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Gordon Sharpless Morris

The University of Montana

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THE EFFECT OF TRAINING INTENSITY
ON PERCEIVED AND PREFERRED EXERTION

By
Gordon Sharpless Morris
B.S., Rutgers University, 1968

Presented in partial fulfillment of the requirements
for the degree of

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G.S.M.
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CHAPTER I

INTRODUCTION

Exercise produces physiological changes in man. Some researchers feel that exercise is a form of stress and can thereby be harmful, rather than beneficial to man's internal environment. Stress has been classified in social, environmental, physical, and psychological terms. Selye (20) classified muscular exercise as a physical stressor. He suggested that the body adjusts to this form of stress by the discharge and regulation of chemicals from the adrenal glands. The chemicals, known as corticotropin hormones, were thought to counter the stress and thus help maintain the body's internal environment in a homeostatic state. Selye described a general adaptation syndrome stating that any stressful stimulus caused man's adaptive syndrome to sum all systemic reactions of the body to help protect the body in time of stress (20).

Several researchers attempted to control the emotional factors in their investigations of corticotropin hormone production in relation to exercise and found that the emotional factor caused much of the hormonal increase. Reynolds (19), Steadman (24), and Suzuki and associates (28) concluded that
exercise alone did not produce the stress response. Ganong (14) suggested that only those stimuli that caused an increase in ACTH secretion could be labeled as stressors. Much of the increase in ACTH secretion has been related to emotional stimuli and the interpretation of the stimuli as being stressful. Therefore, when exercise is accompanied with unpleasant emotional stimuli, then it can be said to act as a stressor. Cooper (9) and Steadman (24) have supported this statement.

The interpretation of emotional stimuli involves the processes of perception. One can relate perception to man's physiological adjustment to stimuli from the external environment. Cratty (10) has said that:

Perception involves organizing, feeling change and selecting from among the complexity of events to which humans are continually exposed so that order may be attached to experience. Perception has been shown to be more than an awareness of immediate sensory stimulation. Events occurring in an individual's past and internal visceral changes also seem to play a part.

As an object or event (e.g., exercise) is perceived and then related to other events within the immediate present and past, categorization and classification occurs. The sum of the individual's past experiences with similar objects is compared to the present situation and a quantitative or qualitative value judgement is made. A decision is then made concerning the manner in which the perceiver will interact with the event. A reinterpretation and evaluation of
the decision is fed back via the perceptual system to help the individual prepare for future interpretations and/or responses.

Perception of an event, such as exercise, depends on the intensity of the stimulus and the internal mechanisms that interpret and relate the stimulus with past stimuli. A physiological response occurs with the interpretation of both the external stimuli and internal responses so that an individual perceives exercise within a certain frame of reference. Ganong (14) and Leukel (16) feel that the emotional interpretation of all stimuli occurs in the hypothalamus. As an individual exercises, the external stimuli of the exercise intensity and the internal physiological changes are received, interpreted, and evaluated within the hypothalamus. The body reacts covertly or overtly in terms of observable behavior as the perceptual process evaluates various exercise intensities.

Gunnar A. V. Borg (5) has studied different aspects of physical performance and the perception of exercise. Borg's research has suggested that individuals with hypertonia and coronary disease generally rate the exertion of a given level of exercise to be higher than that of normal individuals in a reference group. This implies that the interpretation of external stimuli is dependent to some degree upon his physiological condition at the time of interpretation (i.e., a man's
present physiological condition influences the interpretation of external stimuli).

Whidden (31) found that his subjects had an initial stress response to exercise. After four weeks of training the test group returned to initial control levels of 17 keto-genic steroids. As the subjects became familiar with the exercise, the blood clotting time also returned to the level that existed prior to the training schedule.

Previous researchers (32, 20, 15) have said that exercise acts as a stressor. Recent studies suggest that the emotional factor may serve to act as the stressor, therefore there seems to be a need to understand the perceptual process involved in the interpretation of emotional stimuli. It seems important to study the effects of the emotional factor upon the perceptual interpretation of exercise at various exertion levels.

I. THE PROBLEM

Statement of the Problem

The primary purpose of this study was to determine the effect of training on preferred and perceived levels of exertion. Of secondary importance was a comparison of the preferred and perceived responses to exertion on several ergometers.
Significance of the Problem

Exercise has been recommended as a possible means of reducing the problem of chronic heart disease and increasing cardio-respiratory fitness. It has also been suggested that exercise can help to relieve psychological tensions. However, exercise has also been considered a stressor. Perceptual interpretation of a given exercise-exertion level seems to be related to stress. If man could alter his perceptual interpretation of the exercise so as to reduce the amount of stress, an exercise program could be devised to help people suffering from chronic heart disease.

Limitations

Due to the time required in the training program there were only twenty-one subjects in the study. There was also only limited control of the subjects' outside activities as indicated in Appendix C.

Definitions

1. **Perception**—A dynamic process that involves organizing, feeling change, and selection from among the complexity of events to which humans are continually exposed, so that order may be attached to experience. The process is felt to be dependent upon immediate sensations affecting sensory end-organs, the events occurred.
in an individual's past and internal visceral changes (10).

2. **Perceived level of exertion**--Verbalization of the subject's response to a stimulus in accordance with the questions: A) How heavy does it feel to pedal the bicycle ergometer? B) How great is the pedal resistance? C) How laborious does it feel to run on the treadmill? (5)

3. **Preferred level of exertion**--The level of exertion at which the individual would like to train in a personal fitness program.

4. **Stress**--Generic term for those diverse, immensely dissimilar stimuli which have in common the experimentally proved property of stimulation increased ACTH secretion (14).
CHAPTER II

REVIEW OF RELATED LITERATURE

Many researchers have been concerned with the relationship between stress and exercise. The following account reviews some of the work concerning the relationship between exercise and stress and also presents some of the research that deals with the perceptual process and specifically the perception of exercise.

I. RELATIONSHIP BETWEEN MUSCULAR EXERCISE AND STRESS

Muscular exercise has traditionally been classified as a stressor. The degree of stress has been measured by the count of circulating eosinophils or the excretion of 17 keto-genic steroids which reflects the adrenal cortical activity (24, 21). It is important to discover if muscular exercise alone produces the stress or if emotional interpretation of the exercise helps produce the stress response. If muscular exercise by itself produces stress then exercise programs cannot be void of producing harmful stress conditions. On the other hand, if stress is not directly related to muscular exercise, then it may be possible to alter exercise programs so that man can receive benefit from the exercise without receiving harmful stress effects.

Selye (20) the individual responsible for developing
the General Adaptation Syndrome Theory, supported the viewpoint that exercise was a stressor. Rats, forced to run, initially displayed an increase in adrenal cortical activity. If this stressful activity continued, eventually the production of adrenal cortical hormones ceased as the animals became exhausted.

Young, Price, Elder, and Adaci (32) exercised dogs after they had finished eating. The researchers discovered that the production of the 17-hydroxycorticoid steroids increased in large amounts during the exercise time. They concluded that exercise was the stressor.

Reynolds, Quigley, Kennard, and Thorn (19) studied the changes in the circulating eosinophils found in the blood of coxswains, coaches, and oarsmen prior to and after a race. The researchers discovered that the eosinophil count fell as much for the coaches and coxswains as it did for the oarsmen. They concluded that the actual physical exertion of rowing was not the primary cause for the changes in the eosinophil count.

Suzuki and associates (28) exercised dogs that were run to exhaustion. They then proceeded to analyze the level of hydroxycorticosteroids from the adrenal venous blood. They concluded that the increase in the 17-hydroxycorticosteroids was related to the exhaustion produced by the exercise duration, and not due to the exercise itself.
Connell, Cooper, and Redfearn (7) tried to relate the effects of emotional tension and physical exercise on man. When an important written examination was administered to the men, the 17 ketogenic steroid level increased significantly. After brief periods of intense physical exercise, the 17 ketogenic steroid level was not significantly altered. The researchers' concluded that the emotional stress caused the increase in the adrenal cortical hormones and this was in anticipation of the physical exercise.

Steadman (24) trained five male students on a treadmill. The greatest increase in the 17 ketogenic steroid level occurred during the first week of training. During the remaining period the 17 ketogenic steroid excretion returned to control levels. Steadman suggested that the latter weeks of training should reflect the adrenal cortical response to the exercise as the amount of physical exertion was increased throughout the study. His results indicated that exercise alone was not the major reason for the change in excretion of the 17 ketogenic steroids.

Whiddon (31) involved five male students in a study relating the effects of nonstressful exercise on whole blood clotting time. The production of 17 ketogenic steroids increased during the initial week of training. The 17 ketogenic steroid production approached the control level during the latter weeks of training. The amount of physical
exertion was progressively increased during the training program. Whiddon concluded that the emotional stress caused by initial apprehension of the exercise was responsible for the increase in the 17 ketogenic steroid production. He therefore suggested that "since the exercise load was increased, the 17 ketogenic excretion pattern seems to reflect emotional stress."

Frankenhaeuser and associates (13) measured the amount of catecholamine produced during various exercise work loads. They then compared the catecholamine amounts to the subjective evaluation of each exercise work load. The catecholamine excretion remained near the control levels at lower work loads but showed a pronounced increase at the heaviest work loads. Subjective evaluation increased linearly with the increased work loads. Frankenhaeuser concluded the following:

...it appears likely that the adrenaline increase was at least partly associated with the subjective emotional reaction accompanying heavy physical work rather than being elicited by the work itself. In other words, the results may be interpreted as indicating that an increase in adrenal-medullary secretion occurs during muscular work when the work grows so heavy that feelings of emotional stress and unpleasantness are evoked.

Ganong (14) suggests that stress can only be defined in terms of those diverse, immensely dissimilar stimuli which have in common the experimentally proved property of stimulating increased ACTH secretion. This production of ACTH has been related to the response the body makes to
emotional stimuli.

II. INTERPRETATION OF EXERCISE--PERCEPTION

The organization and interpretation of emotional stimuli involves the process known as perception. There are many explanations and definitions of the perceptual processes that have been postulated and tested by noted psychologists. Cratty (10) suggests that perception is:

A holistic term referring to meanings attached to an object, event, or situation occurring within spatial and temporal proximity of the individual. The process involves organizing, feeling change, and selecting from among the complexity of events to which humans are continually exposed so that order may be attached to experience. Perception has been shown to be more than an awareness of immediate sensory stimulation. Events occurring in an individual's past and internal visceral changes also seem to play a part.

Leukel (16) expanded the perceptual definition as he suggested the following:

The perception of a stimulus and the organism's reaction to it depends on past experience with similar stimuli and on the current stimulus pattern from other sources. Perception is the development of meaning that depends on past and present sensation input. Perception occurs when sensations interact together with traces of past experiences in the central nervous system.

The study of perception evolved in the fields of psychology, physiology, psychophysics and psychophysiology. Stevens (25) has said that psychophysics concerns the functional relationship between external stimuli and the body's response to the stimuli. Stevens (26) further stated that the field of
psychophysics allowed for the delineation of what is perceived as well as explaining how perception is accomplished. This suggests that researchers need to know about the input-output relationships of sensory transducers.

Ax (1) related the perceptual process in terms of comprehension of a translator system that exists within man. He suggested that the translator system serves as an active system of intercommunication between various patterns of external stimuli and physical states which exist in the nervous and endocrine system. The interaction of the external world with man's internal environment formed a symbolic relationship. The translator system can then be viewed as the perceptual process that attempts to relate drives, emotions, and attitudes to man's overt behavior. This suggests that perception may be partially explained in physiological measurements of external stimuli interpretation by man's internal environment.

Borg (4) tested male volunteers on a bicycle ergometer to determine how they perceived the external stimulus intensity of pedaling the bicycle. He suggested that perception of the exercise depended on the intensity of the stimulus (i.e., pedal resistance) and the internal mechanisms in man's body that interpreted and related the stimulus with past stimuli. Borg concluded that there were three indicators of the external stimuli; pulse rate, rated exertion indicated by a perceptual scale and performance (i.e., maximum work on a preferred

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The subjective feeling of exertion grew according to a positively accelerating function. To relate the reception and interpretation of external stimuli the researchers had to develop methods of quantifying the stimuli.

Lykken (18) tested the validity of the power-function law as he measured individual differences in the interpretation of increasing stimuli by measuring individual's skin potentials with a Galvanic skin resistance apparatus. He concluded that the sensory thresholds varied individually with fatigue. Warren (30) tested subjective responses to varying degrees of stimulus interpretation ranging from how heavy an object felt to how loud a sound was produced by a particular instrument. He postulated that one could measure and relate subjective magnitude evaluation to actual stimulus magnitude. Warren reinforced Steven's (25) general psychophysical law which stated, equal stimulus ratios produced equal subjective ratios. This then allowed the researcher to measure sensory intensity by a quantitative evaluation of the stimulus ratio required for judgements of a given subjective ratio.

Thompson (29) presented an excellent explanation of the developmental methods of interpreting external stimuli. He stated that:

The relations between stimulus intensity and judged intensity began with Weber's early observation that the amount by which a given stimulus must be increased to be
just noticeably more intense than the initial stimulus was directly proportional to the initial strength of the stimulus...Fechner generalized this by making the further assumption that all just noticeable differences (jnds) are equal.

The methods of measurement have tried to assess the relationship between stimulus characteristics and responses.

Researchers have since argued that all jnds are not subjectively equal (i.e., a just noticeable change in a stimulus is not always just noticeable) regardless of the initial stimulus intensity. Stevens (26) demonstrated a new psychophysical principle based on a power-law relationship. Instead of assuming that the amount of change in the psychological interpretation of external stimuli remained constant, Stevens suggested that the amount of judged change was proportional to the judged stimulus value.

Ekman (12) reinforced Stevens' work as he proved that the Weber-Fechner Law was invalid and it needed to be replaced by a power function law. He tested individual responses to increasing weight and light stimuli. He found that Stevens' power function law was valid and reliable.

The type of psychophysical relationship obtained depends upon the method of measuring the judged stimulus intensity. Stevens (25, 26, 27) suggested that researchers could use one of two methods of measurement, measure the jnds or magnitude estimation. From these two types of measurement various types of scales have been devised.
Stevens distinguished between two types of stimuli dimensions. Metathetic stimuli were defined in terms of the intensity dimension (quality). He then placed the two stimulus dimensions on a perceptual continua and measured the stimuli by ratio scales. The scales were determined by four methods; magnitude estimation, ratio production, magnitude estimation and magnitude production. Once the scales were established, Stevens applied the scales to more than a dozen perceptual continua.

Ekman (11) described two generalized scaling methods based, in part, on Stevens' work. Ekman reinforced the ratio scales of subjective magnitudes by the method of fractionation and constant sums. The subjects tried to establish rating scales by adjusting one of two stimuli in each of a set of stimulus pairs. From this procedure, the subjects working with ratios between subjective magnitudes were able to produce scales that allowed subjects to interpret (i.e., qualitatively and quantitatively) the external stimuli in relation to internal bodily adjustments.

Thus it is suggested that the perception of an event, such as exercise, depends on the intensity of the stimulus and internal mechanisms that interpret and relate the stimulus with past stimuli. The means of communicating how an individual perceives the external stimuli can be accomplished by relating (subjectively) the incoming stimuli to scales that
have been established by some notable psychologists (6, 25, 26).

**III. RELATION OF PERCEPTION TO EXERCISE**

Exercise accompanied with emotional stimuli seems to act as a stressor. The perceptual process identifies, organizes, and interprets the emotional stimuli. Very few researchers have attempted to understand how exercise may or may not affect the perceptual process.

Stevens (27) established ratio scales and representative exponents of the power functions relating psychological magnitude to stimulus magnitude on a dozen prothetic continua. The exponent for heaviness was 1.45 as established by the lifting of weights. This meant for every increment of lifted weight, the subjects perceived the judged intensity to be increased 1.45 units.

Utilizing this information, Borg began a series of investigations to determine how man would perceive exercise. The following is an account of Borg's studies.

Borg (3) tested four healthy subjects to ascertain the possibility of measuring the intensity of perceived performance (perceived pedal resistance) on the bicycle ergometer. He concluded that the psychophysical ratio-scaling methods could be used to scale the perception of muscular force or work.

Borg (6) tested a group of twenty-two male subjects

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on a bicycle ergometer. The purpose was to determine the psychophysical power function for a particular period of work. The subjects pedaled for less than a minute. It was discovered that the psychophysical power function given by Stevens and Ekman proved to be valid for the perceptual continuum of force or effort. Borg discovered a positively accelerating function with an exponent of 1.6.

Several more experiments by Borg (5) determined how the amount of work influences the perception of exercise. Twelve adult male students pedaled the bicycle ergometer at three increasing power levels for periods of 5, 10, 20, and 40 seconds. The subjects then evaluated the exertion by means of a halving method. The conclusion was the following:

The perceived performance thus appears not only to depend upon the physical power or the force, but also on the amount of work carried out. This increases linearly with the time, as the power is constant, but seems to influence the perception of the performance during the first ten to twenty seconds so that the resistance is perceived to be less in a shorter than in a longer period of work.

Borg (5) tried to determine a medium intensity level, which he called the preference level, that was perceived by the individuals as being just about right or comfortable. Several lumber workers had to perform preference level adjustments while working on the bicycle ergometer. Interestingly enough, the physical intensity corresponding to a
preferred level in heavy forest work gave significant correlations with the maximal performance for short-time work on the cycle ergometer \( (r=.42) \).

In order for individuals to rate given exertion levels, Borg (3, 5) deemed it necessary to develop a subjective rating scale. He tested seventy-three male subjects for three, six-minute periods of work on the bicycle ergometer. The work load increased from 300 kpm/min to 900 kpm/min. The subjects had to rate the degree of exertion according to a twenty-one grade ratio scale. The correlation between pulse values and the subjective ratings for each of the submaximal power levels was .40, and for the whole test, including all power levels, the correlation was .85. This indicated that Borg's twenty-one grade rating scale was a valid indicator of perceived exertion during a work period.

Borg elaborated on the previous study when he tested fifty-seven lumber workers on the bicycle ergometer. The subjects worked intermittently every fifteen seconds for forty-five seconds as the pedal resistance increased fifty kpm/min every working period. Borg related work level to heart rate and made the following conclusion:

...the perception of exertion experienced by a forest worker seems to influence the field performance as much as the working capacity estimated from physiological variables. Beyond the physical working capacity, the resources of "mental energy," the motivation and the ability to tolerate heavy physical strain and stress also seem to be of great importance.
Utilizing the knowledge he had now gained, Borg continued his investigations and with the help of Linderholm (17) began to study ways in which people who suffer from hypertonia interpret physical exertion. They discovered that people suffering from hypertonia and coronary disease generally rated the exertion of work greater in relation to the pulse frequency than those in a reference group.

A. J. Barry (2) trained 224 men, aged 44 to 64, on a bicycle ergometer. He asked them to respond on a seven-point scale to the question, how did the exercise feel. There were three groups of men, those who were physically normal, those who were in poor physical condition, and those who suffered from various forms of heart disease. Analysis of the data showed that the presence of heart disease was significantly and positively correlated with increased perceived exertion, \((r = .41)\). Barry concluded that men who had heart disease moved to less physically demanding occupations.

Borg (5) tested a group of lumber workers and a heterogeneous group of professionals to determine the effects increasing grades of exercise had upon each group's perceptual interpretation of the exertion. They all pedaled the bicycle ergometer with stepwise increasing loads until exhaustion occurred. In the group of lumber workers the pulse rate decreased with increasing age at the same
work intensity, while they rated the work level at a constant value. In the heterogeneous group, the pulse rate at the same work intensity remained constant, while they rated the work level increasing with a corresponding increase in age. Borg concluded that in general, with increasing age, the work resulting in a given pulse rate was rated to be more laborious.

The relationship between physical exertion and perception has been measured by pulse and physical working capacity. Borg (5) suggested the following:

In normal cases physical training or motion is not intended to increase the maximal physical performance capacity in itself, but the sensation of stress and strain in normal work should be reduced. When the terminal threshold has been increased the perception of one and the same submaximal level should decrease, or one and the same perception level, e.g., a preference level, should correspond to a higher physical performance level. When there is a decrease in the working capacity the condition is the reverse.

IV. SUMMARY

Literature has labelled exercise as a stressor. Recently several writers, Reynolds (19), Steadman (24), Suzuki (28), Whiddon (31) and Frankenhaeuser and associates (13) have indicated that the emotional stimuli accompanying exercise produces the stress. Man interprets, organizes, evaluates, and responds to the emotional stimuli through a perceptual process. Stevens (25), Ekman (12), Ax (1), and Thompson (29) have been involved in devising means to
measure perceptual responses to various forms of external stimuli. Warren (30) and Stevens (27) developed methods and scales to interpret the external stimuli. Trying to understand the complexity of interpreting external stimuli, specifically physical exertion, has led Borg to relate the perceptual process to exercise. Borg devised a subjective rating scale that allowed subjects to relate the exercise intensity to perceptual responses. A linear relationship seemed to exist between physical exertion and the perception of the physical exertion. As the work loads increased a corresponding increase in the perceptual scores occurred. Borg's studies suggested that a training program could effectively reduce the perception of a given work load as stressful. Therefore, the interpretation of exercise (i.e., perception) can be altered via a training program so that individuals perceive the exercise as less demanding and in most cases prefer to work at that same work load.
CHAPTER III

PROCEDURE

I. SUBJECTS

Twenty-four subjects were selected from a weight training and a bowling class at the University of Montana and were randomly assigned to three training groups. The subjects were selected on the criteria that they have:

1. possessed moderate body weight for their height
2. expressed a desire to participate in a vigorous exercise program
3. been approved by a physician
4. expressed a willingness not to participate in any other physical activity beyond the laboratory fitness program.

Prior to the commencement of the testing and fitness program, the subjects were oriented to the study. Each subject was instructed in the procedures that would be followed prior to testing and training. He was told of the expected behavior, diet, and manner in which his heart rate would be recorded. The subjects were allowed to walk on the treadmill for a period of sixty to seventy-five seconds so that they could become accustomed to the skill of walking on the treadmill. They were also informed of the purpose and nature of
the study. Academic credit was given for participation in the study if they successfully completed all the work. This procedure allowed control over the subjects as well as providing some motivation to participate. The subjects were also informed about the pre-test, post-test and training procedures that would be followed. The subject's physical characteristics appear in Table I.

II. EQUIPMENT

Treadmill

The subjects were tested and trained on a motor driven treadmill located in the Human Performance Laboratory at the University of Montana. The treadmill has a continuous rubber belt driven by an electric motor so that subjects can either walk or run. The speed may be adjusted from one-half to over ten miles per hour by adjusting the drive belt tension. It was also possible to adjust the grade level between 0 to 50 per cent by turning the hand crank three turns for every one per cent grade increase.

Cardiotachometer

A cardiotachometer system was used to help indicate the heart rate levels of the subjects. The system contained disposable electrodes, flexible connective wires, and a
## TABLE I

**PHYSICAL CHARACTERISTICS OF THE TRAINING SUBJECTS**

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Height (inches)</th>
<th>Weight (pounds)</th>
<th>Age (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M.D.</td>
<td>71</td>
<td>175</td>
<td>19</td>
</tr>
<tr>
<td>S.G.</td>
<td>71</td>
<td>188</td>
<td>19</td>
</tr>
<tr>
<td>L.D.</td>
<td>67</td>
<td>134</td>
<td>18</td>
</tr>
<tr>
<td>J.E.</td>
<td>69</td>
<td>138</td>
<td>18</td>
</tr>
<tr>
<td>T.K.</td>
<td>75</td>
<td>181</td>
<td>20</td>
</tr>
<tr>
<td>D.L.</td>
<td>68</td>
<td>173</td>
<td>18</td>
</tr>
<tr>
<td>J.F.</td>
<td>74</td>
<td>198</td>
<td>20</td>
</tr>
<tr>
<td>B.B.</td>
<td>66</td>
<td>147</td>
<td>19</td>
</tr>
<tr>
<td>C.J.</td>
<td>68</td>
<td>147</td>
<td>19</td>
</tr>
<tr>
<td>K.O.</td>
<td>72</td>
<td>173</td>
<td>22</td>
</tr>
<tr>
<td>R.G.</td>
<td>70</td>
<td>153</td>
<td>20</td>
</tr>
<tr>
<td>G.A.</td>
<td>72</td>
<td>161</td>
<td>18</td>
</tr>
<tr>
<td>R.H.</td>
<td>68</td>
<td>155</td>
<td>21</td>
</tr>
<tr>
<td>D.C.</td>
<td>69</td>
<td>147</td>
<td>19</td>
</tr>
<tr>
<td>R.B.</td>
<td>67</td>
<td>137</td>
<td>19</td>
</tr>
<tr>
<td>D.L.</td>
<td>72</td>
<td>210</td>
<td>22</td>
</tr>
<tr>
<td>T.M.</td>
<td>69</td>
<td>149</td>
<td>20</td>
</tr>
<tr>
<td>J.G.</td>
<td>69</td>
<td>170</td>
<td>19</td>
</tr>
<tr>
<td>D.R.</td>
<td>69</td>
<td>148</td>
<td>21</td>
</tr>
<tr>
<td>M.B.</td>
<td>71</td>
<td>130</td>
<td>19</td>
</tr>
<tr>
<td>D.M.</td>
<td>71</td>
<td>167</td>
<td>20</td>
</tr>
</tbody>
</table>

Mean Scores 70 171 20

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recording instrument. The electrodes were held to the skin by an adhesive moleskin patch. The electrodes were placed between the fifth and sixth ribs, slightly forward of the mid-axillary line. Flexible wires carried the EKG signals from the electrodes to one recording instrument (Water Cardio-tac) which was equipped with a meter to indicate the average heart rate in beats per minute. The Q-R-S complex of the amplified EKG signal triggered the meter. The other recording instrument, a Tektonic Cathode Ray Oscilloscope graphically illustrated each EKG complex and indicated heart rate in beats per minute.

**Bicycle Ergometer**

The instrument was a stationary Monark bicycle. The resistance against which the subject pedals was provided by a frictional load. The work load was easily adjusted by changing the tension of the frictional band. The work was calibrated from a scale reading measured in kilo-pond-meters. The subjects pedaled fifty revolutions per minute as indicated by a metronome. During the bicycle test heart rate was recorded with the aid of a stethoscope.

**Bench-step**

A bench of forty centimeters in height was used for the step test. Each person took 22.5 steps per minute

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measured at a rate of ninety beats per minute. A metronome established the ninety beat per minute rate.

III. TESTS AND MEASUREMENTS

Physical Fitness Step-Test

The Modified Astrand-Rhyming Step-Test (21) was used to predict the maximum volume of oxygen. The test was administered in the following manner:

1. Subject rested for five minutes prior to administration of the test.
2. The subject began the test by alternating steps up onto the bench and back onto the floor. This was done in time to the metronome set at ninety beats per minute (i.e., one step for every beat of the metronome or 22.5 complete steps per minute).
3. The test was terminated after five minutes of work.
4. The subject was instructed to sit as his pulse was taken fifteen to thirty seconds after the exercise was terminated.
5. The predicted maximum volume of oxygen was then tabulated.
6. The fitness level was found by comparing the fitness index to the subject's age (21).
Modified Balke Treadmill Test

The Modified Balke Treadmill Test (8) was given to each subject in the following manner:

1. The subject walked on the treadmill at the rate of $3.5 \pm 0.1$ miles per hour beginning at zero grade level and continued at this same rate as the grade was increased.

2. At the end of the first minute the grade was raised two per cent, and one per cent per minute thereafter until the test was terminated.

3. The test was concluded when the heart rate reached 170 beats per minute.

4. The time of the test was recorded in minutes with any fraction rounded to the nearest ten seconds.

PWC\textsubscript{170} Test

This test helped to evaluate the subject's physical working capacity. It has long been known that heart rate rises linearly with increasing work loads. From the heart rate produced by certain work loads, it was possible to use the information as a measure of physical condition. The test was performed in the following manner:

1. The subject rode on the bicycle ergometer for three 2-1/2 minute bouts. This was a modified version of Sjostrand's (23) test.
2. If the subject scored 22.1 ml/lb/min or less on the fitness index he began work at 300 kgm/min; if he scored more than 22.1 on the fitness index he began work at 600 kgm/min. All subjects increased 300 kgm/min for the remaining two bouts.

3. The work loads tended to produce heart rates of 130, 150, and 170 beats per minute.

4. The working capacity was calculated by plotting the heart rates of the last two bouts against the work loads. A straight line was drawn through the two points to intersect the line of 170 beats per minute. The estimated amount of work that corresponded to a heart rate of 170 was then recorded as the individual's PWC\textsubscript{170}.

**Application of Borg's Perceived and Preferred Exertion Scales**

It was necessary to determine the effects various work loads had upon the subjects' perception of the external stimuli. Borg (5) found a strong correlation ($r=.83$) between subjective ratings according to the 21-grade rating scale and the number of pulse beats per minute during a work test. Borg also devised a seven-grade rating scale for the subjects' preference level. This level was defined as the level that was perceived by the subjects as being just about right or comfortable. The scales were administered in the
following manner:

1. The subjects were instructed to answer the questions by responding in numerical terms: How does the exercise feel and how does the exercise compare with the level at which you would like to train?
2. The graded rating scale for perception was based numerically from 1 to 21 with phrases indicating level of preference from 1 to 7. These are located in Appendix A.
3. Each rating scale was administered at selected time periods for each of the previously mentioned tests (i.e., the Physical Fitness Step Test, Modified Balke Treadmill, and PWC$_{170}$ Test).
4. Evaluation of the differences in scores from pre-tests to post-tests occurred upon completion of the experiment.

IV. TESTING PROCEDURE

The testing and training of the subjects were conducted during the 1969 Winter Quarter at the University of Montana. The same tests were administered both in the pre-test and post-test phases. The subjects trained for six weeks after they were pre-tested. Three days after completion of the training program, the subjects were post-tested. Both the testing and training sessions took place in the Human
Performance Laboratory. The Physical Fitness Step Test, the Modified Balke Treadmill Test, and the PWC\textsubscript{170} Test were administered as pre-tests and post-tests. The training consisted of riding the bicycle ergometer for a specified time limit, at a specified work load as determined by random assignment to various exertion levels.

**Pre-Tests and Post-Tests**

The pre-testing took place between January 9 and January 21, 1969. The post-tests were administered upon completion of six weeks of training. The post-test procedure lasted from February 23 to March 10, 1969. Exercise heart rates, time of exercise, and perceived and preferred exertion responses were all recorded for both the pre-tests and post-tests.

**The Training Procedure**

The subjects were told that during the six-week training session they should refrain from any vigorous extracurricular physical activity. Upon arriving at the laboratory, the subjects were weighed and asked questions about their outside activities, hours of sleep, other exercise and diet. The room temperature was recorded during each training session. The subjects then pedaled the bicycle ergometer at a pre-determined heart rate level until a specific work
load was completed. Heart rates were recorded every two to three minutes during the training. The subjects trained every Monday, Wednesday, and Friday. Due to illness and an automobile accident, it was necessary for three subjects to withdraw from the study.
CHAPTER IV

RESULTS, DISCUSSION AND SUGGESTIONS

The study necessitated a means of demonstrating training changes, perceptual changes and preferred changes. Several tests were used to establish the changes that existed between the pre-tests and post-tests in each of the three preceding categories. The Step Test, Modified Balke Treadmill Test and $PWC_{170}$ Test were the tests used to determine the effects of training. Perceptual and preferred exertion changes were related to the changes in physical condition.

I. TRAINING EFFECTS

All of the analysis of variance tests were programmed and analyzed on the IBM 1620 Computer by Patricia Morris. The computer is located at the University of Montana Data Processing Center.

A. Step Test

One indication of training change was illustrated by an increase in the predicted maximum $O_2$ consumption determined from the Modified Astrand Rhyming Step Test. A one-way analysis of variance on the three training groups (130, 150, 170) yielded an F score equal to 1.2341 which was not
statistically significant. The F score indicates that there was no significant difference in the effect of training on the three levels of training. However, Table II compares the pre-test to post-test values of the predicted maximum $O_2$ consumption. For each training group, the predicted maximum $O_2$ consumption increased after the six-week training program. Although the three training groups were not significantly different in terms of one group achieving a greater increase in maximum $O_2$, each training group increased their predicted maximum $O_2$ scores. A t-test of significance on the difference between pre-test and post-test scores produced a $t=0.31$ which was not a significant statistical change. However, each subject did increase his predicted maximum $O_2$ score which suggested that the training program did increase the subjects' fitness level.

A decrease in exercise heart rate is another indication of training change. Table III illustrates that all three training groups (130, 150, 170) decreased their post-exercise heart rates after the six-week training period. Therefore, each training group increased their fitness levels as indicated by a heart rate decrease.

B. Treadmill

Walking duration on the Modified Balke Treadmill Test indicates an individual's degree of physical fitness (i.e., the
### Table II

**Predicted Maximum $O_2$ Consumption**

<table>
<thead>
<tr>
<th></th>
<th>130</th>
<th></th>
<th>150</th>
<th></th>
<th>170</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
</tr>
<tr>
<td>J.G.</td>
<td>41.80*</td>
<td>53.46</td>
<td>S.G.</td>
<td>34.10</td>
<td>36.74</td>
</tr>
<tr>
<td>J.E.</td>
<td>40.92</td>
<td>47.52</td>
<td>G.A.</td>
<td>44.44</td>
<td>55.66</td>
</tr>
<tr>
<td>R.H.</td>
<td>37.18</td>
<td>41.80</td>
<td>B.B.</td>
<td>39.16</td>
<td>44.88</td>
</tr>
<tr>
<td>K.O.</td>
<td>41.80</td>
<td>41.80</td>
<td>D.R.</td>
<td>48.84</td>
<td>53.68</td>
</tr>
<tr>
<td>D.C.</td>
<td>40.04</td>
<td>47.08</td>
<td>M.D.</td>
<td>38.72</td>
<td>45.54</td>
</tr>
<tr>
<td>T.K.</td>
<td>37.62</td>
<td>41.58</td>
<td>R.B.</td>
<td>45.10</td>
<td>51.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>J.F.</td>
<td>37.62</td>
<td>38.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>R.G.</td>
<td>47.08</td>
<td>53.68</td>
</tr>
<tr>
<td></td>
<td>$\bar{x}$=39.89</td>
<td>$\bar{x}$=48.87</td>
<td>$\bar{x}$=41.88</td>
<td>$\bar{x}$=47.14</td>
<td>$\bar{x}$=46.89</td>
</tr>
</tbody>
</table>

* Milliliters/kilogram/minute
TABLE III

HEART RATE CHANGES--STEP TEST

<table>
<thead>
<tr>
<th></th>
<th>130</th>
<th></th>
<th>150</th>
<th></th>
<th>170</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
</tr>
<tr>
<td>J.G.</td>
<td>140*</td>
<td>108</td>
<td>S.G.</td>
<td>172</td>
<td>160</td>
</tr>
<tr>
<td>J.E.</td>
<td>144</td>
<td>124</td>
<td>G.A.</td>
<td>132</td>
<td>104</td>
</tr>
<tr>
<td>R.H.</td>
<td>164</td>
<td>140</td>
<td>B.B.</td>
<td>152</td>
<td>132</td>
</tr>
<tr>
<td>K.O.</td>
<td>140</td>
<td>140</td>
<td>D.R.</td>
<td>120</td>
<td>108</td>
</tr>
<tr>
<td>D.C.</td>
<td>148</td>
<td>124</td>
<td>M.D.</td>
<td>152</td>
<td>128</td>
</tr>
<tr>
<td>T.K.</td>
<td>156</td>
<td>140</td>
<td>R.B.</td>
<td>132</td>
<td>116</td>
</tr>
<tr>
<td>J.F.</td>
<td>156</td>
<td>152</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R.G.</td>
<td>124</td>
<td>108</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ \bar{X} = 148.6 \quad \bar{X} = 128.0 \]
\[ \bar{X} = 142.5 \quad \bar{X} = 126.0 \]
\[ \bar{X} = 127.0 \quad \bar{X} = 120.0 \]

* Denotes beats per minute--pulse taken 15-30 seconds after completion of step test
longer a subject walks the more physically fit he is). A training change can be illustrated by comparing the differences in $T_{170}$ times between the pre-tests and post-tests. A one-way analysis of variance on the three training groups yielded an F score equal to .6958 which was not statistically significant. The three training groups' data indicated the number of seconds each individual increased his walking time. The F score indicated that among the three training groups, one was not significantly different from the others. A t-test of significance on the difference between pre-test and post-test scores produced $t=.24$ for the 130 training group, $t=.42$ for the 150 training group, and $t=.22$ for the 170 training group. This was not a significant statistical change. However, Table IV indicates that each training group did increase their walking time on the treadmill by at least as much as 100 seconds.

C. Bicycle

Using a modified version of Sjøstrand's (23) $PWC_{170}$ test, it was possible to illustrate the difference in $PWC_{170}$ scores between the pre-test and the post-test. An increase in $PWC_{170}$ scores would indicate that the subjects had received a training effect and increased their fitness.

Initially, a one-way analysis of variance on the three training groups (130, 150, 170) yielded an F score of 6.6771
**TABLE IV**

$T_{170}$ TREADMILL TIMES

<table>
<thead>
<tr>
<th></th>
<th>130</th>
<th></th>
<th>150</th>
<th></th>
<th>170</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
</tr>
<tr>
<td>S.G.</td>
<td>490*</td>
<td>550</td>
<td>S.G.</td>
<td>320</td>
<td>380</td>
</tr>
<tr>
<td>J.E.</td>
<td>660</td>
<td>725</td>
<td>G.A.</td>
<td>590</td>
<td>740</td>
</tr>
<tr>
<td>R.H.</td>
<td>360</td>
<td>590</td>
<td>B.B.</td>
<td>330</td>
<td>500</td>
</tr>
<tr>
<td>K.O.</td>
<td>510</td>
<td>570</td>
<td>D.R.</td>
<td>710</td>
<td>840</td>
</tr>
<tr>
<td>D.C.</td>
<td>650</td>
<td>640</td>
<td>M.D.</td>
<td>470</td>
<td>550</td>
</tr>
<tr>
<td>T.K.</td>
<td>490</td>
<td>740</td>
<td>R.B.</td>
<td>400</td>
<td>580</td>
</tr>
<tr>
<td>J.F.</td>
<td>520</td>
<td>730</td>
<td>R.G.</td>
<td>660</td>
<td>840</td>
</tr>
</tbody>
</table>

$\bar{x}=527$  $\bar{x}=628$  $\bar{x}=500$  $\bar{x}=645$  $\bar{x}=543$  $\bar{x}=638$

* Denotes time walked in seconds
which was statistically significant. This score indicated that among the three training groups, one or two groups were significantly different from the others. Using the Scheffe method to find a comparison between groups following a significant F test, indicated that the 130 and 150 training groups did significantly differ from the 170 training group. The difference was significant at the .05 level of confidence between the 130 and 170 groups, and the 150 and 170 groups. The Scheffe method and figures are indicated in Appendix B.

Table V illustrates that the 170 group is the group that is different as it contains a negative difference while the 130 and 150 groups contain positive sums. A positive sum indicates an increase in physical working capacity, hence an increase in fitness. A negative sum indicates a decrease in physical working capacity, hence a decline in fitness level. Table V illustrates that the 130 and 150 groups increased in physical working capacity while the 170 group decreased in physical working capacity. A training effect occurred in the 130 and 150 groups but not in the 170 group as indicated by the physical working capacities. The 150 group had a greater fitness change than the 130 group as indicated by Table IV. The 150 group demonstrated a 172.5 kgm/min change while the 130 group had a 131.6 kgm/min change.

Heart rates were measured and recorded at three
<table>
<thead>
<tr>
<th></th>
<th>130 Pre</th>
<th>130 Post</th>
<th>150 Pre</th>
<th>150 Post</th>
<th>170 Pre</th>
<th>170 Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>J.G.</td>
<td>900*</td>
<td>1020</td>
<td>S.G.</td>
<td>840</td>
<td>1000</td>
<td>D.L.</td>
</tr>
<tr>
<td>J.E.</td>
<td>810</td>
<td>710</td>
<td>G.A.</td>
<td>1100</td>
<td>1250</td>
<td>D.L.</td>
</tr>
<tr>
<td>R.H.</td>
<td>780</td>
<td>995</td>
<td>B.B.</td>
<td>800</td>
<td>900</td>
<td>C.J.</td>
</tr>
<tr>
<td>K.O.</td>
<td>800</td>
<td>950</td>
<td>D.R.</td>
<td>750</td>
<td>1120</td>
<td>M.B.</td>
</tr>
<tr>
<td>D.C.</td>
<td>805</td>
<td>1100</td>
<td>M.D.</td>
<td>800</td>
<td>1060</td>
<td>L.D.</td>
</tr>
<tr>
<td>T.K.</td>
<td>820</td>
<td>930</td>
<td>R.B.</td>
<td>850</td>
<td>1060</td>
<td>D.M.</td>
</tr>
<tr>
<td>J.F.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1200</td>
<td>1420</td>
</tr>
<tr>
<td>R.G.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1190</td>
<td>1100</td>
</tr>
</tbody>
</table>

\[ \bar{X}=819 \quad \bar{X}=951 \quad \bar{X}=941 \quad \bar{X}=1114 \quad \bar{X}=1005 \quad \bar{X}=960 \]

* Units are in kilogram meters per minute
### TABLE VI

**HEART RATE CHANGES--PWC_{170} TEST**

<table>
<thead>
<tr>
<th></th>
<th>130</th>
<th></th>
<th>150</th>
<th></th>
<th>170</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>120.6*</td>
<td>Post</td>
<td>146.5</td>
<td>Pre</td>
<td>171.6</td>
<td>Post</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>134.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>127.2**</td>
<td></td>
<td>152.0</td>
<td></td>
<td>175.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>125.6</td>
<td></td>
<td>152.0</td>
<td></td>
<td>176.0</td>
<td></td>
</tr>
</tbody>
</table>

* Denotes subjects who began pedaling at 300 kgm/min

** Denotes subjects who began pedaling at 600 kgm/min
different work intervals during the PWC_{170} test. A decrease in mean values between the pre-tests and post-tests should indicate a training change and increased fitness. Table VI illustrates the heart rate changes. There are two sets of scores; one set for those subjects who began pedaling at 300 kgm/min and another set for those subjects who began pedaling at 600 kgm/min. The 300 kgm/min group decreased their heart rates for each of the three work intervals while the 600 kgm/min group did not demonstrate any significant decrease in heart rate. This heart rate data measured the mean values of all subjects who began the PWC_{170} test doing 300 kgm/min work and 600 kgm/min work. All the subjects' mean values were compiled and no effort was initiated to compare the mean heart rate differences among the three training groups (130, 150, 170). The results indicated that the 300 kgm/min subjects increased their fitness as illustrated by a decrease in heart rate. The 600 kgm/min subjects remained practically at the same fitness levels as their heart rates did not decrease appreciably. This may be explained in the following manner. Only those subjects who achieved a high fitness level on the step test (22.1) were allowed to begin work at the 600 kgm/min level. Therefore, they exhibited high fitness which may have been near their optimal fitness level. Shephard (22) suggested that the magnitude of fitness change is inversely related to the initial level of fitness.
Thus, the training program did not appreciably increase their fitness level as much as it did for those subjects who began work at 300 kgm/min. The 300 kgm/min subjects could demonstrate a more significant heart rate drop as a result of their lower beginning fitness level.

II. PERCEIVED AND PREFERRED CHANGES

Borg's (5) indexes for perceived and preferred levels of exertion progressively increase (i.e., the low numbers equal low exertion, higher numbers equal greater exertion).

A. Step Test

During the fourth minute of the Step Test, the subjects responded to Borg's perception scales. The mean perceptual scores were calculated for all three training groups. The pre-test scores were compared with the post-test scores as illustrated in Table VII.

The 130 and 150 groups showed a mean difference of 1.1 perceptual units while the 170 group showed a mean difference of .5 perceptual units as seen in Table VII. (The mean difference is indicated by subtracting the post-test scores from the pre-test perceptual scores.) This data suggests that the step test seemed less difficult as perceived by the subjects in each of the three groups.
TABLE VII

THE RELATIONSHIP OF PERCEPTUAL CHANGES TO FITNESS CHANGES FOR ALL THREE TRAINING GROUPS ON THE STEP TEST AND TREADMILL ERGOMETERS

### STEP TEST

<table>
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<tr>
<th>Group</th>
<th>Pre</th>
<th>Post</th>
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<tbody>
<tr>
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<tr>
<td>Heart Rate</td>
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<td>129.3</td>
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<td>Pred. Max O₂</td>
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<td>45.5</td>
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<td></td>
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<tr>
<td>Heart Rate</td>
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<td>-11.7</td>
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<tr>
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<tr>
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<td>- 0.5</td>
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### TREADMILL

<table>
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<tr>
<td>Time*</td>
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<td>Time</td>
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<td>675.7</td>
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<tr>
<td>Perceptual Scores</td>
<td>9.9</td>
<td>11.0</td>
<td>+ 1.1</td>
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<tr>
<td>170</td>
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<td></td>
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<tr>
<td>Time</td>
<td>555.7</td>
<td>670.0</td>
<td>+114.3</td>
</tr>
<tr>
<td>Perceptual Scores</td>
<td>10.7</td>
<td>10.8</td>
<td>+ 0.1</td>
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* Denotes time required to reach terminal heart rate of 170
B. Treadmill

During the Modified Balke Treadmill Test, the subjects were asked to relate their perception of the exercise to the researcher when their heart beats reached 120, 140, and 160. Consequently for each training group, there existed three perceptual responses. The mean perceptual scores were calculated for each heart rate level (120, 140, 160) for all three training groups. The pre-test scores were compared with the post-test scores as illustrated in Table VII. With the exception of the 130 training group the post-test perception levels increased in magnitude rather than decreased as in the step test data. The 130 training group decreased slightly during the post-test. The perception of the exercise on the treadmill was measured against a constant heart rate (120, 140, 160) in both the pre-test and post-test. The perceptual data reflected the perceptual interpretation each subject had during 120, 140, 160 heart rates on the treadmill. Thus, heart rate was defined as work load. The treadmill work load was defined differently than the work load definition that existed for the step test and bicycle PWC\(_{170}\) test. The latter two tests defined work load in terms of a constant work intensity (i.e., 300 kgm/min to 1200 kgm/min for the bicycle), rather than as related to heart rate. Therefore, as the subjects increased their.
ability to walk for greater periods of time on the treadmill, it took each one longer to reach the 120, 140, 160 heart rate level. Each subject related that perceptual interpretation of the exercise at the same heart rate level for both pre-tests and post-tests. The responses were similar in magnitude as was expected because the heart rate (defined as work load) was the factor that determined when the subjects would relate their perceptual interpretation to the researcher.

The treadmill data suggests that there was no perceptual decrease for all three training groups as a result of the six-week training period. It should be noted that the perceptual responses were elicited at higher grades during the post-test. Hence the same heart rate and perceptual responses occurred at a higher work load on the treadmill.

C. Bicycle

At the two, four and one-half, and seven and one-half minute periods of the test the subjects were asked to relate their perception of the exercise to the researcher. The ride was terminated after seven and one-half minutes. After each perceptual interpretation, the work load was increased 300 kgm/min. The starting level was either 300 kgm/min or 600 kgm/min depending upon each subject's fitness level as determined by the step test fitness index. Every subject in the 130 training group began at 300 kgm/min while only

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selected subjects in the 150 and 170 training groups began at 600 kgm/min. A mean perceptual score was found for each training group.

The mean perceptual scores were calculated collectively. The pre-test scores were then compared with the post-test scores as illustrated by Table VIII. Both work load levels in the 150 and 170 training groups and the 300 kgm/min work level in the 130 training group showed a decrease in perceptual response in the post-test as compared to the pre-test scores. This indicates that the six-week training program did enable the subjects to perceive the same work loads as less difficult after training.

D. Preferred Levels of Exertion

It was necessary to determine the relationship between perceived and preferred levels of exertion. Using only pre-test data for the bicycle, the perceived and preferred means for each work load level were calculated as illustrated in Figure 1. With each increase in work load, the perception and preferred scores also increased. Even though the two scales were not the same in terms of degrees of interpretation (21 for perceptual scale, 7 for preferred scale) the data suggests a linear relationship between the perceptual and preferred scales. As the work loads increase, the perceptual and preferred scales tend to increase together.
TABLE VIII

THE RELATIONSHIP OF PERCEPTUAL CHANGES TO HEART RATE CHANGES
FOR ALL THREE TRAINING GROUPS ON THE BICYCLE ERGOMETER

<table>
<thead>
<tr>
<th>Group</th>
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<th>PWC&lt;sub&gt;170&lt;/sub&gt;</th>
<th>Perceptual Scores</th>
<th>Heart Rate</th>
<th>PWC&lt;sub&gt;170&lt;/sub&gt;</th>
<th>Perceptual Scores</th>
<th>Heart Rate</th>
<th>PWC&lt;sub&gt;170&lt;/sub&gt;</th>
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<tr>
<td>130</td>
<td>120.6</td>
<td>112.1</td>
<td>-8.5</td>
<td>819.2</td>
<td>950.8</td>
<td>+131.6</td>
<td>8.6</td>
<td>6.7</td>
<td>-1.9</td>
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<tr>
<td>150</td>
<td>146.5</td>
<td>134.3</td>
<td>-12.2</td>
<td>968.5</td>
<td>1112.8</td>
<td>+144.3</td>
<td>11.1</td>
<td>9.3</td>
<td>-1.8</td>
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<tr>
<td>170</td>
<td>171.6</td>
<td>160.1</td>
<td>-11.5</td>
<td>1000.0</td>
<td>1030.0</td>
<td>+30.0</td>
<td>13.4</td>
<td>12.3</td>
<td>-1.1</td>
</tr>
</tbody>
</table>

* Represents group that began test at 300 kgm/min
** Represents group that began test at 600 kgm/min
FIGURE I

THE MEAN PERCEIVED AND PREFERRED PRE-TEST SCORES FOR ALL WORK LOAD LEVELS
The preferred mean scores were also calculated from the post-test data and compared to the pre-test data. These scores were in turn compared to the perceptual pre-test and post-test scores, as illustrated by Figure 2. This was done to indicate the linear relationship that existed between the perceived and preferred scores both in the pre-tests and post-tests. The preferred post-test data indicated that the training enabled the subjects to lower their preference levels for the same work loads performed in the pre-test for all work levels except the 1200 kgm/min work level. Therefore, most of the subjects indicated after a training period that they perceived the same work levels as less stressful and a higher level of work could be tolerated at the same preference level.

Again using only pre-test data, the perceived and preferred means were calculated for all of the 130, 150, 170 heart rates on the treadmill test. Figure 3 illustrates the results. Similar results were found with the treadmill data as were found with the bike data. As the work load increased (heart rate), the perceived and preferred scores increased. The perceptual and preferred scales tended to increase in a linear manner.

Comparing the relationship of perception and preference levels against work and pulse, the results suggest that the preferred scores will change with the perceived scores. As
FIGURE 2

THE MEAN PERCEIVED AND PREFERRED POST-TEST SCORES FOR ALL BICYCLE WORK LOAD LEVELS
FIGURE 3
THE MEAN PERCEIVED AND PREFERRED PRE-TEST SCORES FOR ALL TREADMILL HEART RATE LEVELS
the perceived interpretation of exercise either increased or decreased, the preferred level of exercise also increased or decreased.

As a result of this relationship, the researcher did not deem it necessary to examine the preferred changes after the six-week training program on the step test and treadmill ergometers.

III. RELATIONSHIP OF TRAINING CHANGES TO PERCEPTUAL CHANGES

In order to illustrate the relationship of training changes to perceptual changes, it was necessary to graph and table the pre-test and post-test training and perceptual scores. The mean differences indicated that a change occurred; however, the mean differences would not clearly indicate that an increase or decrease in fitness and perception had occurred. Therefore, the pre-test and post-test scores were graphed and placed in tables to determine the relationship between fitness and perceptual scores. The mean differences were used to indicate which training group experienced the most fitness or perceptual changes.

A. Step Test

The mean perceptual pre-test scores were compared to the mean heart rate pre-post scores for all three training groups as illustrated by Figure 4. The post-test data...
THE COMPARISON OF MEAN PERCEPTUAL PRE-POST SCORES TO THE MEAN HEART RATE PRE-POST SCORES FOR ALL THREE TRAINING GROUPS ON THE STEP TEST
illustrates a decrease in heart rate and perception for all three training groups. This suggests that as each training group experienced an increase in fitness, represented by decreased heart rate, each training group perceived the exercise as less difficult.

The mean perceptual pre-post scores were also compared to the mean predicted maximum $O_2$ pre-post scores for all three training groups as illustrated by Figure 5. The post-test data illustrates an increase in predicted maximum $O_2$ and a decrease in perception for all three training groups. This suggests that as each training group experienced an increase in fitness, represented by increased predicted maximum $O_2$ consumption, each training group perceived the exercise as less difficult.

Two indexes of fitness change were used, decreased heart rate and increased predicted maximum $O_2$ consumption. In both cases, the fitness levels increased for all three training groups and the perceived interpretation scores decreased for all three training groups. Therefore, the step test suggests the following: as the subjects increased their fitness, they perceived the exertion as less difficult.

B. Treadmill

Perceptual pre-post scores were compared to the mean $T_170$ pre-post scores for all three training groups as
THE COMPARISON OF MEAN PERCEPTUAL PRE-POST SCORES TO THE MEAN PREDICTED MAXIMUM O$_2$ PRE-POST SCORES FOR ALL THREE TRAINING GROUPS ON THE STEP TEST

FIGURE 5

---pred. max O$_2$ scores

---perception scores
illustrated by Figure 6. Each training group was asked to interpret the treadmill exercise when the heart rate reached 120, 140, and 160 beats per minute. Therefore, each subject had three perceptual scores. These three scores were then averaged for each subject in each training group. The mean perceptual score was calculated for each training group by averaging the individual subject's mean scores. The mean T170 scores were calculated by averaging the individuals' scores in each training group.

The post-test data illustrates an increase in treadmill walking time for all three training groups and an increase in perceptual scores for the 150 and 170 training groups. This suggests that as each training group experienced an increase in fitness, represented by increased treadmill walking time, two groups perceived the exercise as more difficult. Therefore, even though all three groups experienced fitness increases, two of the three training groups felt that the exertion was of equal or more difficulty than they experienced during the pre-test. The treadmill ergometer data did not suggest a positive relationship between fitness increases and decreases in perceived exertion. However, 120, 140, 160 heart rates indicated the time for the perceptual response; therefore, at higher grades the subjects walked longer periods of time to produce the desired heart rates. Thus, they accomplished more work and would, therefore,
THE COMPARISON OF MEAN PERCEPTUAL PRE-POST SCORES TO THE MEAN T170 PRE-POST SCORES FOR ALL THREE TRAINING GROUPS

FIGURE 6
logically interpret the work as more difficult than they did in the pre-test.

C. Bicycle PWC\textsubscript{170} Test

There were five subjects who began at the 600 kgm/min work load level. One subject was in the 150 training group, while the other four subjects were in the 170 training group. This is the reason Table VIII indicates two sets of scores for training groups 150 and 170 under the PWC\textsubscript{170}-Bicycle heading.

The post-test data illustrates an increase in PWC\textsubscript{170} scores for all groups except the 600 kgm/min work load subjects in the 170 training group. As the 300 kgm/min work load subjects experienced an increase in fitness, represented by increased PWC\textsubscript{170} score, the subjects perceived the exercise as less difficult. All training groups perceived the exercise as less difficult during the post-test after training had occurred. The 600 kgm/min work load subjects in the 170 training group perceived the post-test as less difficult even though the PWC\textsubscript{170} score suggested a decrease in fitness.

The perceptual pre-post scores were related to the heart rates of the subjects in all three training groups. Table VIII indicates ten sets of scores for the 150 and 170 training groups because none of the subjects in the 130 training group began at the 600 kgm/min work level. All
training groups in all work levels experienced decreased heart rates and decreased perceptual scores during the post-test except for the 170 training group who began at the 600 kgm/min work load level. The 170 training group experienced a slight increase in heart rate (175.2 to 176.0). This is not an appreciable increase.

IV. DISCUSSION

In this study pre-tests and post-tests on three ergometers were used to determine the effects an exercise training program would have upon fitness, perceptual, preferred changes, and the relationship of each to the other.

All subjects exhibited an increase in fitness on all ergometers. The treadmill involved an unfamiliar task, walking on a noisy treadmill with increasing walking angles. This unfamiliar piece of apparatus accompanied with the utilization of different muscles than those used in the step and bicycle test may have caused apprehension on the part of the subjects. The apprehension may have been interpreted as a stress-producing situation which caused the subjects to give higher perceptual post-test scores. Whiddon's study (31) indicated that an initial stress produced by the emotional factor in exercise resulted in faster whole blood clotting time. Whiddon's work also suggested that after becoming familiar (i.e., habituation) with the exercise, the whole
blood clotting time returned to control levels. This suggested that the emotional anxiety produced by an unfamiliar task may have caused the increase in the stress situation.

As exercise became more intense, the subject perceived it as more difficult. As subjects increased their fitness they perceived the same work load intensities as less difficult during the post-test. A positive relationship existed between preferred scores and perceptual scores. Thus, at the conclusion of the training period the subjects interpreted the same work load intensities as less difficult and a higher level of work could be tolerated at the same preference level. The greatest perceptual decreases and fitness increases occurred on the bicycle ergometer, which was the piece of equipment that the subjects were most familiar with due to the fact that they trained on the bicycle for six weeks. This indicated that habituation of the physical activity and the training of the autonomic nervous system may have caused the subjects to perceive the exercise as less difficult and less stress-producing.

Physiological stress (i.e., increased ACTH production) has been related to the emotional factor in exercise by several recent studies. Frankenhaeuser and associates (13) and Steadman (24) have all concluded that the adrenaline increase during exercise was due to emotional factors or the unpleasantness associated with the exercise. Frankenhaeuser concluded
that the adrenaline increase was in part related to the subjective reaction accompanying the physical work, rather than being elicited by the work itself. The present study indicated that habituation or familiarity with exercise work loads helped to decrease perceptual scores. This suggests that it was possible to effectively reduce the subjects' subjective reactions accompanying the work loads.

V. SUGGESTIONS

Exercise has been suggested for reducing emotional anxiety and increasing individuals' levels of physical fitness. This study suggests that a training program may increase an individual's level of fitness and at the same time reduce the perceived difficulty of the exercise. Thus, the anxious person may receive the physiological benefits of a training program if the perceptual interpretation of the training program is reduced significantly. The anxiety produced by exercise would be reduced, which in turn would produce less hormonal elaboration (i.e., stress).
CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

I. SUMMARY

This study was conducted to determine the perceptual interpretation of various exercise intensities as measured on three ergometers. The three tests and ergometers consisted of a step test, modified Balke Treadmill test, and a modified PWC\textsubscript{170} test. Twenty-four subjects between the ages of 18 and 22 served as subjects. Each subject was placed randomly in one of three training groups. The program consisted of three heart rate intensities (130, 150, 170). The subjects trained for six weeks with group placement determining duration and intensity of the training period (i.e., cell placement dictated the amount of work accomplished, average 11,250 KPM total, and rate of work, 130, 150, 170 heart rates). The subjects were post-tested on the same three ergometers.

The data indicated that the perceptual interpretation of exercise is directly related to the physical fitness level of the individual. As an individual became more physically fit, he interpreted the same work intensity as less stressful. Each training group achieved some increase in fitness level as measured on the three ergometers, with the exception of
the 170 training group in the $PWC_{170}$ bike test. Concur-
rently, all the training groups perceived the exercise as
less stressful with the exception of the treadmill ergometer.
However, the treadmill ergometer data did not suggest that
the subjects perceived the exercise as more stressful. This
information leads to the following conclusions.

II. CONCLUSIONS

1. A six-week training program of various exercise
   intensities can increase the fitness levels and
decrease the perceptual interpretation levels for
   college males.

2. A direct relationship seems to exist between pre-
   ferred and perceived changes in the interpretation
   of exercise. As one's perceived level of exercise
   interpretation decreases, so does the preferred
   level.

3. The greatest perceptual and fitness changes occurred
   in the 150 training group.

4. The greatest perceptual decrease occurred on the
   ergometer which the subjects trained. This suggests
   that familiarity with a particular exercise seems to
   facilitate the interpretation that the exercise is
   less stressful.

5. As an individual familiarizes himself with a particular
exercise program and/or piece of equipment, his autonomic responses seemed to be trained to perceive pre-test exercise intensities as less stressful during the post-test.

III. RECOMMENDATIONS

In view of the findings of this study, the following recommendations are made:

1. It would be worthwhile to establish the relationship between the perceptual interpretation of exercise to fitness changes which exist for subjects of under twenty and over thirty years of age.

2. It would be valuable to discover the effect a physical fitness program has upon the anxiety of those individuals who are chronic sufferers or hyperreactors to the stresses of life.
SELECTED BIBLIOGRAPHY


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APPENDIX A

BORG'S RATING SCALES

I. Perception

1
3 extremely light
5 very light
7 light
9 fairly light
11 neither light nor difficult
13 fairly difficult
15 difficult
17 very difficult
19 extremely difficult
21

II. Preferred

1
2 below
3 slightly below
4 just right
5 slightly above
6 above
7
APPENDIX B

STATISTICAL ANALYSIS

I. Scheffe Formula

A. \[ F = \frac{\left( \overline{X}_1 - \overline{X}_2 \right)^2}{S_w^2 \left( \frac{n_1 + n_2}{n_1 n_2} \right)} \]

B. Obtain value of \( F \) required for significance at the .05 level.

C. Calculate \( F' \)

\[ F' = (k-1)F \]

D. Compare values of \( F \) and \( F' \). For any difference to be significant at the required level, \( F \) must be greater than or equal to \( F' \).

II. Group Comparison Scores

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<td>130, 170</td>
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<tr>
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<td>19.2</td>
<td>significant</td>
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APPENDIX C

VOLUNTEER FORM

Human Performance Laboratory
Bureau for Research on Physical Activity and Sport
University of Montana

Studies of man and his physiological reaction to training

I hereby freely volunteer to act as a subject in a scientific investigation as an authorized part of the educational and research program of the University of Montana. I acknowledge that I have read and concur in the procedures and objectives of this investigation as summarized on this sheet.

I certify that to the best of my knowledge and belief, I have no physical or mental illness or weakness that would increase the risk to me of participation in this investigation.

I further certify that I have been examined by a qualified physician, and have been found fit to participate in vigorous physical activities.

The investigation involves an analysis of several training schemes and their effect on the development of cardiorespiratory endurance. Volunteers will be tested on several laboratory devices. The men will then train three days per week for six weeks—approximately 20 minutes per day.

If you decide to volunteer we ask that you sign this sheet indicating your willingness to comply with the provisions of the investigation and your willingness to assume personal risks of participation.

Date Age of Subject Signature of Subject

Campus phone number Campus Address

During the course of the investigation we ask that you refrain from regular vigorous physical activity exclusive of that involved in the study. If you do become involved in such activity we ask that you report it to the investigators on the daily information form. We thank you for your willingness to become involved in our investigation and hope that you will find it both physically rewarding and intellectually stimulating.