1996

The Effects of Conditioning and Gender on Ratings of Perceived Exertion During Physical Exercise

Dr. Roberta A. Pellant
Minnesota State University, Mankato

THE EFFECTS OF CONDITIONING AND GENDER ON RATINGS OF PERCEIVED EXERTION DURING PHYSICAL EXERCISE

by

Roberta A. Pellant

A thesis submitted in partial

fulfillment of the requirements for the

degree of Master of Science at

Mankato State University

Mankato, Minnesota

June, 1996

Date 5/13/96

This thesis has been examined and approved.

Examining Committee:

DEDICATION

In memory of my mother, who has shown me that the true challenge in life is to persevere. For her patience, devotion and willingness to live a full and rewarding life.

To my father, who has given me my sense of humor; to be able to laugh and find the fun in everyday situations. They both have always shown me great support, understanding, and love as I plodded through the trials and tribulations of my own life. Thanks for making me who I am today. I love you very much.

ACKNOWLEDGEMENTS

The author would like to express her sincerest gratitude to Dr. Ken Ecker, Dr. Mary Visser, and Dr. Ned Williams; their help, concern, encouragement, and patience for me as a student won't be forgotten. Thank you for taking time out of your busy schedules to answer my many questions.

Thank you to my research assistant and friend, Terence Vanderheiden, for all of his long hours in the lab. His honesty, loyalty and friendship never wavered during the weeks that were spent on this investigation.

Thank you to all of my subjects for their help and participation in this study. It was because of them that I was able to write and complete this thesis.

Lastly, thanks to my family: my husband, Jon, and my children, J. R. and Kyra – who have went many hours without a wife or a mother. I hope that you haven't forgotten how deeply I love you, and without your understanding and support, I wouldn't have been able to undertake this achievement. Thanks for putting up with me.

ABSTRACT

COMPLETED RESEARCH IN HEALTH AND HUMAN PERFORMANCE

Cheryl T. Samuels, Dean

Institutional Representative

Mankato State University, Mankato, Minnesota

PELLANT, Roberta A. The effects of conditioning and gender on ratings of perceived exertion during physical exercise. M. S. in Human Performance, 1996. 83 pp. (K. Ecker)

The purpose of this investigation was to determine if gender played a factor in perception during physical exertion, and whether those perceptions were influenced by conditioning level. Sixteen male and sixteen female volunteer subjects, ranging in age from 21 to 35, constituted the sample for this study. The Bruce protocol for a Symptom-Limited Graded Exercise test was the instrument utilized to evaluate heart rate during the maximal physical exercise program. A ventilatory analyzer measured each subject's maximal oxygen consumption. Borg's Rated Perceived Exertion Scale was employed for subjective evaluation of an individual's perception of effort. The t-test compared mean scores of RPE during test 1 and test 2, and was utilized to determine significant difference. Analysis of variance and Scheffe post hoc tests were used to determine if there were differences between males and females, or between the conditioned and non-conditioned subjects. The Pearson product-moment was employed to determine correlation between heart rate and RPE values. It was hypothesized that there would be a significant RPE difference at the alpha value .05, between males and females, and between conditioning levels of those subjects.

TABLE OF CONTENTS

Page

DEDICATION ii

ACKNOWLEDGEMENTS iii

ABSTRACT

TABLE OF CONTENTS iv

LIST OF APPENDICES vii

LIST OF ILLUSTRATIONS viii

LIST OF TABLES ix

Chapter

1. INTRODUCTION 1

    STATEMENT OF THE PROBLEM 1

    HYPOTHESES 2

    DELIMITATIONS 2

    LIMITATIONS 4

    SIGNIFICANCE OF THE STUDY 4

    DEFINITION OF TERMS 5

2. REVIEW OF LITERATURE 9

    DEVELOPMENT/VALIDATION OF PERCEIVED EXERTION 9

    PERCEPTION OF EFFORT 10

    PHYSIOLOGICAL INFLUENCES ON RPE 11

TABLE OF CONTENTS—Continued

Chapter Page

2.

WORK INTENSITY 12

PHYSICAL TRAINING 13

EFFECTS OF AGING 15

GENDER DIFFERENCES 15

BODY COMPOSITION 16

ENVIRONMENTAL CONDITIONS 17

PSYCHOLOGICAL INFLUENCES ON RPE 17

SUMMARY 18

3. METHODOLOGY 19

PILOT STUDY 19

SELECTION OF SUBJECTS 21

INSTRUMENT ASSESSMENT 21

VALIDITY AND RELIABILITY 23

TESTING PROCEDURES 26

DATA COLLECTION 29

DATA TREATMENT 32

4. RESULTS 33

TABLE OF CONTENTS—Continued

Chapter Page

4.

RELIABILITY OF RPE BETWEEN REPEAT TESTS 33

DIFFERENCES IN RPE AMONG SUBGROUPS 35

RPE AND HR CORRELATION 38

DIFFERENCES IN VO_2MAX AMONG SUBGROUPS 42

DISCUSSION 48

5. SUMMARY 52

CONCLUSIONS 52

RECOMMENDATIONS 53

BIBLIOGRAPHY 55

LIST OF APPENDICES

Page

APPENDICES

A. DATA COLLECTED FROM PILOT STUDY 64

B. MEDICAL HISTORY QUESTIONNAIRE 65

C. INFORMED CONSENT FORM 67

D. PHYSICAL ACTIVITY QUESTIONNAIRE 70

E. INSTRUCTIONS TO THE SUBJECTS 71

F. INFORMATION FOR THE BRUCE PROTOCOL 72

G. INFORMATION FOR RATING PERCEIVED EXERTION 73

H. CALIBRATION OF TREADMILL SPEED 75

I. CALIBRATION OF GAS ANALYZER 76

J. ELECTRODE SKIN SITE PREPARATION 77

K. GUIDELINES FOR SAFE PROCEDURES ON THE TREADMILL.... 78

L. DATA COLLECTION SHEET 79

M. FINAL DATA SUMMARY SHEET 80

LIST OF ILLUSTRATIONS

Page

FIGURE

1. BORG'S RATED PERCEIVED EXERTION SCALE 22
2. BRUCE PROTOCOL 24
3. ELECTRODE PLACEMENT DURING SLM-GXT 25
4. TREADMILL CONTROL KEYS AND KEYBOARD LAYOUT 30
5. RPE DIFFERENCES BETWEEN CONDITIONING LEVELS 39
6. RPE DIFFERENCES BETWEEN MALES AND FEMALES 40
7. RELATIONSHIP BETWEEN HEART RATE AND RPE 43
8. HR DIFFERENCES BETWEEN CONDITIONING LEVELS 44
9. HR DIFFERENCES BETWEEN MALES AND FEMALES 45

LIST OF TABLES

Page

TABLE

1. PHYSICAL CHARACTERISTICS OF SUBJECTS 33
2. COMPARISONS OF TEST 1 AND TEST 2 RPE 34
3. COMPARISONS OF TEST 1 AND TEST 2 RPE AT 6 MINUTES 35
4. SUBGROUP VARIATIONS OF RPE AT 3, 6, AND 9 MINUTES..........36
5. SUMMARY OF ANOVA FOR PERCEIVED EXERTION RATINGS ..36
6. ANOVA AT 3 MINUTES BETWEEN MALES AND FEMALES..............37
7. ANOVA AT 6 MINUTES BETWEEN MALES AND FEMALES..............37
8. ANOVA AT 9 MINUTES BETWEEN MALES AND FEMALES..............37
9. ANOVA AT 12 MINUTES BETWEEN MALES AND FEMALES.............38
10. TEST 1 CORRELATION OF RPE AND HEART RATE 41
11. TEST 2 CORRELATION OF RPE AND HEART RATE 42
12. ANOVA FOR MAXIMAL OXYGEN CONSUMPTION............................47
13. CARDIORESPIRATORY FITNESS CLASSIFICATION 47

Chapter 1

INTRODUCTION

Heart rate, by pulse palpitation or waist and wristband monitoring, has become the standard among many active adults engaging in physical exercise. To obtain more accurate results, the predicted submaximal and maximal stress tests have been employed as guidelines for exercise prescription (American College of Sports Medicine, 1991). Gunnar Borg, in 1962, developed the Rated Perceived Exertion Scale (RPE) as a simplified way to measure intensity level of activity and how it relates to fatigue. He found a linear relationship between heart rate, perceived exertion and work load. Inaccurate counting, faulty equipment and human error were stated as reasons to develop the scale. This eliminated the problems with heartbeat counting, expensive tests and equipment (Borg, 1962; Leger and Thivierge, 1988; White 1977). Since then, Morgan and Borg (1976) have concluded that perceived exertion, along with heart rate in healthy adult males, can be used as a standard measure of maximal exercise capacity. Dunbar, Robertson, Baun, Blandin, Metz, Burdett, Goss (1992) and Dishman (1994) have provided more recent data supporting the use of ratings of perceived exertion to prescribe and monitor exercise intensity.

STATEMENT OF THE PROBLEM

The purpose of this study was to determine if gender or conditioning level played a role in how intense an exercise feels during physical activity, as opposed to actual heart rate at that time. Do males and females perceive the intensity of work being performed differently?

Sub-problems investigated in this study included:

1. To determine the effects of conditioning on RPE. Specifically, looking at

comparisons between conditioned and non-conditioned athletes, and their perceptions of the intensity of work being performed at identical absolute workloads.

2. To determine the correlation between RPE and each of several physiological factors, including: heart rate and VO_2max, during test 1 and test 2 assessments. In other words, which physiological variable shows the strongest linear relationship with RPE in each of the four subgroups.

HYPOTHESES

The investigator assumed the null position in stating the following hypothesis:

1. There will be no significant differences between male and female subjects' RPE and heart rate correlation at identical absolute workloads.

The investigator assumed the research position in stating the following hypotheses:

1. There will be significant differences between males and females in rating perceived exertion at identical absolute workloads. Males will assign lower ratings of perceived exertion than will females.
2. There will be significant differences between conditioned and non-conditioned subjects' RPE at identical absolute workloads. Conditioned subjects will assign lower ratings of perceived exertion than will non-conditioned subjects.

DELIMITATIONS

The following delimitations were associated with this study:

1. Sixteen male and sixteen female subjects, aged 21-35, (mean age 25.73), representative of each other, constituted the sample for this study. It primarily consisted of, but was not limited to college students of Mankato State University. Thus, is was not a true

random sample of the accessible population.

2. Only healthy, asymptomatic participants, in regard to coronary artery disease, were involved in this study.

3. Subjects consisted of both conditioned and non-conditioned individuals.

4. The accuracy of heart rate recording was based on the investigator administering the test. This included taking EKG readings off electrodes placed on the subject.

5. Subjects' responses to RPE were based on Borg's scale.

6. Conditioning levels were determined by subjects' responses to a research developed survey instrument. Later, they were broken down further by the investigator, based on their VO_2max test derived from the actual protocol.

7. The survey questionnaire instrument only had content validity and was not tested for construct validity.

8. Lactic acid and catecholamine levels were not included in this study, although they are sometimes part of similar studies.

9. Personal interaction between the investigator and subjects varied on a day to day basis. The effects of this cannot be determined, but RPE could have been influenced by a variety of psychological, as well as physiological factors (Morgan, 1973).

10. The number of people in the testing room varied from day to day. Most often, the investigator and one other research assistant were in the room. Sometimes the investigator conducted the testing alone, or had spectators in the laboratory. It should be noted, that the influence of another person in the room, could have caused the 'social facilitation effect' (Cottrell, Wack, Sekerack and Rittle, 1968; Henchy and Glass, 1968; Klinger, 1969; Martens and Landers, 1972; Noble, Maresh and Ritchey,

1980, Sylva, Byrd and Mangum, 1990; Zajonc, 1965). This effect will be explained in the discussion section of Chapter 4.

LIMITATIONS

The following limitations were associated with this study:

1. The findings of this study can only be generalized within the defined parameters of this investigation.
2. The accuracy of the subjects' responses depended upon their honesty and integrity in answering the survey questions.
3. The physical activity level of the subjects was not controlled for in the study.
4. Due to the large number of subjects and limited equipment, only two independent tests of each subject were held within a four week span.

It was assumed that all subjects were motivated in their voluntary participation.

SIGNIFICANCE OF THE STUDY

In today's society, the need for a regular fitness program has become increasingly popular. The concern of what types of exercise, the duration of the exercise and the guidelines in the prescription of the exercise have been closely scrutinized. It has long been concluded that RPE and heart rate can be an accurate measure of maximal oxygen uptake. The intent of this comparative study was to ascertain if there was a gender difference in rating perceived exertion, and if the level of conditioning was a significant factor in their perceived exertion ratings. Past research implies that there are no significant differences based on gender. However, current research on gender and conditioning level has shown inconclusive agreements in physiological responses. Given the trend, of males and females becoming more concerned with their conditioning level, this study may demonstrate different findings than the past studies. Gender differences, in addition to the conditioning level of the subjects, should aid in the validity and reliability of Borg's RPE scale.

DEFINITION OF TERMS

The investigator deemed the following terms necessary for definition:

ACSM-American College of Sports Medicine- Multi-disciplinary professional and scientific society dedicated to...the knowledge concerning exercise and competitive sport. (ACSM brochure)

ASYMPTOMATIC-denotes that subjects are free of any major coronary heart disease risk factors. These factors can be lifestyle or hereditary based, which can predispose that subject to coronary heart disease.

BP-Blood Pressure-a measurement of the force exerted by the blood on the arteries during ventricular contraction and relaxation of the heart.

BRUCE PROTOCOL-a standardized maximal exercise protocol designed for a subject to perform a stress test under known conditions on a treadmill. It consists of seven, 3 minute stages, with slope and speed increasing every third minute of the protocol.

CONDITIONED-subjects who participate in continuous aerobic activity for at least 20 minutes per session, three days per week. These aerobic activities include running, biking, and swimming.

EKG-Electrocardiogram-an evaluation of the action potential of the heart's activity, expressed in waveforms. In this investigation the Quinton$_{TM}$ was utilized for recording heart rate, using a 4-lead electrode placement, and to detect any contraindications of the exercise test on the heart. A baseline reading is recorded to determine significant changes when compared to working levels of the heart.

ELECTRODE LEAD WIRE-a wire that conducts electrical impulses from an electrode, as synthesized impulses from specific sites on the body are referenced, amplified and displayed to the stress test monitor.

ELECTRODE SITE-locations on the subject's skin where the electrodes are attached.

ENVIRONMENT-a set of current conditions that define both the physical settings and surroundings of the testing site. These include air temperature, humidity and barometric pressure.

EXERCISE PHASE-the period of an exercise stress test during which the subject is performing a controlled exercise routine, such as walking or running on a treadmill at defined speeds and grades. Generally, EKG and other data are collected during the exercise phase (Quinton, 1986).

EXERCISE PRESCRIPTION-A program of activity based on intensity, mode, duration, progression, frequency and ability to maintain an acceptable level of physical fitness (American College of Sports Medicine, 1991).

EXERCISE TIME-the duration of the exercise protocol of the stress test. The count is in minutes and seconds accumulated during the testing process.

HR-Heart rate-the number of ventricular contractions of the heart, indicated in beats per minute. Resting heart rate, RHR, is taken prior to exercise, and is used as a baseline for adjusting maximum heart rate.

MAX-Maximum-highest level that can be measured or attained.

MAXIMUM HEART RATE-highest heart rate that can be obtained during exercise. This is generally adjusted to age and resting heart rate (American College of Sports Medicine, 1991).

MEDGRAPHICS$_{TM}$-a computerized pulmonary system utilized in the current study to analyze and measure the subject's pulmonary responses to the stress test. The system consists of a computer monitor, keyboard and printer. The measurement involves the subject breathing through a respiratory valve, with a noseclip attached. Gas exchange is then analyzed to determine each subject's functional capacity of the lungs. The two parameters that determine this are VO_2max and ventilatory threshold (MedGraphics, 1990).

MET-Metabolic Equivalent-the metabolic energy expenditure of an individual as compared to rest. One MET is equivalent to approximately 3.6 millimeters of oxygen per body weight per minute (Astrand and Rodahl, 1977; McArdle, 1991).

MONITOR-a mobile, adjustable computer screen, along with a keyboard and disk drive to store procedures, protocols and subject test results of the stress test.

NON-CONDITIONED-subjects who did not fulfill the requirements of the term conditioned.

PROCEDURE-a set of parameters that define the testing environment.

PROTOCOL-a specific workload sequence used for a particular stress test. A protocol is divided into a number of stages; each stage has a defined speed, grade and duration. The exercise stages are preceded by a rest stage, followed by a post-exercise recovery stage.

QUINTON$_{TM}$-a cardiovascular system (EKG), that measures and records a subject's heart rate during the exercise protocol. It consists of a treadmill (Q55), which is under the operational control of the monitor and EKG recorder (Q4500), software version 3.0.

RPE-Rated Perceived Exertion-Self rating scale developed by Borg to measure an individual's perceived efforts during exercise. It represents a multitude of factors including, heart rate, muscle strain, oxygen uptake, lactate accumulation and body temperature. It is expressed in numbers six through twenty, ranging from 7-very, very light to 19-very, very hard (Thomas and Nelson, 1990).

STAGE TIME-the duration of the protocol stage.

STRESS TEST-a procedure used to test cardiovascular and pulmonary responses. Consists of a subject performing controlled exercise while heart rate and lung activity are measured with precise instruments. It is also called a Symptom-Limited Graded Exercise Test, SLM-GXT.

VO_2MAX- Maximal oxygen consumption or uptake during exercise, per unit time. It reflects the heart's performance as a pump, and the efficiency of the blood flow distribution. VO_2max equals cardiac output and oxygen, expressed in liters per minute (Astrand and Rodahl, 1977).

Chapter 2

REVIEW OF LITERATURE

DEVELOPMENT AND VALIDATION OF PERCEIVED EXERTION

In 1958, the first psychophysical studies began in Sweden and dealt with the problems of subjective force and perceived exertion. Borg's first study (1962), "Physical Performance and Perceived Exertion", consisted of the adaptation of work and the environment. He utilized lumberjacks, and had them exercise on a bicycle ergometer pedaling at relatively constant speeds of 50 to 60 revolutions per minute (RPM). He then asked them to establish their own working preference level, based on a comparable workload out in the forests. Borg defined this as being the most comfortable or right level during activity. He concluded that each individual's variation in the intensity of perception follows a curve that correlates pulse rate and blood lactate concentration. It was also concluded that a subjective rating provided important information on motivation and how that rating influenced physical work perceptions. This research was expanded to include working capacity, performance, motivation, and perception of work (Borg, 1973). These factors, as perceived by body sensations with past experiences, were used as a frame of reference for evaluating perception of effort. Borg's RPE attempts to give these "feelings" a subjective rating during exercise. The overall perception of exertion which is defined by Borg and Noble (1974, pg. 150), includes, "a gestalt or configuration of various sensations of effort and stress due to physical work. Peripheral sensations from joints and muscles, and central sensations from the cardiovascular system, formed together with previous experiences". Other factors such as heart rate, VO_2max, ventilatory minute volume (V_E), carbon dioxide production (VCO_2), lactate accumulation, catecholamine production, body temperature, and localized aches and pains of the working muscles and joints, represent some of the many other variables in perceived exertion rating (Morgan and Borg, 1976). Perceptual responses to physical work also greatly complement these physiological indicators, which are commonly used in research design studies (Docktor and Sharkey, 1971; Ekblom and Goldbarg, 1971; Skinner, Borg, and Buskirk, 1969). Ekblom and Goldbarg (1971), discovered while studying heart rate and RPE, that RPE is not only determined by the input of central cues (tachycardia), but also by local factors (muscle strain). This two factor theory attempted to explain the differences seen between modes of exercise (i.e., running which is more cardiorespiratory than walking, would exhibit a more central cue). This was also supported by Allen, Pandolf (1976) and Hetzler, Seip, Boutcher, Pierce, Snead, Weltman (1991) who found that 50-80% of VO_2max uptake significantly affected the RPE and blood lactate, which was shown to be one of the primary cues for RPE. The subjective rating of the intensity of the exertion as perceived by the individual has been proven to be a reliable and valid indicator of physiological stress (Borg and Linderholm, 1967, 1970).

PERCEPTION OF EFFORT

Borg (1962, 1970), when developing his Rated Perceived Exertion Scale (RPE), intended it to be a good predictor of heart rate during the exercise at that precise moment. The scale was specifically designed to determine interindividual comparisons within research studies. Borg originally adopted a 21 point rating scale, and later condensed it to a 15 point scale (Carton and Rhodes, 1985). The fifteen point scale "estimated the total amount of exertion and physical fatigue combining all sensations... feelings of physical stress, effort and fatigue, concentrating on one's total inner feeling of exertion" (Borg, 1973, pg. 93). The scale, with the numbers ranging from 6-20, has verbal cues corresponding to the odd numbers (7 being very, very light and 19 being very, very hard). The numbers when multiplied by ten, should then represent an individual's typical resting heart rate (60) and an individual's heart rate at its maximum (200). Borg then concluded that in healthy middle-aged men, doing medium intensities of work, heart rate can be estimated by multiplying RPE by ten. This scale has proven to be of high reliability (r= .76-.90) and sufficient validity (Skinner, Hutsler, Bergsteinova and Buskirk, 1973a; Stamford, 1976). Later, however, Borg (1971) demonstrated that there are many deviations that can occur from this norm including: age, motivation level, and health or conditioning status of the individual. In 1972, The American College of Sports Medicine (ACSM) devoted its conference to perceived exertion. In the 1973 issue of "Medicine and Science in Sports", an ACSM journal, presentations of meetings given at the conference were reported and synopsed. Borg (1973) outlined psychophysical factors when subjectively evaluating an individual's physical work. These factors included: perceived exertion and fatigue, behavioral methods of performance, the relationship between fitness and stress, and the problems associated with estimation of force.

PHYSIOLOGICAL INFLUENCES OF PERCEIVED EXERTION

Studies done on RPE and other parameters, primarily their results, tend to vary greatly. These disputes stem from the researcher's emphasis to try and determine which dominant physiological or psychological cue is primarily responsible for the subject's response to Borg's scale. The results are not helped by the fact that the investigations are often widely different in their experimental design control. The different specific variables which are manipulated include: the RPE scale utilized, the range of the workload, the environmental conditions, the exercise mode, the duration of the testing process, and the age, gender, body composition, and conditioning level of the subject. It is no wonder then, that there is a strong disagreement as to which physiological parameter shows the strongest linear relationship with RPE. Recent studies have examined RPE and several of these physiological factors in an attempt to solve the problem of which of these variables is the most important when rating perceived exertion. Many other studies, found in the proceeding pages, have reported that other metabolic and non-metabolic factors may play a role in the subjective RPE response of an individual.

WORK INTENSITY

Perceived exertion and work intensity on both the treadmill and the bicycle ergometer, have demonstrated to be correlated in a linear fashion (Borg, 1962; Borg and Linderholm, 1967; Dunbar, Goris, Michielli and Kalinski, 1994; Frankenhauser, Post, Nordheden and Sjoeberg, 1969; Skinner et al., 1969). Because of this well documented relationship and the linear correlation between VO_2max and work intensity (Astrand and Rodahl, 1977), it is not surprising that many researchers support the existence of a strong relationship between RPE and both VO_2max and HR. VO_2max and RPE correlation coefficients from .76-.97 have been documented (Edwards, Melcher, Hesser, Wigertz and Ekelund, 1972; Sargeant and Davies, 1973). Heart rate and RPE correlation coefficients from .65-.90 have also been documented (Bar-Or, Skinner, Buskirk and Borg, 1972; Borg, 1962; Borg and Linderholm, 1967; Borg, Sherman and Noble, 1968; Edwards et al., 1972; Sargeant and Davies, 1973; Skinner et al., 1969). In a study conducted by Borg (1962), it was reported that RPE had a high correlation ($r=.83$) with the subject's absolute heart rate when the intensity of the work was varied from light to heavy. Morgan and Borg (1976) found a high correlation between heart rate and RPE during submaximal exercise in healthy adult males. They also found that RPE and heart rate, when used together, are better indicators of maximal work capacity than if they were used separately. This was undisputedly proven for both progressive work tests and for workloads that were presented in a random order (Morgan, 1973; Skinner et al., 1973a; Skinner, Hutsler, Bergsteinova and Buskirk, 1973b; Stamford, 1976). It led to the conclusion that RPE is a useful tool when prescribing exercise and when evaluating training performance.

Borg and Noble (1974) also studied the relationship of perceived exertion and work intensity. When the intensity of the work varied from light to heavy, in adult males, they found a higher correlation of RPE with absolute heart rate. When intensity was constant, correlation between workload and perceived exertion was low. Therefore, it was concluded that Borg's RPE scale was more accurate when intensity level of an exercise varied from low to high. It should be noted that these studies, done at the University of Pittsburgh and Pennsylvania State University, have not been officially published.

PHYSICAL TRAINING

Physiological and perceptual responses and varying conditioning levels have been studied by many researchers. Skinner et al. (1969) studied RPE in young men who differed in conditioning levels. During cycling at progressive exercise intensities to exhaustion, the subject's RPE was found to be closely related to their relative VO_2max. It should be noted, that at lower intensity workloads (75 kilopond-meters per minute (kpm/min) and 300 kpm/min), there were no significant differences in RPE and fitness levels of the subjects. At higher intensity workloads (600 kpm/min and 900 kpm/min), the conditioned subjects tended to have a lower heart rate and RPE response than that of the non-conditioned subjects. This study has been widely criticized, due to the fact that cardiorespiratory fitness levels were never initially assessed. In other words, VO_2max was not determined (Patton, Morgan and Vogel, 1977). Differences of RPE have also been reported between conditioned and non-conditioned middle-aged men at given submaximal workloads (Bar-Or et al., 1972). The conditioned subjects tended to rate their perception of effort lower than that of non-conditioned subjects. It was concluded that RPE is closely related to submaximal heart rate, relative to the workload at that time. In this study, VO_2max was also not initially determined, therefore, this study is also often dismissed as unreliable by other researchers (Patton et al., 1977). The differences seen in this study are not substantiated by the investigators. It can be hypothesized, therefore, that at any given workload, differences could exist between RPE and conditioning levels if maximal oxygen uptake had been measured.

Studies have also addressed the physiological and perceptual responses to physical training. When an individual is involved in a training program, it is well known that their maximal performance capacity increases. This has been shown to decrease the subject's response to a given submaximal workload intensity of effort (Borg, 1971; Haskvitz, Seip, Weltman, Rogol and Weltman, 1992). It has been found that training reduces the perception of effort of absolute work performed at submaximal levels (Docktor and Sharkey, 1971; Ekblom and Goldbarg, 1971; Kilbom, 1971; Borg and Linderholm, 1967; Patton et al., 1977). When these previous studies have been reviewed further (Borg and Noble, 1974), the relationship between RPE and heart rate appears to be unchanged with training. In a later study done by Skrinar, Ingram and Pandolf (1983), it was found that endurance trained subjects often rated their perceived exertion to be less than that of untrained subjects. The most important determination in studies involving various fitness levels of individuals seems to be the percentage of VO_2max they are working at. If non-conditioned subjects are working at 81% of their VO_2max, and conditioned subjects are working at only 75% of their VO_2max, then we would expect to see significant differences in their perception of effort. Therefore, it can be concluded, that neither aerobic power, nor physical fitness is a significant factor in light or moderate work, but is significant when the subject works at 80% or more of their maximal power (Patton et al., 1977; Skrinar et al., 1983). There has, however, been some disagreement in this area when elderly subjects underwent training. It was found that RPE tended to increase in the trained individuals rather than the suspected decrease as previously noted (Sidney and Shephard, 1977). The researchers offered no plausible explanation for these findings.

EFFECTS OF AGE

Borg and Linderholm (1967) studied the influence of age on perceived exertion. A maximal stress protocol using bicycle ergometers, compared various age groups and their perceived exertion. It was reported that in older subjects the heart rate was perceived to be greater than that of the younger subjects. Thus, Borg and Linderholm concluded that "with increasing age, the work resulting in a given pulse frequency was rated to be more laborious" (pg. 205).

The longitudinal studies undertaken for perception of effort tend to have inadequate control groups for comparative purposes. The problems with many such studies, is that subjects often become biased in their responses by wanting to 'please' the researcher with their answers. In other words, they can respond to demand characteristics imposed by this type of research design (Orne, 1962). It is often obvious that RPE should decrease with training even to the most unaware subject (Patton et al., 1977; Sylva et al., 1990).

GENDER DIFFERENCES

The majority of the investigations on RPE have involved men. There is very little that is known about the perception of effort among women. Much of the data available is controversial and extremely limited (Nobel et al., 1980; Skrinar et al., 1983). Females have been found to have a slightly higher heart rate than males at equal perceptual ratings (Borg and Linderholm, 1970). Henriksson, Knuttgen, and Bonde-Petersen (1972) have found that females also perceived their exertion, at certain workloads and VO_2max, to be greater than that for male subjects. It should be noted, that there would have been significant differences seen if relative values would have been taken into consideration (Borg and Noble, 1974). In Mihevic's (1979, 1981) study of conditioned and non-conditioned women and their perception of effort, she found that less physically fit women tended to be more extroverted and tense in their responses of RPE as it pertained to physical effort. Sidney and Shephard (1977) studied RPE during progressive treadmill walking in elderly (aged 60-70 years of age) men and women. Ratings tended to be higher for the women than for the men, at any given VO_2max. When this was expressed as a VO_2max percentage (i.e.-relative), however, there were no significant differences between the men or the women. Absolute verses relative values of VO_2max were studied in male and female subjects during exhaustive exercise on a treadmill (Noble et al., 1980). During all stages of the test, at absolute VO_2max values, the females tended to display a higher RPE than that of the males. When VO_2max values were expressed in relative terms, there were no significant differences cited. It was concluded that differences in RPE are primarily a matter of mean body size and the women's lower cardiac output when compared to men's.

BODY COMPOSITION

Skinner et al. (1969) studied perceived exertion of obese and lean males, and determined there were no significant differences between the two groups during a randomly applied work force or in a progressively applied work force. He concluded that progressive work takes less time to produce highly reliable and valid test results. In a study conducted by Bar-Or et al. (1972), ratings of perceived exertion between lean and 'overweight' young and middle aged men, who were tested on a bicycle ergometer, were found not to be significantly different. The 'overweight' men tended to have an average body fat content of between 16 and 20%, and therefore could not be considered obese.

This study helps confirm findings by Skinner et al. (1969) that body composition, in relation to lean muscle mass and fat body mass, was found not to significantly affect RPE.

ENVIRONMENTAL CONDITIONS

Noble, Metz, Pandolf and Cafarelli (1973) tested the responses of RPE in regard to different environmental conditions. They looked at the responses of six adult males in a heated environment. RPE was found to linearly increase with heart rate, ventilation, skin temperature and respiration rate. However, a later study done by Pandolf, Cafarelli, Noble and Vogel (1977) concluded that "man does not directly attend to physiological processes per se, but tends to externalize-i.e., an increase in ventilation, heart rate and temperature can be directly perceived" (pg. 109).

PSYCHOLOGICAL INFLUENCES ON PERCEIVED EXERTION

Morgan (1973) investigated the psychological effects on perceived exertion. He studied 15 male psychiatric patients and evaluated personality traits, depression traits, anxiety levels and somatic depression through the use of a test battery. He found that these psychometric variables interacted with the RPE (Borg's modified scale was utilized) and recommended that when studying RPE a psychobiological approach be utilized. He concluded, however, that these subjects lacked the ability to interpret subjective sensations, so it was not a true indicator of RPE. Morgan and Borg (1976) later reported that RPE can be considered accurate, "unless the individual is anxious, neurotic or depressed at the time of the test" (pg. 127). Robertson, Hiatt, Gillespie and Rose (1975) studied augmenters and reducers while cycling. Augmenters tended to consistently magnify perceptions of incoming stimuli, whereas reducers tended to decrease what they perceived. The study sought to determine if augmenters increased RPE scores at a given work level as compared to reducers. No significant differences were found between groups in aerobic fitness and physiological responses. However, there were between group differences in RPE that were significant. Scores of augmenters were elevated compared to that of the reducers. It was concluded that the likelihood of a physiological cause of RPE differences was decreased and sensory augmentation and reduction appears to be more influential on RPE at less stressful workloads and becomes less influential as the stress is increased. Furthermore, Carver, Coleman and Glass (1976) reported that individuals classified as Type A personalities displayed lower fatigue ratings than the Type B personalities at equivalent relative workloads. This investigation suggests that the perception of exertion can be mediated by trait personality characteristics. However, Ross (1977) reported that there were no significant differences between Type A and Type B personalities, RPE and heart rate correlation. This suggests that different personality types do not influence perception more than physiological and psychological states do.

SUMMARY

In summary, a number of recent studies have examined the influences of factors such as conditioning level, training, hypnosis and motivational suggestions on RPE, with results that have often been equivocal. The present study investigates the influence of gender and conditioning level on perceived exertion. Specifically, this study was designed to determine whether there were any differences between males and females, and between conditioned and non-conditioned subjects, and their perceptions of the intensity of work being performed.

Chapter 3

METHODOLOGY

The intent of this study was to determine if there was a significant difference in gender ratings of perceived exertion, and between conditioned and non-conditioned subjects. This chapter includes the methodology as it applied to this investigation. The following information will be conveyed: pilot study, subjects, instrument assessment, data collection and data treatment.

PILOT STUDY

Spring Quarter, 1994, the investigator conducted a pilot study at the College of St. Catherine's in St. Paul, Minnesota. Subjects for the study consisted of 8 male volunteers that ranged in age from 16-55. The fitness level of each subject was evaluated by a research developed survey. As a result of the responses to the survey questions, those subjects who displayed physical activity at least three times per week, for twenty minutes each time, were considered conditioned athletes. Subjects who did not display physical activity at least three times per week, were considered non-conditioned. Perception of effort was based on Borg's Rated Perceived Exertion Scale (RPE) and differences in test 1 and test 2 scores were related to actual heart rate at that time. Heart rate was monitored using a Polar$_{TM}$ heart-rate device worn by each subject, with only the investigator having access to the wristband. Two independent trials for each subject were held within a two week period of each other. The format consisted of a five minute warm-up, with RPE taken during that time. A twenty minute workout on the treadmill, with each subject working within their specific target heart rate (based on ACSM guidelines for exercise prescription), was then enacted. RPE was taken at five minute intervals, along with the monitored heart rate. A five minute cool down ended the trial session.

The results of the pilot study were as follows:

1. There were no significant differences in RPE scores and heart rate between conditioned and non-conditioned subjects.

2. There were no significant differences between RPE scores of test 1 and test 2.

As a result of the pilot investigation, the following recommendations were made for further study:

1. The wide range in ages of the subjects involved in the pilot study could have affected the data. Therefore, to increase the homogeneity of the group, the investigator recommended limiting the age difference within the group to no more than fifteen years.

2. The subjects involved consisted of all males, which lead the investigator to believe that the scores of RPE could be slightly skewed. Therefore, the investigator incorporated both male and female subjects into this investigation.

3. Since the sample size of the pilot study was considered to be small, any potential to generalize the data was in question. To compensate for this, the investigator increased the sample size to sixteen male and sixteen female participants.

4. The Polar$_{TM}$ heart rate monitor utilized was not effective in determining heart rate at all points in the trial. Therefore, the investigator determined that printed EKG recordings of the heart's activity would be a more accurate determination of heart rate.

5. Because the trial utilized a single stage test in the pilot study, the investigator recommended the use of a multi-stage treadmill test to provide a better correlation of heart rate and RPE values.

The mean data collected from the pilot study can be found in Appendix A.

SELECTION OF SUBJECTS

Sixteen males and sixteen females, ranging from 21-35, (mean age 25.73) were selected from a pool of subjects attending Mankato State University. Information regarding this investigation was available on electronic mail messaging, and flyers distributed throughout the college. All notices were in compliance with rules and regulations set forth by Mankato State University. These volunteers consisted of both conditioned and non-conditioned subjects. All subjects were considered asymptomatic in regard to coronary heart disease. This was determined by reviewing their medical history questionnaire (see Appendix B, sections 1 and 2).

After all governing bodies accepted the proposed research study, approval was granted by the Institutional Review Board (IRB) at Mankato State University. The investigator obtained the consent of each of the subjects by having them sign a written form prior to any of the testing. This insured the privacy and confidentiality of all subjects involved in the test and met proper human subject protocol (see Appendix C, sections 1, 2, and 3). This consent form also informed the subjects of the risks involved in participating in a maximal exercise test.

INSTRUMENT ASSESSMENT

The investigator administered a researcher developed survey that determined the status of each subject's physical activity level (see Appendix D). In addition, the subjects received a packet of general instructions (see Appendix E), and information regarding the Bruce protocol (see Appendix F). Borg's Rated Perceived Exertion Scale (RPE), based on 15-points ranging from 6 (no effort at all) to 20 (exhaustion), was utilized (see Figure 1). Each subject was briefed on how this rating scale worked (see Appendix G, sections 1

BORG'S RATED PERCEIVED EXERTION SCALE

6

7 VERY, VERY LIGHT

8

9 VERY LIGHT

10

11 LIGHT

12

13 SOMEWHAT HARD

14

15 HARD

16

17 VERY HARD

18

19 VERY, VERY HARD

20

Figure 1. Borg's Rated Perceived Exertion Scale (RPE).

and 2) and was educated based on the concept that if the RPE value was multiplied by ten it should be approximately the heart rate of the individual at that given time. RPE values have been shown to correlate with heart rate in healthy males (Borg and Noble, 1974). During the briefing the subjects were asked to rate their total feeling at that time, not to rate the feeling based on one single factor, such as a leg cramp or muscle twinge. The subjects were asked to concentrate on the overall level of exertion during the treadmill protocol.

The Bruce treadmill protocol was utilized for the test 1 and test 2 evaluations. The test consisted of seven stages, with each stage lasting three minutes. Grade was increased by two percent every three minutes, initially starting at ten percent. The speed was started at 1.7 mph and increased according to the grade increases. An estimation of the Bruce protocol, including the measurements of speed, elevation and METS (metabolic equivalents) can be found in Figure 2. Termination of the testing was based on any one of the following criteria: achievement of maximum heart rate, significant or abnormal EKG readings, patient request to terminate the test, or a dramatic increase or decrease in subject's blood pressure (ACSM guidelines). Four electrodes were placed on the trunk area, which resulted in a 4-lead EKG reading. (see Figure 3). Resting heart rate, blood pressure, and a baseline EKG were obtained prior to the start of the test.

VALIDITY AND RELIABILITY

The investigator and research assistant calibrated the instruments before actual testing began. For the Quinton$_{TM}$ treadmill, this consisted of manually measuring the speed of the belt to make sure it coincided with the speed of the protocol at any given minute of the testing process. The actual procedures followed for this calibration can be found in Appendix H. The slope of the treadmill was also calibrated manually. The treadmill was started at a minimum or 0% elevation, the elevation on the monitor read 0%. The

BRUCE PROTOCOL

STAGE	SPEED (MPH)	DURATION	ELEVATION	METS
1	1.7	3 minutes	10%	5
2	2.5	3 minutes	12%	7
3	3.4	3 minutes	14%	10
4	4.2	3 minutes	16%	13
5	5.0	3 minutes	18%	16
6	5.5	3 minutes	20%	19
7	6.0	3 minutes	22%	22

Figure 2. The Bruce protocol utilized by the subjects during exercise testing.

ELECTRODE PLACEMENT

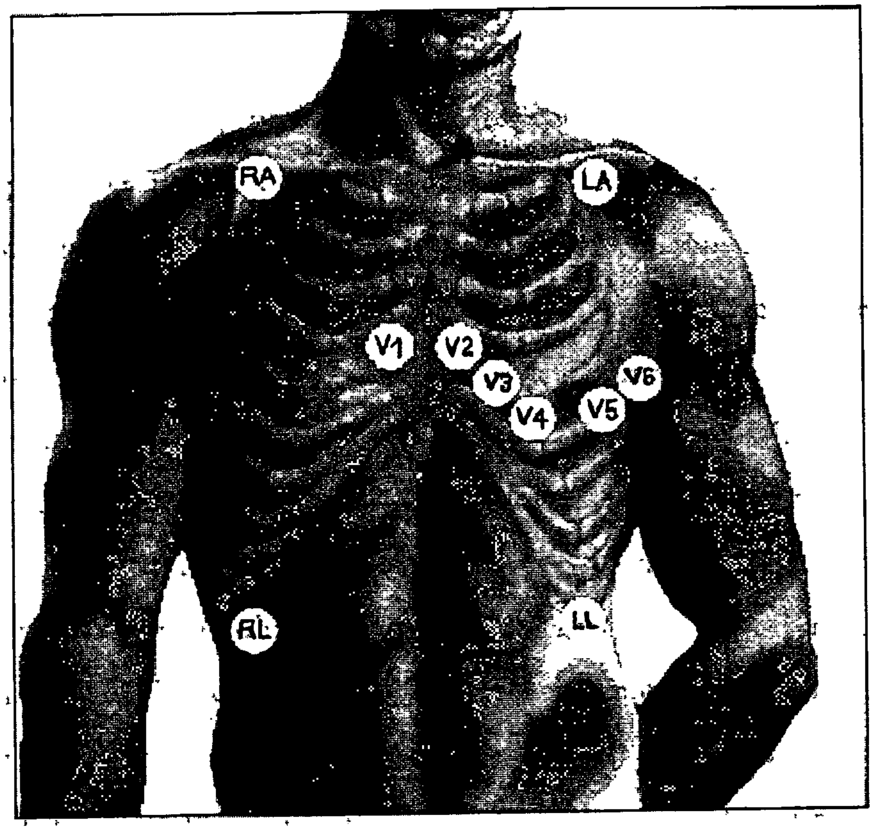


Figure 3. Electrode placement during the SLM-GXT. Only a 4-lead site was used; RA, LA, RL, and LL.

treadmill was raised to a maximum elevation of 25.3%, the elevation on the monitor read 25.3%.

The investigator then ran a 'mock' Bruce protocol, to assure slope was appropriate for each stage in the testing process. The MedGraphics$_{TM}$ analyzer was also calibrated manually to determine the oxygen and carbon dioxide mix of gas, which were used for references when determining measures of VO_2max for each subject. This protocol can be found in Appendix I. Error of the flow rates of the calibration and reference gases were found to be less than .03%, therefore, a correction factor was not used. Once the treadmill and the gas calibrations were complete, five subjects who were independent from the current study, were asked to complete the protocol of the Bruce test, two separate times. These tests were completed under the same environmental conditions. They helped establish reliability and validity for not only the instrumentation, but for rater reliability, which was especially important when obtaining blood pressure readings. Blood pressures were taken at rest and recovery for each subject. There was no significant difference in any physiological factor measured. (Blood pressure: df=3, F ratio=1.69, r=.853).

The survey instrument was chosen based on responses given in prior studies. The results of the physical activity questionnaire were cross-referenced with the medical history questionnaire, which also had a section where the subjects could list the amount of their daily physical activity. All information on the physical activity form appeared to be in agreement with that of the medical history form.

TESTING PROCEDURES

The investigator recorded the environmental data relevant to the testing area. These recordings included air temperature, relative humidity, and barometric pressure.

Temperature (mean=25°C) and barometric pressure (mean=744 mmHg) were taken off a Nova Barometer (Princo: Southampton, PA), while relative humidity (mean=30%) was obtained from a Bacharach Humidity Recorder (Bacharach: Pittsburgh, PA). Prior to the start of the test, the subjects were given a verbal explanation and demonstration of the testing procedures. All subjects were advised of the nature of the study by the investigator. At this time, the subjects were encouraged to ask any questions relevant to the testing. If the subject had no questions, the testing procedures were then started.

The subject's skin was prepared for the 4-lead electrode placement. The white lead (RA), which denoted the right arm, was placed on the right upper side of the trunk area, in the infraclavicular region. The black lead (LA), which denoted the left arm, was placed on the left upper side of the trunk area, in the infraclavicular region. The green lead (RL) and the red lead (LL), which denote the right and left legs respectively, were placed on the right and left lower quadrant of the trunk, just above the inguinal ligament. The procedures followed were according to the instructions on the 3M™ Dot™ Ag/AgCl disposable electrode package, which were the standard electrodes utilized throughout the entire testing process. The procedures for the electrode skin site preparation can be found in Appendix J. A decreased resistance to the electrical connection or current, is desired to prevent interference of the EKG data. Failure to prepare the skin site properly could cause baseline shifts and EKG noise from the subject's motion and respiration, which could result in inaccurate readings or measurements of the heart's activity. The subject's personal data was then entered into the Quinton$_{TM}$. The data included the subject's age, height, weight, gender, smoking status and medications. It should be noted that none of the subjects were smokers or took medications that would effect the results of the tests. The computer automatically calculated each subject's predicted maximum heart rate, along with their target heart rate.

The subjects were allowed to relax for a few minutes while a resting EKG was obtained. An automatic pre-test electrode check was done to prevent improper placement of the electrodes.

The subjects were then hooked up to the MedGraphics$_{TM}$ diagnostic gas analyzer. They were asked to insert a mouthpiece and pneumotach fully into their mouth and seal their lips as tightly around it as possible, without causing any unnecessary discomfort. The mouthpiece and pneumotach were the devices used for breath by breath gas collection from the subjects. They were also asked to attach a noseclip, as not to allow any air through the nasal passageways. It should be noted that an open circuit system was used. For a few minutes, they were allowed to get used to the apparatuses. This helped prevent them from hyperventilation and claustrophobic attacks. It was also noted that speaking would be difficult, therefore, it was recommended that head or hand gestures be enacted at this time.

The subjects were then instructed on the proper use of getting on and off the treadmill. The actual guidelines for safe procedures on the treadmill can be found in Appendix K. It was explained that the treadmill would never be started or stopped while they were standing or running on it. It was also noted that both the grade and the speed of the treadmill would be at minimum levels during the start of the test, and immediately following the completion of the test. The importance of not relying on the handrail for support, unless it was absolutely necessary, was also stressed. They were told that gripping the handrail could cause electrical interference that could affect the accuracy of the measurements being taken. The one exception to this was to notify the investigator to terminate the test, which included the subjects placing both hands on the handrail to signal their fatigue. The subjects were allowed a short one to three minute time interval in order to warm-up. This involved some stretching and light calisthenics. All protocols included an initial rest or warm-up period and were followed by a post-exercise recovery period of three minutes.

DATA COLLECTION

Test 1 and test 2 were administered by the investigator at Mankato State University Spring of 1996. All stress tests were performed within ACSM guidelines for exercise prescription. A Quinton$_{TM}$ 55 treadmill and 4500 recorder, along with a MedGraphics$_{TM}$ ventilatory analyzer, were employed as the testing devices for the Symptom-Limited Graded Exercise Test (SLM-GXT). The Q4500 control systems that were responsible for the initiation of the start of the Bruce protocol are as follows: the start treadmill key (green), the stop treadmill key (red), the start exercise key (gray), which ends the warm-up phase and starts the exercise phase of the protocol, the stop exercise key (gray), which ends the exercise phase and starts the cool down or recovery phase, the end-test key (gray), which ends the recovery phase and terminates the test and the rhythm on and off key (gray), which starts printing continuous rhythm strip recordings of the electrode leads (Note Figure 4). Preparation of the Q4500 took less than 5 minutes after establishing the exercise protocol, testing environment and entering subject data. The stress test monitor features that were utilized during the testing process included: a pre-test electrode check, investigator comments entered during the testing, blood pressure, RPE and heart rate. Heart rate recordings were taken automatically at one minute intervals within the test. Graphed, thermal sensitive chart recorder paper from the Quinton$_{TM}$ Instrument Company was used to ensure quality readings. Blood pressure and RPE were taken the last 15 seconds of every three minute exercise stage. Blood pressure was taken with a stethoscope and a sphygmomanometer. RPE was recorded from each subject's verbal response after being asked the question, "How hard do you

TREADMILL CONTROL KEYS AND KEYBOARD LAYOUT

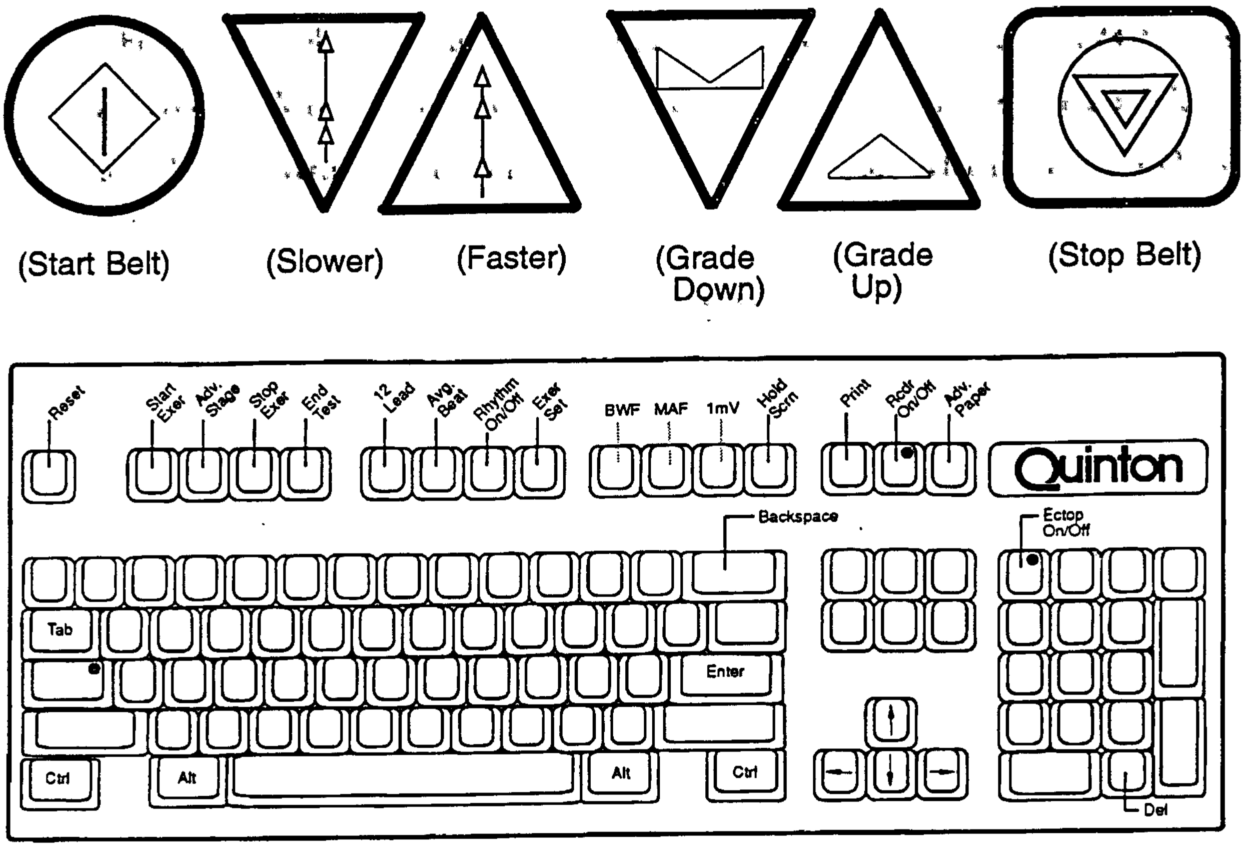


Figure 4. The treadmill control keys and the keyboard layout of the Quinton$_{TM}$ computer.

feel you are you working?" Each subject was asked to inform the investigator of any sudden onset of pain, fatigue or nausea. Verbal encouragement was employed to motivate the subjects to perform maximally. Test 2 followed the identical protocol within a two week time span. All information was stored on formatted 1.44 Mbytes mini-floppy diskettes, then analyzed and printed on a personal computer. Each diskette allowed the investigator to store up to five subject's data, which was particularly beneficial when recalling testing environment and protocol The data was also manually recorded. The data collection sheet can be found in Appendix L.

DATA TREATMENT

The raw data was computed and analyzed on a personal IBM statistical Excel program (Vincent, 1995).

The dependent t-test was the statistical formula utilized to compare mean differences in RPE at absolute workloads between test 1 and test 2 results. The .05 statistical level was selected as indicating significance.

Analysis of variance (ANOVA) and Scheffe post hoc tests were used to determine if there were differences between conditioned and non-conditioned subjects, or between male and female subjects. Significance was set at the .05 level.

A Pearson product-moment correlation was utilized to determine the relationship between heart rate and RPE (x 10) during test 1 and test 2. Heart rate and RPE were obtained during every third minute of the protocol for both tests. Correlations were utilized to determine whether gender or conditioning level affected the accuracy of the subject's perception of effort. The .05 statistical level was acceptable for significance.

Chapter 4

RESULTS

Table 1 lists the physical characteristics of the subjects and includes the means and standard deviations of age (years), height (centimeters), weight (kilograms), resting heart rate (beats per minute) and time to exhaustion (minutes). The subjects' mean VO_2max values were 38.43. A final data summary sheet of the physical characteristics of subjects in each subgroup can be found in Appendix M, sections 1, 2 and 3.

Table 1. Physical Characteristics of Subjects (N=32).

Characteristics	Mean	Standard Deviation
Age (years)	25.73	7.55
Height (cm)	174.04	12.71
Weight (kg)	71.59	9.72
RHR (bts/min)	71.43	3.56
Time to exhaustion (min)	12.96	2.37

RELIABILITY OF PERCEIVED EXERTION VALUES BETWEEN REPEAT TESTS

The correlations and t-test comparisons for RPE during minutes 3, 9 and 12 between repeat maximal tests are presented in Table 2. None of the t-values were significant ($p > .05$), however, the correlations were high to produce consistent results. The relatively lower correlations at the third minute may be explained by the fact that when the non-conditioned subjects were asked to rate their perceived exertion, they felt that the protocol was more strenuous than that of the conditioned subjects. At the ninth and the twelfth minute, both groups of subjects may have had sufficient information during test 1 upon which to base their answers.

Table 2. Correlations and T-Test Comparisons for RPE Between Repeat Maximal Tests.

RPE at:	M_1	M_2	r	t-value	df	2-tailed probability
3 min.	7.9	7.6	.610**	1.33	31	.193
9 min.	11.0	10.6	.756**	1.62	31	.116
12 min.	14.2	13.7	.828**	1.12	31	.270

**Significant at the .01 level.

The correlation and t-test comparison for RPE during the sixth minute between repeat maximal tests are presented in Table 3. Contrary to what was expected, the t-values for the sixth minute of rating perceived exertion were significant ($p < .01$). Thus, at several data points, the RPE values between repeat tests were not consistent. It should be noted that on seven of these data points, the RPE values decreased for test 2 when compared to the RPE recorded for that of test 1. It could be argued that some type of learning effect could have taken place between test 1 and test 2. This would be hard to support, however, due to the fact that the t-values at all other data points were not significant. Statistical averages were still done, based on the high correlation factors. It can also be argued that two averaged data points are more representative than one data point. Thus, the investigator chose to average the RPE values at all data points.

Table 3. Correlation and T-Test Comparison for RPE Between Repeat Maximal Tests.

RPE at:	M_1	M_2	r	t-value	df	2-tailed probability
6 min.	10.1	9.5	.889**	4.55**	31	.000

**Significant at the .01 level.

DIFFERENCES IN PERCEIVED EXERTION AMONG SUBGROUPS

Table 4 shows the mean values and standard deviations for perceived exertion ratings at 3, 6 and 9 minutes for each subgroup. Table 5 shows a summary of the 2-way analysis of variance (ANOVA) for perceived exertion ratings. The results of this analysis are discussed below.

The non-significant ($p > .05$) F ratio for gender could be an indication that gender has no effect on RPE. It should be emphasized that gender produced no significant effect on RPE when averaged over the two conditioning levels. Tables 6-9 show the results of the 1-way ANOVAs that were conducted to determine whether or not any differences existed in RPE between conditioned and non-conditioned subjects at 3, 6, 9 and 12 minutes, respectively. Although the investigator's research Hypothesis 1 was not supported in its entirety, it was partially supported in that males perceived their exertion to be significantly ($p < .05$) less, physiologically and psychologically, stressful than did females at the same highest absolute workload (see Tables 6-9). The finding of a significant gender difference, generally seen at higher workloads, is in agreement with results supported by Borg and Linderholm (1970), Henriksson et al. (1972), Michael, Durnin, Wormsley, Whitelaw and Morgan (1972), Noble et al.(1980) and Sidney and Shephard (1977).

Table 4. Mean Values and Standard Deviations for Perceived Exertion Ratings at 3, 6 and 9 Minutes for Each Subgroup.

		3 minutes		6 minutes		9 minutes	
Subgroup	N	M	SD	M	SD	M	SD
Males	16	7.96	1.40	10.31	1.10	11.40	1.80
Females	16	7.92	1.27	10.55	1.06	11.63	1.58
Cond.	16	7.50	1.07	9.88	1.27	10.27	1.16
Males	8	7.22	.88	9.25	1.09	11.63	1.55
Females	8	7.50	1.00	11.10	1.69	13.79	1.39
Non-Cond.	16	8.43	1.20	11.36	1.36	12.71	1.04
Males	8	8.75	1.28	11.75	.83	13.66	2.23
Females	8	7.93	1.45	12.14	1.21	14.31	2.51
All subjects	32	7.90	1.19	10.80	1.20	12.41	1.66

Table 5. Summary of Analysis of Variance for Perceived Exertion Ratings (N=32).

Source	SS	df	MS	F ratio
Gender	20.190	1	20.190	3.926
Conditioning level	34.119	1	34.119	6.634*
Gender x Cond. level	7.862	1	7.862	1.546

*Significant at .05 level.

The obtained F value for conditioning level was significant ($p < .05$) and indicates that RPE means, averaged for the conditioned and non-conditioned subjects at absolute workload, differed significantly. Like Hypothesis 1, Hypothesis 2 was supported in the fact that conditioned subjects perceived their exertion to be less than did non-conditioned subjects. It should be noted that nine out of the thirty-two subjects did not complete minute 12 of the protocol.

Table 6. Summary of 1-Way ANOVA for Perceived Exertion Ratings of Males and Females at 3 Minutes.

Source	SS	df	MS	F value
between groups	0.4444	1	0.4444	0.276
within groups	54.9053	30	1.6129	

*Significant at the .05 level.

Table 7. Summary of 1-Way ANOVA for Perceived Exertion Ratings of Males and Females at 6 Minutes.

Source	SS	df	MS	F value
between groups	0.9337	1	0.9337	0.722
within groups	75.4780	30	1.9056	

*Significant at the .05 level.

Table 8. Summary of 1-Way ANOVA for Perceived Exertion Ratings of Males and Females at 9 Minutes.

Source	SS	df	MS	F value
between groups	6.6534	1	6.6534	2.628
within groups	86.0678	30	2.5275	

*Significant at the .05 level.

Table 9. Summary of 1-Way ANOVA for Perceived Exertion Ratings of Males and Females at 12 minutes.

Source	SS	df	MS	F value
between groups	20.4511	1	20.4511	5.572*
within groups	139.7832	21	3.8284	

*Significant at the .05 level.

A significant two factor interaction can be examined in Figures 5 and 6, which graphically compare the magnitude of the differences between RPE of conditioned and non-conditioned, male and female subjects, respectively. The conditioned subjects consistently tended to rate their exertion lower than the non-conditioned subjects. Gender influences of RPE tended to be minimal until minute twelve, where the slope then increased for the females compared to that of the males.

PERCEIVED EXERTION AND HEART RATE CORRELATION

The investigator assumed the null hypothesis, that there would be no significant differences in the correlation between perceived exertion and heart rate obtained in test 1 and test 2.

Heart rate and perceived exertion were recorded at every stage of the protocol and utilized for statistical analysis. Correlations were used to determine whether gender or conditioning level affected the accuracy of one's perceived exertion rating.

Figure 5. RPE Differences Between Conditioned and Non-Conditioned Subjects (N=32).

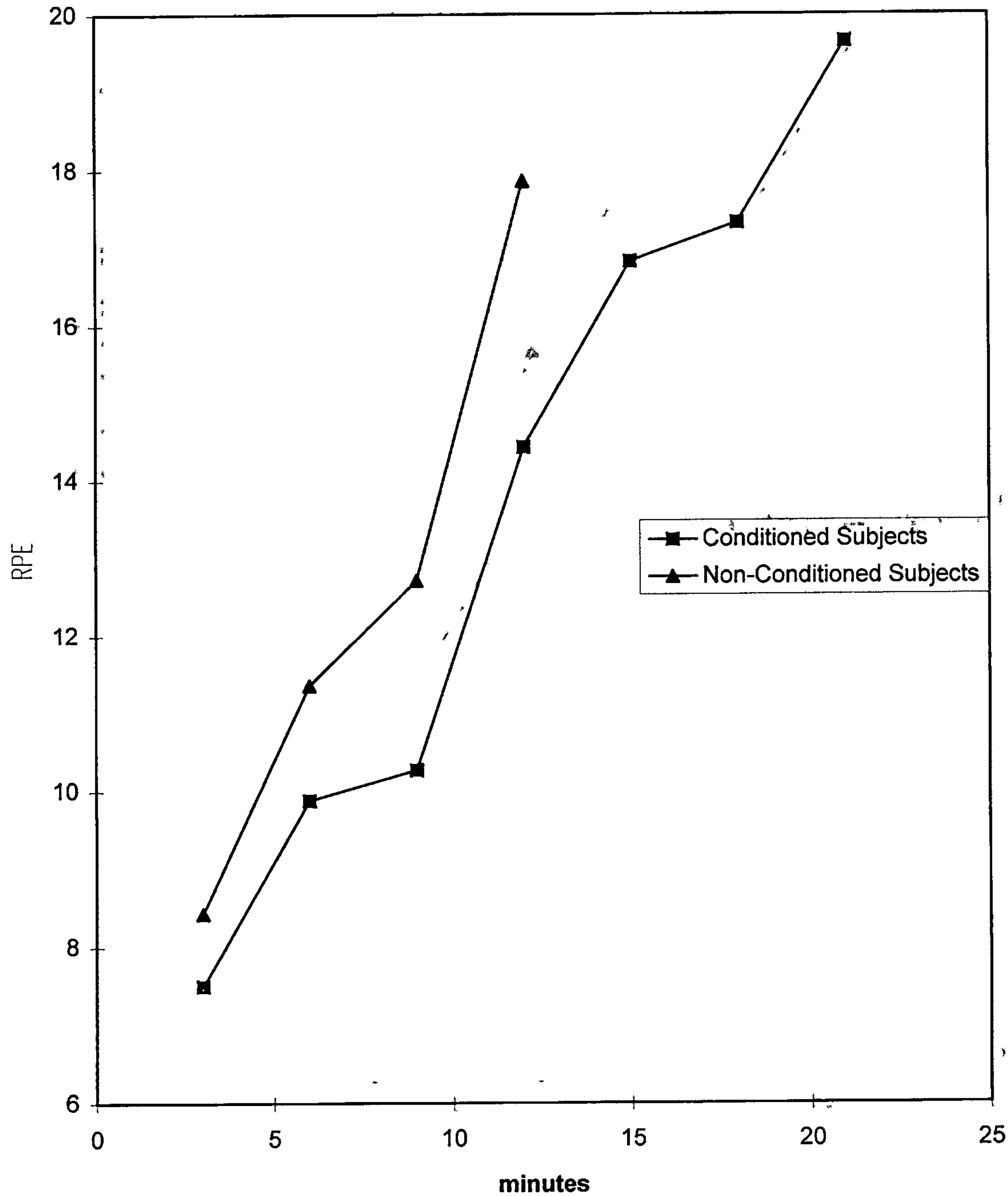
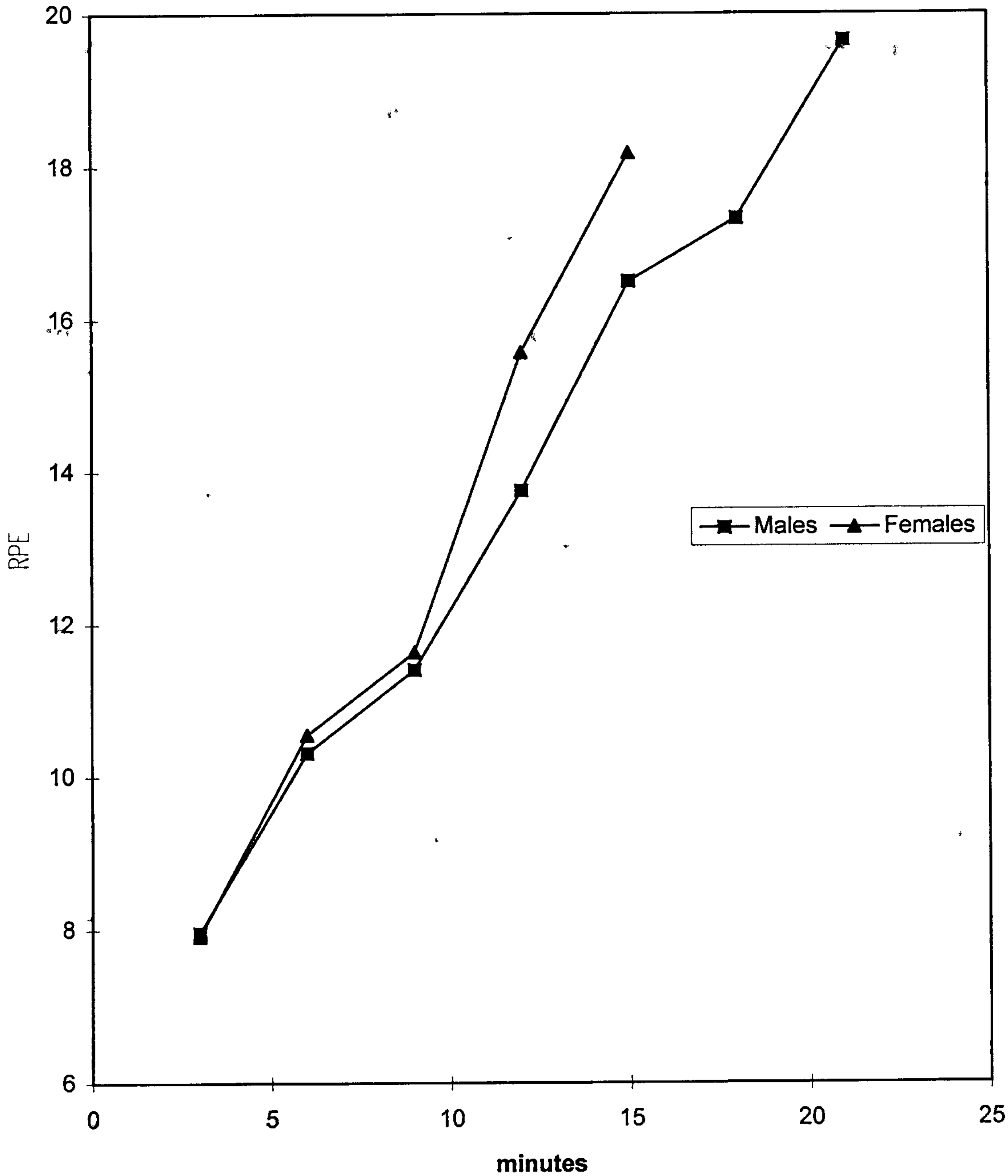


Figure 6. RPE Differences Between Males and Females (N=32).



The RPE, multiplied by ten, and heart rate were compared at the third, sixth, ninth and twelfth minute of test 1 and test 2. As stated earlier, nine out of the thirty-two subjects did not complete minute 12 of test 1 or test 2. Table 10 shows correlations which resulted during each stage of the protocol during test 1. All r values represented showed significant correlations. The higher correlations at 9 and 12 minutes indicated a strong perceptual ability of the subjects to rate exertion as they neared maximal exhaustion.

Table 10. Test 1 Correlation of Perceived Exertion and Heart Rate.

Minute	Mean HR	Mean RPE x 10	df	r
Three	92.50	79.00	31	.73**
Six	116.00	101.00	31	.75**
Nine	135.38	127.50	31	.83**
Twelve	148.16	141.75	22	.95**

**Significant at the .01 level.

Table 11 represents mean scores and correlations between heart rate and RPE obtained during test 2. Significance at the .05 level was not obtained until minute 9 of the protocol. This could be due to the fact that some type of learning effect occurred, which could have taken place between test 1 and test 2. A high correlation was once again reached at the ninth and twelfth minute, indicating the subject's ability to rate exertion as they neared exhaustion.

Table 11. Test 2 Correlation of Perceived Exertion and Heart Rate.

Minute	Mean HR	Mean RPE x 10	df	r
Three	97.88	76.00	31	.32
Six	107.83	96.33	31	.29
Nine	129.87	117.99	31	.79**
Twelve	150.00	138.66	22	.88**

**Significant at the .01 level.

Both test 1 and test 2 results showed a linear relationship between mean RPE scores and heart rate. Figure 7 illustrates the linear relationship between heart rate and perceived exertion during test 1 and test 2 for all subjects. Test 2 results indicated less of a relationship between RPE and heart rate, but remained linear. The effects of heart rate between conditioned and non-conditioned, male and female subjects, can be found in Figures 8 and 9. Conditioned subjects graphically showed that they possess a much lower heart rate than the non-conditioned subjects at absolute work, as was expected.

Females were found to have a lower heart rate at lower levels of absolute work, then tended to surpass the males' heart rates at approximately minute eleven of the protocol. When interpreting Figures 8 and 9, it is important to note that as time on the treadmill increased, the number of female subjects able to continue with the protocol decreased. This helps explain the cross-over of the females' heart rates during the eleventh minute.

DIFFERENCES IN VO_2MAX AMONG SUBGROUPS

One of the primary purposes of this investigation was to examine the influence of conditioning level on ratings of perceived exertion during physical exercise to

Figure 7.- Relationship Between Heart Rate and Perceived Exertion (N=32).

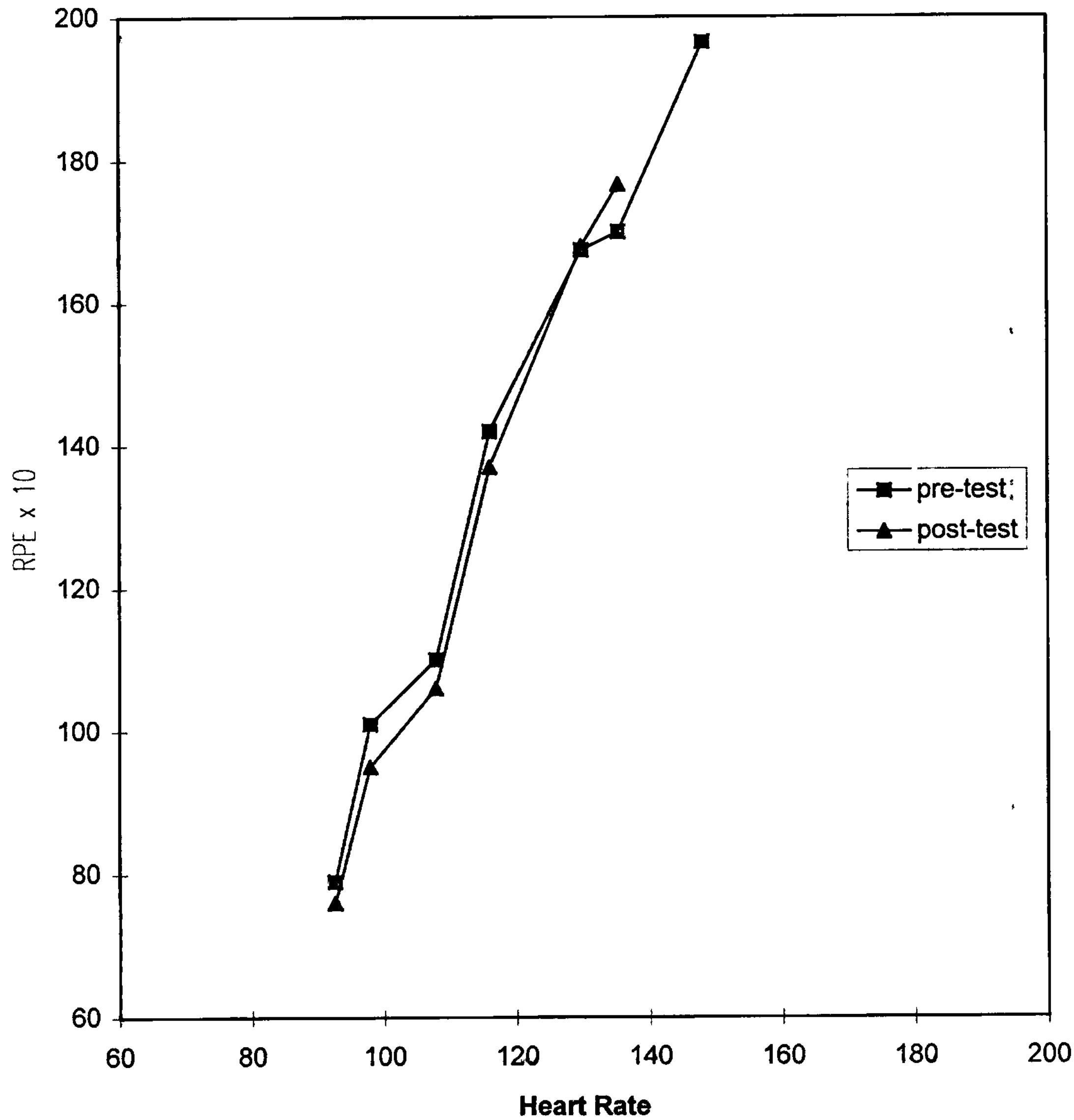


Figure 8. Heart Rate Differences Between Conditioned and Non-Conditioned Subjects (N=32).

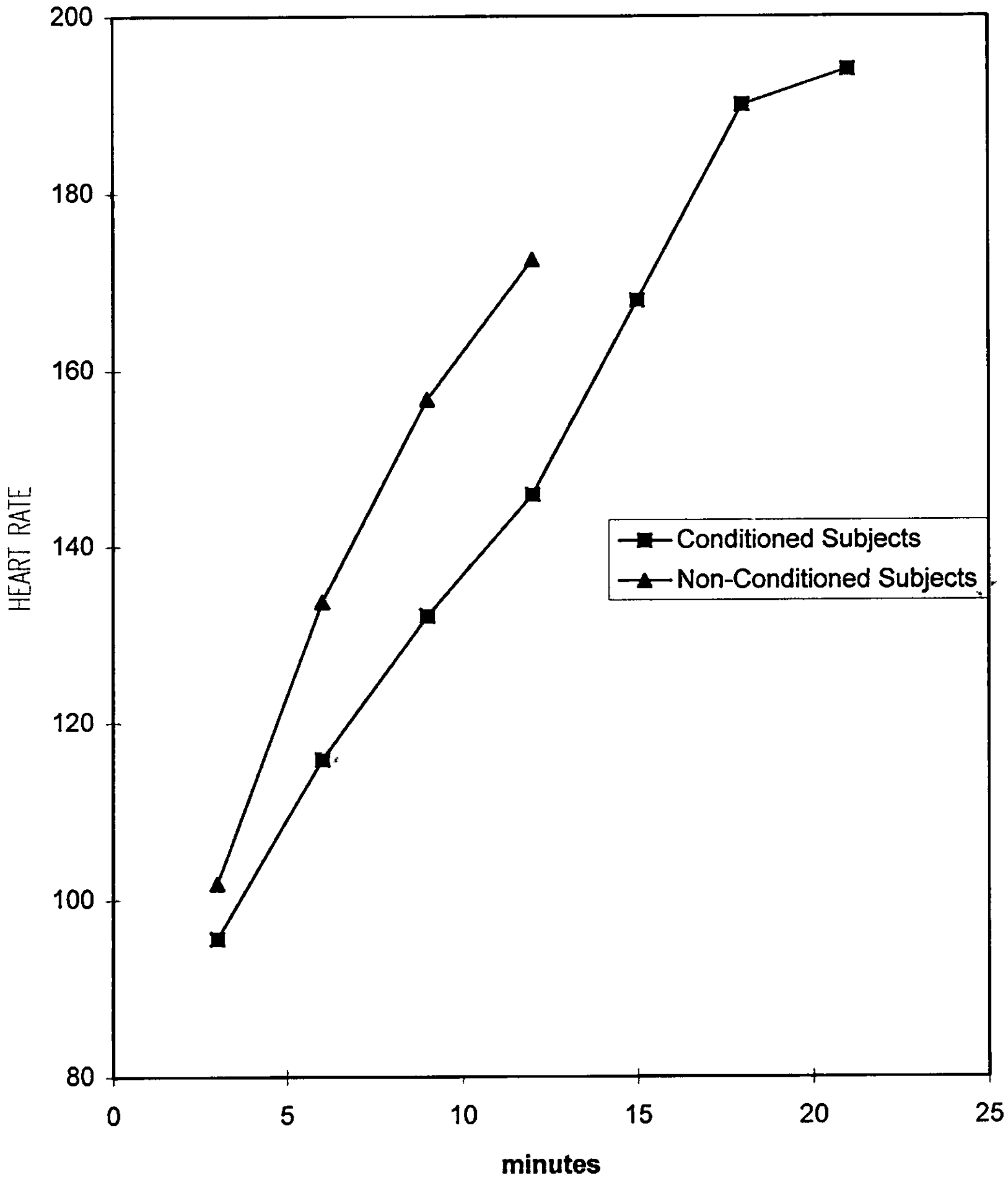
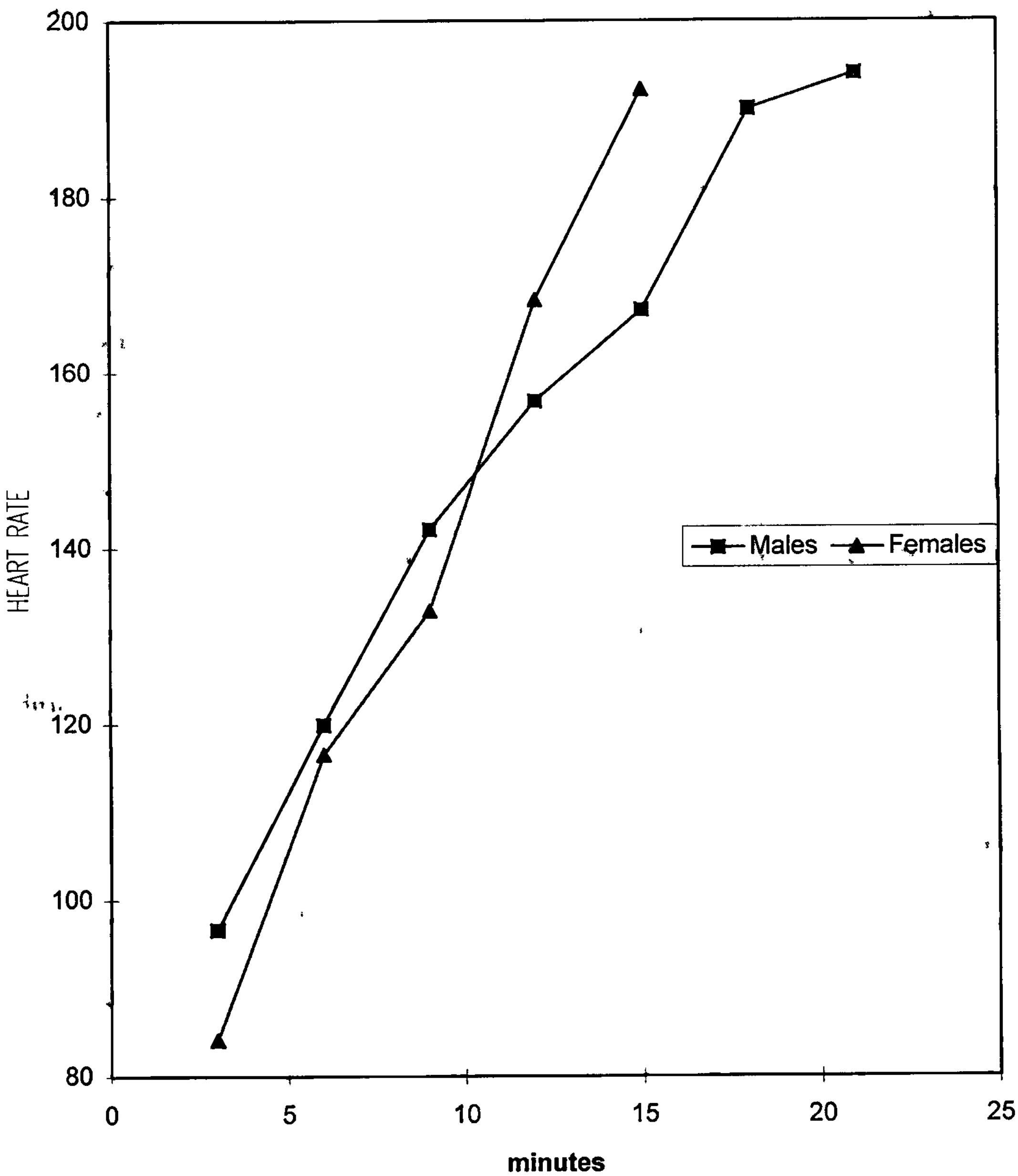


Figure 9. Heart Rate Differences Between Males and Females (N=32).



exhaustion. Subjects were assigned to one of two groups, conditioned or non-conditioned, based on their response to the physical activity questionnaire. Time to exhaustion was significantly greater for the conditioned group than for the non-conditioned group. Mean exhaustion times were 14.80 and 11.31 minutes, respectively.

Maximal oxygen consumption values indicated a significant difference in aerobic capacity between the two groups. A 2-way ANOVA showed that the differences in $\dot{V}O_2max$ between males and females and between conditioned and non-conditioned subjects were significant ($p < .01$) (see Table 12). A significant F value obtained from an ANOVA does not specify where in the subgroup the difference lies. Therefore, the differences in VO_2max were broken down further with the Scheffe post hoc test. Conditioned males had a significantly ($p < .01$) higher oxygen consumption than conditioned females ($F_{scheffe} = 19.059$), non-conditioned males ($F_{scheffe} = 24.901$), or non-conditioned females ($F_{scheffe} = 112.860$). There was no significant difference ($p > .05$) between conditioned females or non-conditioned males ($F_{scheffe} = .390$). Non-conditioned females had a significantly lower ($p < .01$) oxygen consumption as compared to conditioned males and females ($F_{scheffe} = 39.159$) and non-conditioned males ($F_{scheffe} = 31.73$).

Table 12. Summary of Analysis of Variance for Maximal Oxygen Consumption.

Source	SS	df	MS	F value
Gender	657.835	1	657.835	67.606**
Conditioning level	1225.815	1	1225.815	126.784**
Gender x Cond. level	17.879	1	17.879	2.922

**Significant at the .01 level.

Table 13 displays a cardiorespiratory fitness classification based on VO_2max per ml/kg/min. Conditioned males and females placed in the high and good categories, respectively. Non-conditioned males and females placed in the average and fair categories, respectively. This supports the investigator's allocation of the subjects into subgroups.

Table 13. Cardiorespiratory Fitness Classification.

Gender	Low	Fair	Average	Good	High
Females	<21.6	21.6-27.9	27.9-33.3	33.3-44.1	>44.1
Males	<22.5	22.5-29.7	29.7-37.8	37.8-44.7	>44.7

DISCUSSION

The present investigation was undertaken to examine the influence of gender and conditioning levels on ratings of perceived exertion.

All of the reliability coefficients reported in this study for RPE values between repeat maximal tests were similar to those found by Skinner et al. (1973a) and Stamford (1976). Based on these correlations, it can be concluded that the RPE scale was of high reliability. However, these investigations (Skinner et al., 1973a; Stamford, 1976) did not conduct t-tests in order to determine if significant differences existed in the RPE means between the repeat maximal tests. In confirming the reliability of the RPE scales, it would be more accurate if both correlation coefficients and t-tests were conducted in future studies. The present study did utilize t-tests to increase the reliability of the RPE scale.

It was hypothesized that male and female subjects would differ significantly when rating perceived exertion. Although this hypothesis was not entirely supported, the difference of RPE between males and females was significant only at high absolute workloads. This could be due to the fact that VO_2max gender differences were not significant between conditioned females and non-conditioned males. It could be conceivable that if a greater VO_2max difference existed between these males and females, there would have been a significant RPE difference observed. One should also consider the social conditioning influences that society places on gender. In the United States, females are often taught that it is acceptable to show their feelings and they are often perceived as the 'weaker' sex. Males on the other hand, are often taught that they must be mentally and physically strong. As a result of this societal influence, even if males are working very hard, they may try to convince themselves that they are not, by rating their exertion levels less than what they actually perceived them to be (Cottrell et al., 1968; Henchy and Glass, 1968; Klinger, 1969; Martens and Landers, 1972; Noble et al., 1980; Sylva et al., 1990; Zajonc, 1965). Females then, may be less inhibited to show how they actually feel and therefore rate their perceived exertion by choosing numbers more representative of their feelings at that time.

Although females were shown to have a lower heart rate for the third, sixth and ninth minute of the protocol, they tended to rate their perceived exertion higher than that of males. At minute 12 of the protocol, it was observed that the females' heart rates exceeded that of the males. Perceptual ratings were significantly greater during this minute for the females compared to the males. This finding is in general agreement with Henriksson et al. (1972), Michael et al. (1972), Noble et al. (1980) and Sidney and Shephard (1977). The difference observed for the conditioned and non-conditioned females was shown to become more significant as time on the treadmill increased. This supports Mihevic's (1981) study that less physically fit women tend to rate their perceived exertion levels higher than that of physically fit women. It should be noted that there was the same type of progressive difference noticed for the conditioned and non-conditioned males. As demonstrated by Noble et al. (1980), we would tend to see less or no significant difference between males and females had relative oxygen consumption been considered throughout the protocol. A correction factor for lean body mass size should be incorporated into future studies.

A remarkable difference existed between conditioned and non-conditioned subjects. Conditioned subjects were found to consistently rate their exertion level lower than the non-conditioned subjects during each stage of the maximal treadmill tests. The conditioned subjects appeared to perceive their work as less strenuous when the treadmill speed and slope were increased. This is fairly understandable, since the more conditioned a subject is, the less strenuous the exercise actually is. These findings are in agreement with the study done by Patton et al. (1977). They found that physical fitness and aerobic power are important significant factors when subjects work at high absolute workloads. It was determined that these conditioned and non-conditioned subjects were working at 80% or above of their VO_2max during these high absolute workloads. The present study also lends credibility to studies done by Docktor and Sharkey (1971), Ekblom and Goldbarg (1971), Kilbom (1971) and Borg and Linderholm (1967), who found that training or high conditioning levels reduced the perception of the subject's effort at absolute work being performed at submaximal levels.

When comparing heart rates between the conditioned and non-conditioned groups, the conditioned subjects once again had consistently lower heart rates at each minute of the exercise. These results would be expected when comparing subjects who differ in conditioning level at absolute work on the treadmill. This study further substantiates Borg and Noble's (1974) study, which concluded that the relationship between heart rate and RPE appears to be relatively unchanged with conditioning level. Further studies should consider each subject's relative oxygen consumption at each minute of the protocol. This would more accurately assess what percentage of VO_2max each subject is working at.

Chapter 5

SUMMARY

The intent of this investigation was to study the influences of gender and conditioning level on one's perception of physical effort. The Bruce protocol, $MedGraphics_{TM}$, and Borg's Rated Perceived Exertion Scale, were the measuring instruments utilized to evaluate physical work capacity, oxygen consumption and perception of effort respectively.

The subjects for the investigation were thirty-two male and female volunteers selected from a population at Mankato State University. The subjects participated in two independent tests held within a four week time period. Testing conditions of test 2 were identical to that of test 1.

T-tests were utilized to compare mean RPE at absolute workloads of test 1 and test 2. Analysis of variance and Scheffe post hoc tests were selected to determine significant differences between gender and conditioning levels. The Pearson product-moment correlation compared the heart rates and perceived exertions of test 1 and test 2. Heart rate and perceived exertion have been proven to possess a linear relationship. Measurements were recorded during every third minute of the protocol and were correlated for visual comparison.

CONCLUSIONS

Based on the analysis of the data obtained in this investigation, the following conclusions were warranted:

1. At absolute workloads, conditioning level was the critical factor in producing RPE differences, while gender was not of major importance. The magnitude of difference

in ratings between males and females and between conditioned and non-conditioned subjects became greater as the workload increased. The differences in VO_2max that existed between: conditioned males and non-conditioned males and females; conditioned males and conditioned females; and conditioned females and non-conditioned females, during the heaviest workload, showed that differences in RPE were significant. Thus, it can be concluded that as opposed to being just significant, the differences that were seen in aerobic power must be great, in order to find significant differences at absolute workloads.

2. The finding of a strong linear relationship between RPE and several physiological variables, which include heart rate and maximal oxygen consumption, suggests the possibility of using these perceived exertion ratings to predict physiological measures during exercise. These predictions can be used on subjects who have been previously familiarized with Borg's RPE scale and who have been tested in laboratory procedures while several physiological and psychological measurements have been made. Ratings of perceived exertion do not seem to be a function of a single physiological factor, rather RPE seems to involve several physiological integrations of these parameters.

RECOMMENDATIONS

As a result of the conclusions drawn from this investigation, the following recommendations for future study were made:

1. A replication of this investigation utilizing a larger sample size.
2. A replication of this study with a measurement of the anxiety level of the subjects prior to testing procedures.

3. An investigation which would include only female subjects, the determination of where they are at in their menstrual cycle and if it correlates to point of exhaustion in the protocol.

4. An investigation which would consider each subject's relative oxygen consumption at each minute of the protocol. A correction factor for lean body mass should also be included.

BIBLIOGRAPHY

BIBLIOGRAPHY

Allen, P. D. and Pandolf, K. B. (1976). Rated perceived exertion associated with breathing hypernoxic mixture during submaximal work. Medicine and Science in Sports, 8, 64 (Abstract).

American College of Sports Medicine (ACSM). (1991). Guidelines for Graded Exercise Testing and Exercise Prescription, (Fourth Edition). Philadelphia, PA: Lea and Febiger.

Astrand, P. O. and Rodahl, K. (1977). Textbook of Work Physiology, (Second Edition). New York, N. Y., McGraw-Hill.

Bar-Or, O., Skinner, J. S., Buskirk, E. R. and Borg, G. A. V. (1972). Physiological and perceptual indicators of physical stress in 41-60 year old men who vary in conditioning level and in body fatness. Medicine and Science in Sports, 4, 96-100.

Borg, G. A. V. (1962). Physical performance and perceived exertion. Lund, Sweden: Gleerups.

Borg, G. A. V. (1971). The perception of physical performance. Frontiers of Fitness, R. R. Shephard, Editor, Springfield, Illinois: Thomas, 280-295.

Borg, G. A. V. (1973). Perceived exertion: A note on history and methods. Medicine and Science in Sports, Summer, 90-93.

Borg, G. A. V. and Linderholm, H. (1967). Perceived exertion and pulse rate during graded exercise in various age groups. Acta Medica Scandinavica, 472, 194-206.

Borg, G. A. V. and Linderholm, H. (1970). Exercise performance and perceived exertion in patients with coronary insufficiency, arterial hypertension, and vasoregulatory asthenia. Acta Medica Scandinavica, 187, 17-26.

Borg, G. A. V. and Noble, B. J. (1974). Perceived exertion. Exercise and sports sciences reviews, 2. J. H. Wilmore, Editor, New York, N. Y.: Academic Press.

Borg, G. A. V., Sherman, M. A. and Noble, B. J. (May, 1968). A perceptual indicator of physical stress and the reliability and validity of various measurements of physical working capacity. Paper presented at the Annual Meeting of the American College of Sports Medicine, University Park, Pennsylvania.

Carton, R. L. and Rhodes, E. C. (1985). A critical review of the literature on rating scales for perceived exertion. Sports Medicine, 2, 198-222.

Carver, C. S., Coleman, A. E. and Glass, D. C. (1976). The coronary-prone behavior pattern and the suppression of fatigue on treadmill tests. Journal of Personality and Social Psychology, 33, 460-466.

Cottrell, N. B., Wack, D. L., Sekerack, G. J. and Rittle, R. H. (1968). Social facilitation of dominant responses by the presence of an audience and the presence of others. Journal of Personality and Social Psychology, 9, 245-250.

Dishman, R. K. (1994). Prescribing exercise intensity for healthy adults using perceived exertion. Medicine and Science in Sports and Exercise, 26, 1087-1094.

Dunbar, C. C., Goris, C., Michielli, D. W. and Kalinski, M. I. (1994). Accuracy and reproducibility of an exercise prescription based on ratings of perceived exertion for treadmill and cycle ergometer exercise. Perceptual and Motor Skills, 78, 1335-1344.

Dunbar, C. C., Robertson, R. J., Baun, R., Blandin, M. F., Metz, K., Burdett, R. and

Goss, F. L. (1992). The validity of regulating exercise intensity by ratings of perceived exertion. Medicine and Science in Sports and Exercise, 24, 94-99.

Docktor, R. and Sharkey, B. J. (1971). Note on some physiological and subjective reactions to exercise and training. Perceptual and Motor Skills, 32, 233-235.

Edwards, R. H. T., Melcher, A., Hesser, C. M., Wigertz, O. and Ekelund, L. G. (1972). Physiological correlates of perceived exertion in continuous and intermittent exercise with same average power output. European Journal of Clinical Investigation, 2, 108-114.

Ekblom, B. and Goldbarg, A. N. (1971). The influence of physical training and other factors on the subjective rating of perceived exertion. Acta Physiologica Scandinavia, 83, 399-406.

Frankenhauser, M., Post, B., Nordheden, B. and Sjoeberg, H. (1969). Physiological and subjective reactions to different physical workloads. Perceptual and Motor Skills, 28, 343-349.

Hansen, S. and Wasserman, F. (1984). Predicted values for clinical exercise testing. American Review of Respiratory Disease, 129, (Suppl.): 549-555.

Haskvitz, E. M., Seip, R. L., Weltman, J. Y., Rogol, A. D. and Weltman A. (1992). The effect of training intensity on ratings of perceived exertion. International Journal of Sports Medicine, 13, 377-383.

Henchy, T. and Glass, D. C. (1968). Evaluation apprehension and the social facilitation of dominant and subordinate responses. Journal of Personality and Social Psychology, 10, 446-454.

Henriksson, J., Knuttgen, J. G. and Bonde-Petersen, F. (1972). Perceived exertion during exercise with concentric and eccentric muscle contractions. Ergonomics, 15, 537-544.

Hetzler, R. K., Seip, R. L., Boutcher, S. H., Pierce, E., Snead, D. and Weltman, A. (1991). Effect of exercise modality on ratings of perceived exertion at various lactate concentrations. Medicine and Science in Sports and Exercise, 23, 88-92.

Kilbom, A. (1971). Physical training in women. Scandinavian Journal of Clinical Laboratory Investigation, 28, 1-34, (suppl. 119).

Klinger, E. (1969). Feedback effects and social facilitation of vigilance performance: Mere coaction versus potential evaluation. Psychonomic Science, 14, 161-162.

Leger, L. and Thivierge, M. (1988). Heart rate monitors: validity, stability and functionality. The Physician and Sportsmedicine, 5, 143-151.

McArdle, W. D., Katch, F. I. and Katch, V. L. (1991). Exercise Physiology: Energy, Nutrition, and Human Performance. Lea and Febiger, Philadelphia, PA.

Martens, R. and Landers, D. M. (1972). Evaluation potential as a determinant of coaction effects. Journal of Experimental Social Psychology, 8, 347-359.

MedGraphics$_{TM}$ (1990). MedGraphics$_{TM}$ Systems User's Manual St. Paul, Minnesota: Medical Graphics Corporation.

Michael, E., Durnin, J. V. G. A., Wormsley, J., Whitelaw, S. G. and Morgan N. G. (1972). Selection of a fifteen-minute workload on a treadmill and bicycle. Research Quarterly, 43, 451-459.

Mihevic, P. M. (March, 1979). The influences of fitness and selected psychological variables on perceived exertion. Paper presented at the National Convention of the American Alliance for Health, Physical Education, Recreation and Dance

(AAHPERD), New Orleans, Louisiana.

Mihevic, P. M. (1981). Sensory cues for perceived exertion: a review. Medicine and Science in Sports and Exercise, 13, 150-163.

Morgan, Wm. P. (1973). Psychological factors influencing perceived exertion. Medicine and Science in Sports, 5, 97-103.

Morgan, W. P. (1981). Psychophysiology of self awareness during vigorous physical activity. Research Quarterly in Exercise and Sport, 52, 385-427.

Morgan, Wm. P. and Borg, G. A. V. (1976). Perception of effort in the prescription of physical activity. The Humanistic and Mental Health Aspects of Sports, Exercise and Recreation. T. T. Craig, Editor, Chicago, Illinois: American Medical Association.

Noble, B. J., Maresh, C. M. and Ritchey, M. (1980). Comparison of exercise sensations between males and females. Paper presented at the Congress on Women in Sport, Rome, Italy.

Noble, B. J., Metz, K., Pandolf, K. and Cafarelli, E. (1973). Perceptual responses to exercise: A multiple regression study. Medicine and Science in Sports, 5, 104-109.

Orne, M. T. (1962). On the social psychology of the psychological experiment: with particular reference to demand characteristics and their implications. American Psychology, 17, 776-783.

Pandolf, K., Cafarelli, E., Noble, B. and Metz, K. (1977). Perceptual responses during prolonged work. Perceptual and Motor Skills, 35, 975-985.

Patton, J. F., Morgan, W. P. and Vogel, J. A. (1977). Perceived exertion of absolute work during a military physical training program. European Journal of Applied Physiology, 36, 107-114.

Quinton$_{TM}$ (1994). Quinton$_{TM}$ 4500 Stress Monitor Operating Manual Bothell, Washington: Quinton$_{TM}$ Instrument Company.

Quinton$_{TM}$ (1986). Quinton$_{TM}$ 55 Treadmill Operating Manual Seattle, Washington: Quinton$_{TM}$ Instrument Company.

Robertson, R., Hiatt, E., Gillespie, R. and Rose, K. (1975). The influence of sensory augmentation and reduction on perceived exertion. Medicine and Science in Sports, 7, 81-82.

Ross, M. (1977). The perception of effort in adult males possessing either Type A or Type B behavior pattern. Master's thesis, University of Wisconsin, Madison.

Sargeant, A. J. and Davies, C. T. M. (1973). Perceived exertion during rhythmic exercise involving different muscle masses. Journal of Human Ergology, 2, 3-11.

Sidney, K. H. and Shephard, R. J. (1977). Perception of exertion in the elderly, effects of aging, mode of exercise and physical training. Perceptual and Motor Skills, 44, 999-1010.

Skinner, J. S., Borg, G. A. V. and Buskirk, E. R. (1969). Physiological and perceptual reactions to exertion of young men differing in activity and body size. Exercise and fitness. B. D. Franks, Editor, Chicago, Illinois: The Athletic Institute.

Skinner, J. S., Hutsler, R., Bergsteinova, V. and Buskirk, E. R. (1973a). The validity and reliability of a rating scale of perceived exertion. Medicine and Science in Sports, 5, 94-96.

Skinner, J. S., Hutsler, R., Bergsteinova, V. and Buskirk, E. R. (1973b). Perception of effort during different types of exercise and under different environmental conditions. Medicine and Science in Sports, 5, 110-115.

Skrinar, G. S., Ingram, S. P. and Pandolf, K. B. (1983). Effect of training on perceived exertion and stress hormones in women. Perceptual and Motor Skills, 57, 1239-1250.

Stamford, B. A. (1976). Validity and reliability of subjective rating of perceived exertion during work. Ergonomics, 19, 53-60.

Sylva, M., Byrd, R. and Mangum, M. (1990). Effects of social influences and sex on rating of perceived exertion in exercising elite athletes. Perceptual and Motor Skills, 70, 591-594.

Thomas, J. R. and Nelson, J. (1990). Research Methods in Physical Activity, (Second Edition). Illinois: Human Kinetics Press.

Vincent, W. J. (1995). Statistics in Kinesiology, Champaign, IL: Human Kinetics.

White, J. R. (1977). EKG changes using carotid artery for heart rate monitoring. Medicine and Science in Sports and Exercise, 9, 88-89.

Zajonc, R. (1965). Social facilitation. Science, 149, 269-274.

APPENDICES

APPENDIX A

DATA COLLECTED FROM PILOT STUDY

Physical characteristics of male subjects together, and broken down into subgroups.

Characteristics	Mean	Standard Deviation
Age (years)	27.88	10.97
Height (cm)	182.88	6.84
Weight (kg)	75.63	7.22
RHR (bts/min)	64.63	7.66
Max HR (bts/min)	179.53	11.71
Conditioned		
Age (years)	26.95	11.62
Height (cm)	182.29	5.21
Weight (kg)	66.84	7.98
RHR (bts/min)	61.42	8.27
Max HR (bts/min)	175.67	9.04
Non-Conditioned		
Age (years)	26.02	10.74
Height (cm)	179.53	6.92
Weight (kg)	80.92	6.45
RHR (bts/min)	70.21	5.33
Max HR (bts/min)	188.06	9.88

APPENDIX B

SECTIONS 1 AND 2

MEDICAL HISTORY QUESTIONNAIRE

All information will remain strictly confidential - please fill out completely.

PERSONAL INFORMATION

NAME/Last ________ First ________ M.I. ____ Date of Birth ________ Sex ________

Current Address(Street #) ________ City ________ State ____ Zip ____ Home Phone ________

Department Location ________ Office Phone ________ Title ________

Social Security Number________ Date of last physical exam?________

Please list any serious or chronic illness you are aware of :________

Pleaselist any allergies to medications, foods, substances:________

Please list any medication you have been on or presently take:

Type of Medication	Dosage & Frequency	How long	Reason

MEDICAL HISTORY

ILLNESS

Please check if any of the following pertain to you.

Illness	Present	Past	Dates
Heart Attack	__	__	________
Anemia	__	__	________
Asthma	__	__	________
Epilepsy/convulsions	__	__	________
Heart Murmur	__	__	________
Lung Disease	__	__	________
Stroke	__	__	________
Gout	__	__	________
Diabetes	__	__	________
Hypoglycemia	__	__	________
Rheumatic Fever	__	__	________
Hernia	__	__	________
Back or Disc Condition	__	__	________

If yes, how long is illness controlled?________

Symptoms:

During the last twelve months, have you experienced :

	Yes	No
High Blood Pressure	__	__
Swelling of Hands/Feet	__	__
Pain or Cramps in Legs	__	__
EKG Abnormalities	__	__
Blurred Vision	__	__
Skipped Beats/Palpitations	__	__
Numbness/Tingling in Arms, Hands, Legs or Face	__	__
Shortness of Breath	__	__
Unusual Fatigue/Dizziness	__	__
Significant Weight Fluctuation	__	__
High Triglycerides	__	__
High Cholesterol	__	__
Chest Pain/Pressure	__	__

Hospitalizations

List the dates and the reasons for hospitalization for any significant illness (Women: do not list pregnancies).

FAMILY HISTORY Yes No

Is your father living? ____ ____ If not, age and cause of death:________________

Is your mother living? ____ ____ If not, age and cause of death:________________

Has your father, mother, grandparents, or siblings had:

	Yes	No	Who		Yes	No	Who
High Blood Pressure	___	___	________	Heart Attack (over 50)	___	___	________
Stroke	___	___	________	Diabetes	___	___	________
Heart Attack (50 years or younger)	___	___	________	Cardiovascular Disease	___	___	________
				Other	___	___	________

HEALTH HISTORY HABITS

NUTRITION/WEIGHT

What do you think is your "best" weight?__________lbs.

List your weight: Now__________ One Year Ago__________ At age 21__________

Do you regard yourself as overweight/underweight? Yes____ No____ Not Sure____

If overweight, which of the following contributes most :

Large meals____ Snacks____ Business Lunches____ Entertainment____ Other____

Are you presently following any diet? ____Yes ____No Type__________ Calories/Day____

Indicate the number of times per week you usually eat:

Fruit & Vegetables____ Beef____ Whole Grains____ Fried Foods____

Dairy Products____ Fowl____ Desserts____ Other____

Approximate your daily intake of: **12 oz Caffeine Sodas____

Cups of Coffee____ Cups of Tea____ Glasses of Wine____ Bottles of Beer____ Ounces of Liquor____

SMOKING

Did you ever smoke cigarettes? Yes____ No____ If yes, how many packs per day__________

Do you currently smoke cigarettes? Yes____ No____ If yes, how many packsper day?__________

If you have stopped smoking, what was the approximate date?__________________

Do you smoke cigars or a pipe? Yes____No____I yes, how many per day?__________

TENSION ANXIETY

How would you describe your level of tension most of the time?

**____No tension, very relaxed ____Slight Tension ____Moderate Tension ____ High Tension ____Very Tense

Do you practice any relaxation skills to eliminate tension? Yes____ No____

Describe:______________

PHYSICAL ACTIVITY

Are your currently involved in any fitness activity? Yes____ No____

If no, how long has it been since you participated in any fitness activity?______________

If yes, do you:	Yes	No	Time spent each workout (minutes)		Yes	No	Time Spent (minutes)
Preform calisthenics	___	___	________	Swim	___	___	________
Cycle	___	___	________	Jog	___	___	________
Walk	___	___	________	Other	___	___	________

Approximately how may days per week do you exercise?

1____ 2____ 3____ 4____ 5____ 6____ 7____

What fitness or sports activity would you be interested in leaning more about?______________

Do you consider yourself in better physical condition than others of your own age? ____Yes ____No

How much physical activity do you get during a typical working day?

____Walking Amount of Blocks: ______________

____Stairs Amount of Steps: ______________

____Other Amount: ______________

MUSCULAR-SKELETAL HISTORY

Do you have injuries (past/present) or limitations that may affect full participation in the program? ____Yes ____No

OBJECTIVES

List the objectives you would like to achieve from the program. (examples: lose weight, firm body, prevent heart attack)

____

____

APPENDIX C

SECTIONS 1, 2, AND 3

INFORMED CONSENT FORM

The purpose of this investigation is to explore the role that gender differences may possibly play in perceived exertion ratings in 30 male and female participants, aged 18-35 years, and actual heart rate recordings.

Before entering the study, you will have filled out a medical health history questionnaire, and will have been found to be asymptomatic in regard to heart disease by the research staff. Additional information may be requested by a physician or researcher. Eligibility for participation will be determined by the research staff based on medical information and interview.

Research Design: The training will consist of a graded exercise tolerance test (GXT); time dependent on when you or the researcher feels it is time to be discontinued. Any pain, fatigue, or discomfort are sufficient grounds for termination. Non-invasive procedures, such as blood pressure, heart rate, and rating of perceived exertion will be obtained the first minute of the test and then every three minutes thereafter. You will be monitored by trained research staff during each training session.

Testing: Procedures and Timelines: Testing and/or training will be conducted for 12 weeks. The final results of the investigation will be done by June 1996.

Risks: Every effort will be made to conduct the testing session in a manner that will minimize any possible risk to the subject. The response of the cardiovascular system to exercise cannot be predicted with complete accuracy and consequently, there is a risk of certain changes occurring during or following the exercise. These changes include: muscle soreness or stiffness, disorders of heart beats, abnormal blood pressure responses, and in very rare instances, stroke, heart attack, or cardiac arrest. Before starting the study, you will be instructed as to the signs and symptoms that will alert you to stop or slow down your activities. Also, you will be observed by trained personnel who will alert you to the changes in these signs, which may warrant modification of your exercise. Any part of the testing procedure will be discontinued if you show any signs of distress. Furthermore, emergency equipment, trained medical personnel, and supplies for your safety will be present for all exercise sessions. In the rare event of a medical emergency, you will be taken to Immanuel St. Joseph's Hospital, Mankato, MN. In addition, medical and/or transportation expenses incurred by you during this investigation are your responsibility. The researcher can exercise the right to terminate your participation in this study whenever they deem necessary, with or without your consent.

Benefits: The benefits to you by being involved with this investigation can be; the improvement in cardiovascular function in order to perform daily activities, observation of daily activities for life-endangering signs and symptoms, and the scientific assessment of exercise rehabilitation as therapy for prevention of obesity or heart disease.

In no way will your name be used in connection with the data. The information obtained during this investigation will be treated as privileged and confidential, and will not be released to any person without the expressed written consent by you. The resultant information will be used for statistical analysis with the right to privacy being retained. Any significant research findings will be made available to you at the end of the study.

I fully understand the program or activity in which I am being asked to participate in, and the procedures which will be performed. I understand that I may ask additional questions at any time while the study is in progress.

In addition, the study and its benefits and risks, have been discussed with me by the research investigator, and any questions which may have arisen or occurred to me have been answered to my satisfaction.

I certify that I am participating in the activity of my own free well, and that I may withdraw consent and discontinue participation at any time, without penalty or loss of benefits to which I was otherwise entitled.

Any questions that I may have regarding volunteer's rights in the participation of this study will be answered by Gary Hudson, Institutional Review Board Representative, Mankato State University, at 389-1455.

Project Director: Dr. Ken Ecker, Department of Human Performance, Mankato State University, 389-2679.

Principle Investigator: Bobby Pellant, Department of Human Performance, Mankato State University, 389-5988.

Date:__________

Signature of Subject______________________________

APPENDIX D

PHYSICAL ACTIVITY QUESTIONNAIRE

Name______________________ Date of Birth______________
Address____________________ SSN____________________

____

Phone______________________

1. Are you actively involved in any exercise or sport program?

Yes____

No____

2. If yes, how long have you been involved in this activity?

____

3. Please state the activity:____

4. How many times per week?____

5. Please list any other physically active leisure activities you participate in that were not previously mentioned.____

6. Do you consider yourself to be:
   a. Sedentary at work and leisure
   b. Sedentary at work and light recreation
   c. Sedentary at work and moderate recreational activity
   d. Moderately active at work and leisure
   e. A regular exerciser (20-30 min/day, 3-5 days per week)
   f. A vigorous exerciser (30-40 min/day, 4-7 days per week)
7. Please list any and all medications you are presently taking.

Medication	Dosage	Doses per day

8. Please list any information regarding your health which you consider important for us to know.

____

Signature of Participant____

APPENDIX E

INSTRUCTIONS TO SUBJECTS

Your exercise evaluation from the time of arrival to the conclusion of the test will be approximately 30- 40 minutes.

It is recommended that you eat only up until one and one-half hours before your scheduled test, but the meal should be light without coffee, tea, alcohol, or heavy dairy products. We would suggest a light breakfast, lunch, or supper. Please drink as much juice or water as you desire.

No significant exercise should be performed the day of your test, just prior to your scheduled appointment.

Please do not smoke for the previous eight hours before the test.

Wear or bring appropriate clothing: sneakers, tennis shoes, or preferably running shoes are needed.

Men:	Bring gym shorts along with a loose fitting short sleeve shirt.
Women:	Bring gym shorts along with a loose fitting short sleeve shirt, and proper undergarments.

If you wish to shower, please bring your own towel.

Thank you for consenting to take part in this research study for Spring '96. Please feel free to call me at 389-5988 if you have any questions or wish additional clarification.

Sincerely,

Bobby Pellant
Graduate Project Director

APPENDIX F

INFORMATION FOR THE BRUCE PROTOCOL

The Bruce protocol consists of seven 3-minute stages. Speed and slope will increase every three minutes. The first two to three stages are considered warm-up stages. You generally can walk in these stages. The next stages jogging or running will be necessary. We will encourage you to run until exhaustion. When you feel that this level has been reached, you should put both hands on the treadmill, and the test will then be discontinued. After the test has ended, you will be asked to stay on the treadmill at 0% grade, until you are cooled down.

Heart rate will be monitored every minute of the protocol, by EKG monitoring. RPE, and BP will be taken every three minutes of the protocol.

You will be simultaneously hooked up to a ventilatory analyzer, MedGraphics$_{TM}$. This involves breathing through a respiratory valve, with a noseclip attached. These will be removed as soon as the test is completed.

Rarely does anyone get through the entire Bruce protocol, but it is strongly recommended that you continue the test as long as you possibly can. If you have any questions, or need further clarification, please feel free to ask before the testing has begun. These instructions will also be read to you again, just prior to the start of the test.

APPENDIX G

SECTIONS 1 AND 2

INFORMATION FOR RATING PERCEIVED EXERTION

You will be taking part in a work test. We want you to try to estimate how hard you feel the exercise is; that is, we want you to rate the degree of perceived exertion you feel. By perceived exertion we mean the total amount of exertion and physical fatigue, combining all sensations and feelings of physical stress, effort and fatigue. Don't concern yourself with any one factor such as leg pain, shortness of breath (within limits), or exercise intensity, but try to concentrate on your total, inner feeling of exertion. Try to estimate as honestly and objectively as possible. Don't underestimate the degree of exertion you feel, but don't overestimate it either. Just try to estimate as accurately as possible (Morgan, 1981 p. 401).

The Category Scale for Rating of Perceived Exertion consists of even numbers ranging from 6 to 20. The number 7 represents work that you feel is very, very light in intensity, while the number 19 represents work that you feel is very, very heavy in intensity. The number 20 is often associated with fatigue, and an inability to exercise any longer. If you feel that the work is between number 7, very, very light and number 9, very light, you should respond by acknowledging the number 8.

This subjective rating will be taken every 3 minutes of the exercise test. Someone will be asking the question 'How hard do you feel you are working?', they will then point to a number on a poster in front of you, and you will respond by indicating with your thumb either up or down. When they point to the correct number, you will be asked to nod your head in agreement. If you have any questions, or need further clarification, please feel free to ask before the testing has begun. These instructions will also be read to you again, just prior to the start of the test.

APPENDIX H

CALIBRATION OF TREADMILL SPEED

1. The speed meter on the treadmill should read zero.

2. Measure the circumference of the walking belt, by placing a piece of tape at one point, and measuring the belt lengthwise in one direction all the way around the underside of the belt, until the point with the tape is reached.

3. The distance for the Q55 should be 125 inches (317.5 centimeters).

4. With the tape still on the belt, the belt was run at 1.7 miles per hour and revolutions were counted for one minute.

5. Belt speed was calculated using the following derived mathematical formula:

$$S = (C \times R)/1056$$

S = belt speed in miles per hour

R = belt revolutions in 1 minute

C = belt circumference in inches

1056 is a constant in the equation

If the calculated speed matches the observed speed reading on the monitor, the treadmill has accurately been calibrated. The Q55 has a patient capacity of 350 pounds. The handrail height on the treadmill is 44 inches above the floor (Quinton$_{TM}$ 55 Operating Manual 1986).

APPENDIX I

CALIBRATION OF GAS ANALYZER

1. Adjust 'Electric Zero Adjust' until 0.00 (±0.03).

2. Turn on reference gas tank.

3. Locate reference gas adjusters on back of the analyzer.

4. Press F2, which is the reference gas adjust. Turns it on.

5. Adjust CO_2 reference until observed equals 0.00 (±0.03).

6. Adjust O_2 reference until observed equals 21.00 (±0.03).

7. Press F2, which turns it off.

8. Locate calibration gas adjusters on analyzer.

9. Press F1, which is the calibration gas adjust. Turns it on.

10. Adjust CO_2 calibration until observed equals 5.00 (±0.03).

11. Adjust O_2 calibration until observed equals 12.00 (±0.03).

12. Press F1, which turns it off.

After following the above instructions, the MedGraphics$_{TM}$ gas analyzer calibration was now complete (MedGraphics$_{TM}$ Systems User's Manual 1990).

The investigator obtained predicted VO_2max reports on the subjects after the calibration was completed (Hansen and Wasserman, 1984). These were used to determine conditioning levels of the subjects.

APPENDIX J

ELECTRODE SKIN SITE PREPARATION

1. Electrode paste was applied to the skin site and the skin was then rubbed with a fine sandpaper until it was slightly red. This removed the non-conductive layer of the skin. It was done as quickly as possible to minimize any discomfort of the subject.

2. All traces of the paste were removed with generic Isopropyl Alcohol wipes, 70% by volume.

3. The skin was allowed to air dry before actual electrode placement.

4. The electrode pack was opened and the protective peel was removed. A pre-gelled Ag/AgCl disposable electrode was carefully exposed, as not to disturb the gel, or get it on the adhesive. Finger contact with the adhesive was minimized.

5. The electrode was applied to the prepared site by running a finger around the foam pad, pressing down, and smoothing it from the center out.

6. This procedure was repeated for all the sites, and then the lead wires were attached, by snapping them in place.

7. The subject's harness, which secured all leads, was attached comfortably at the waist.

8. Unused wires were removed as not to generate artifact noise and help prevent loosening the bond between the electrodes and the skin.

9. In some cases, wires and electrodes were taped to the subject's skin to avoid them moving or falling off.

Prior to the start of the test, an electrode check was run on the Quinton$_{TM}$ to prevent incorrect placement.

APPENDIX K

GUIDELINES FOR SAFE PROCEDURES ON THE TREADMILL

1. Subject is asked to straddle the treadmill belt by placing both feet on the outer edge of the treadmill, facing forward with both hands on the handrail.

2. The treadmill belt is then started.

3. The subject is asked to use their foot to swing over the belt several times, allowing it to touch the belt as it moves to the rear. This allows them to get used to the belt speed.

4. When the subject feels comfortable, they are then asked to step onto the belt and begin walking. When they are ready, they are then encouraged to let go of the handrail. This portion of the procedure, also acts like a warm-up period for the subjects. The investigator usually allowed them a three minute adjustment time.

5. While the subject was warming up they were instructed to face forward, and not look at their feet. They were encouraged to maintain their speed by gauging how far they were from the handrail. It was recommended that they position themselves in the center of the treadmill at all times.

Once the above steps were initiated, the actual Bruce protocol testing and ventilatory analyzing were started. When the subject put both hands on the handrail to signal their fatigue, the investigator stopped the testing protocol. The subjects were instructed that the treadmill would immediately go to a minimum speed and grade, but that they should stay on it, until they were cooled down. After sufficient cool down, generally around 5 minutes, the subjects were then asked to grip the handrail, facing forward, and step off the treadmill by the same straddle technique used for getting on.

APPENDIX L

DATA COLLECTION SHEET

NAME ________________ SEX ______ AGE ______ DATE OF BIRTH ________________

HT ______ WT(1) ______ WT(2) ______ ST HT ______ RESTING HR(1) ______ (2) ______

FITNESS GROUP ______

(1) RM TEMP ______ (1) DATE ______ (1) TIME ______ COMMENTS: ______

(2) RM TEMP ______ (2) DATE ______ (2) TIME ______

MAX TEST I

MIN	WKLD	HR	RPE	$\dot{V}O_2$	$\dot{V}CO_2$	R	$\dot{V}_E$	
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								

MAX TEST II

MIN	WKLD	HR	RPE	$\dot{V}O_2$	$\dot{V}CO_2$	R	$\dot{V}_E$
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

APPENDIX M

SECTIONS 1, 2, AND 3

FINAL DATA SUMMARY SHEET

Physical characteristics of subjects broken down into subgroups.

Characteristics	Mean	Standard Deviation
Males		
Age (years)	24.63	5.50
Height (cm)	180.91	4.62
Weight (kg)	81.48	7.46
RHR (bts/min)	69.50	9.73
Time to exhaustion (min)	13.71	4.99
VO_2max (ml/kg/min)	42.18	8.94
Females		
Ages (years)	26.82	4.32
Height (cm)	167.17	4.43
Weight (kg)	61.69	6.57
RHR (bts/min)	73.36	8.03
Time to exhaustion (min)	12.20	3.45
VO_2max (ml/kg/min)	33.81	8.81

Characteristics	Mean	Standard Deviation
Conditioned		
Age (years)	24.32	3.19
Height (cm)	176.06	7.47
Weight (kg)	71.03	10.91
RHR (bts/min)	65.17	4.61
Time to exhaustion (min)	14.80	2.91
VO_2max (ml/kg/min)	45.64	6.68
Non-Conditioned		
Age (years)	27.14	3.01
Height (cm)	172.01	6.28
Weight (kg)	72.14	8.89
RHR (bts/min)	77.62	3.85
Time to exhaustion (min)	11.31	1.63
VO_2max (ml/kg/min)	31.22	5.56
Conditioned Males		
Age (years)	24.13	3.47
Height (cm)	183.52	4.97
Weight (kg)	81.93	9.40
RHR (bts/min)	64.97	3.09

Characteristics	Mean	Standard Deviation
Time to exhaustion (min)	15.69	2.23
VO_2max (ml/kg/min)	49.16	8.11
Non-Conditioned Males		
Age (years)	25.13	3.55
Height (cm)	178.29	9.36
Weight (kg)	81.02	11.69
RHR (bts/min)	74.03	5.90
Time to exhaustion (min)	13.91	3.07
VO_2max (ml/kg/min)	38.61	4.65
Conditioned Females		
Age (years)	24.50	2.12
Height (cm)	168.59	4.57
Weight (kg)	60.12	5.97
RHR (bts/min)	65.38	4.26
Time to exhaustion (min)	13.91	2.07
VO_2max (ml/kg/min)	39.93	6.83
Non-Conditioned Females		
Age (years)	29.14	4.32
Height (cm)	165.74	4.88
Weight (kg)	63.25	7.10

Characteristics	Mean	Standard Deviation
RHR (bts/min)	81.20	3.51
Time to exhaustion (min)	10.87	2.58
VO_2max (ml/kg/min)	26.70	4.73