	100	150	200	250	300	350	400
HR	98	102	101	112	117	125	133
SBP	-	120	130	150	150	170	180
DBP	-	80	80	80	100	100	100
RPP	-	122.4	131.3	168.0	175.5	212.5	239.4
$\dot{V}_E$	10.7	15.4	16.5	18.4	21.5	24.1	28.1
$\dot{V}_{O_2}$	6.2	10.2	11.9	12.8	13.9	15.9	18.0
$\dot{V}_{CO_2}$	5.1	8.3	9.7	10.7	12.7	14.6	17.0
R	0.82	0.81	0.82	0.84	0.91	0.92	0.94
RPE	7	10	11	12	12	13	13

PO	450	500	550	600
HR	136	142	146	150
SBP	200	210	-	220
DBP	95	105	-	105
RPP	272.0	298.2	-	330.0
$\dot{V}_E$	32.1	30.8	29.9	39.8
$\dot{V}_{O_2}$	19.3	18.5	17.3	22.0
$\dot{V}_{CO_2}$	19.0	18.3	18.1	23.1
R	0.98	0.99	1.05	1.05
RPE	14	16	17	19

Maximal H_{LA} - 6.4

SUBJECT: A.L. BTPS - 1.080 STPD - 0.876

Resting

HR 115
SBP 115
DBP 80

FEV_1 1.65
FVC 2.00
Wt 84.5

PO	100	150	200	250	300	350
HR	165	161	142	144	158	169
SBP	130	130	-	170	170	180
DBP	80	80	-	90	90	90
RPP	214.5	209.3	-	244.8	268.6	304.2
$\dot{V}_E$	18.7	20.9	25.0	27.9	30.8	32.7
$\dot{V}_{O_2}$	6.2	8.1	9.2	9.2	10.2	9.5
$\dot{V}_{CO_2}$	5.0	6.8	8.2	9.1	10.0	10.2
R	0.81	0.84	0.89	0.99	0.98	1.07
RPE	11	13	13	16	16	17

Maximal H_{LA} - 3.3

SUBJECT: D.B. BTPS - 1.085 STPD - 0.888

Resting

HR 72
SBP 110
DPB 70

FEV_1 2.38
FVC 3.15
Wt 54.0

PO	100	150	200	250	300	350	400
HR	90	97	100	108	116	124	134
SBP	110	110	120	130	140	135	140
DBP	70	70	80	80	90	85	85
RPP	99.0	106.7	120.0	140.4	162.4	167.4	187.6
$\dot{V}_E$	10.1	13.2	15.1	18.6	22.5	23.0	31.3
$\dot{V}_{O_2}$	5.5	9.4	10.2	12.9	15.5	14.0	19.5
$\dot{V}_{CO_2}$	3.5	7.0	8.8	11.3	13.6	14.3	19.9
R	0.64	0.74	0.86	0.88	0.88	1.02	1.02
RPE	11	12	11	13	13	14	15

PO	450
HR	144
SBP	150
DBP	90
RPP	216.0
$\dot{V}_E$	35.9
$\dot{V}_{O_2}$	20.0
$\dot{V}_{CO_2}$	21.9
R	1.10
RPE	17

Maximal H_{LA} - 6.7

SUBJECT: L.C. BTPS - 1.085 STPD - 0.879

Resting

HR	82
SBP	125
DBP	90

FEV_1	2.18
FVC	2.58
Wt	56.5

PO	100	150	200	250	300	350	400
HR	121	121	133	146	163	155	170
SBP	145	150	145	145	145	-	175
DBP	90	90	90	90	90	-	95
RPP	175.5	181.5	192.9	211.7	236.4	-	297.5
$\dot{V}_E$	12.1	15.8	19.9	22.3	31.7	32.4	38.3
$\dot{V}_{O_2}$	6.0	9.1	11.1	12.1	14.1	12.9	15.0
$\dot{V}_{CO_2}$	4.1	7.6	9.8	11.5	14.8	14.4	17.6
R	0.68	0.84	0.88	0.95	1.05	1.12	1.17
RPE	7	9	11	13	13	15	17

PO	450
HR	172
SBP	170
DBP	100
RPP	292.4
$\dot{V}_E$	48.0
$\dot{V}_{O_2}$	16.8
$\dot{V}_{CO_2}$	19.9
R	1.18
RPE	19

Maximal H_{LA} - 8.2

SUBJECT: B.C. BTPS - 1.085 STPD - 0.881

Resting

HR 57
SBP 140
DBP 80

FEV_1 2.65
FVC 3.04
Wt 82.5

PO	100	150	200	250	300	350	400
HR	80	-	85	-	101	111	116
SBP	150	-	160	-	170	-	180
DBP	80	-	80	-	90	-	90
RPP	120.0	-	136.0	-	171.7	-	208.8
$\dot{V}_E$	29.4	-	35.7	-	49.0	55.3	63.1
$\dot{V}_{O_2}$	5.2	-	7.1	-	10.0	11.0	12.5
$\dot{V}_{CO_2}$	6.6	-	9.1	-	12.8	14.1	16.1
R	1.27	-	1.28	-	1.28	1.28	1.29
RPE	11	-	13	-	16	16	18

No maximal H_{LA}

PRE-CONDITIONING STEADY STATE TEST: CARDIAC SUBJECTS

Subject	PO	$\dot{V}_{O_2}$	HR	V_s	$\dot{Q}_c$	$(a-\bar{v})O_2$ difference	R
K.S.	200	9.7	98	1.19	116.4	8.3	0.96
J.P.	350	17.5	133	1.19	159.5	11.0	0.98
A.L.	150	8.6	132	0.63	83.3	10.4	1.21
D.B.	300	17.5	142	1.14	172.8	10.1	1.08
L.C.	250	13.3	160	0.82	131.2	10.2	1.03
B.C.	200	10.4	100	0.85	85.3	12.2	1.01

POST-CONDITIONING PROGRESSIVE TEST: CARDIAC SUBJECTS

SUBJECT: K.S. BTPS - 1.085 STPD - 0.888

Resting

HR	73	FEV_1	2.83
SBP	110	FVC	3.30
DBP	70	Wt	65.0

PO	100	150	200	250	300	350	400
HR	73	86	96	97	101	105	109
SBP	125	125	145	155	160	160	165
DBP	90	90	90	95	95	100	95
RPP	91.3	107.5	139.2	150.4	161.6	168.0	179.9
$\dot{V}_E$	-	-	13.0	13.5	15.4	17.2	20.9
$\dot{V}O_2$	-	-	9.2	9.8	10.9	11.8	13.4
$\dot{V}CO_2$	-	-	7.4	7.9	9.1	10.4	12.5
R	-	-	0.80	0.81	0.83	0.88	0.93
RPE	6	6	6	6	7	8	11

PO	450	500	550	600	650
HR	113	120	125	132	142
SBP	-	-	190	170	180
DBP	-	-	105	100	110
RPP	-	-	237.5	224.4	255.6
$\dot{V}_E$	23.3	28.8	35.0	45.7	59.0
$\dot{V}O_2$	15.1	17.6	17.6	19.9	22.2
$\dot{V}CO_2$	14.4	17.4	19.6	23.3	27.5
R	0.95	0.99	1.11	1.17	1.24
RPE	13	13	14	17	19

Maximal H_{LA} - 7.5

SUBJECT: J.P. BTPS - 1.080 STPD - 0.874

Resting

HR	73	FEV_1	2.30
SBP	125	FVC	2.55
DBP	85	Wt	66.0

PO	100	200	300	400	500	600	700
HR	91	100	109	112	122	132	143
SBP	120	140	160	-	175	190	190
DBP	80	90	90	-	90	100	100
RPP	109.2	140.0	174.4	-	213.5	250.8	271.7
$\dot{V}_E$	14.9	17.4	21.6	23.9	27.2	34.9	42.5
$\dot{V}_{O_2}$	7.3	9.8	12.6	14.5	16.3	18.7	20.2
$\dot{V}_{CO_2}$	6.6	8.3	11.2	13.2	15.5	20.2	24.2
R	0.90	0.85	0.89	0.91	0.95	1.08	1.20
RPE	7	8	7	7	9	11	13

PO	800
HR	149
SBP	200
DBP	100
RPP	298.0
$\dot{V}_E$	54.0
$\dot{V}_{O_2}$	23.2
$\dot{V}_{CO_2}$	29.1
R	1.25
RPE	17

Maximal H_{LA} - 7.1

SUBJECT: A.L. BTPS - 1.085 STPD - 0.888

Resting

HR	100	FEV_1	2.00
SBP	140	FVC	2.44
DBP	90	Wt	84.0

PO	100	150	200	250	300	350
HR	125	153	152	156	167	174
SBP	135	170	200	180	200	220
DBP	90	100	90	100	100	120
RPP	168.8	260.1	304.0	280.8	334.0	382.8
$\dot{V}_E$	16.5	13.9	27.0	25.0	33.7	37.3
$\dot{V}_{O_2}$	5.0	5.1	9.3	8.6	10.3	10.4
$\dot{V}_{CO_2}$	3.6	4.3	8.0	7.9	10.4	10.8
R	0.72	0.84	0.86	0.92	1.01	1.04
RPE	9	9	12	12	12	17

Maximal H_{LA} - 2.5

POST-CONDITIONING STEADY STATE TEST: CARDIAC SUBJECTS

Subject	PO	$\dot{V}_{O_2}$	HR	V_s	$\dot{Q}_c$	$(a-\bar{v})O_2$ difference	R
K.S.	200	10.1	86	1.37	117.5	8.6	0.80
J.P.	350	17.0	126	1.27	161.2	10.5	0.92
A.L.	150	6.7	122	0.53	65.0	10.3	0.93