To the Graduate Council:

I am submitting herewith a thesis written by Kim T. Meeker entitled "The Effect of Total Work on Cardiorespiratory Function." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Physical Education.

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THE EFFECT OF TOTAL WORK ON CARDIORESPIRATORY FUNCTION

A Thesis

Presented for the

Master of Science

Degree

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Kim T. Meeker

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DEDICATION

This thesis is dedicated to my mother, father, and wife, Robin, who were constant sources of support and inspiration.

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ABSTRACT

The purpose of this study was to determine the effects of training at three levels of caloric expenditure on selected cardiovascular fitness variables. In order to observe the isolated effects of total work (kilocalorie expenditure during exercise), intensity and frequency of training were held constant at specified levels that exceeded proposed training thresholds for these factors.

For this 16 week investigation, 34 sedentary male volunteers (ages 18-24) were randomly assigned to one of three groups involved in expending a prescribed number of kilocalories each exercise session. The three groups were: a 150 kcal/session group, a 300 kcal/session group, and a 450 kcal/session group. Jogging was the mode of training. A control group was drawn from the same population. Each experimental group trained three times per week at 80% of maximum heart rate for 16 weeks. Testing was done after 8 weeks and after 16 weeks of training. The subjects were evaluated by resting measures (resting heart rate, weight, and a sum of six skinfold sites) and exercise measures derived from a treadmill test (heart rate response to a fixed submaximal task, maximum heart rate, and VO_2 max). At eight weeks, only the 450 kcal/session group was superior to the control group in VO_2 max. At 16 weeks, only the 450 kcal/session group showed significant improvements compared with the control group in resting heart rate, weight reduction, and VO_2 max. No other significant differences were found between groups. It was concluded that total work per session was the important training factor when

intensity and frequency were above threshold levels. It was further concluded that, for young men, it may be necessary to expend more than 300 kcal/session in order to make cardiovascular fitness changes.

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CHAPTER I

INTRODUCTION

Interest in Training Factors

Accompanying the rising interest in aerobic activity and cardiovascular fitness programs has been an increasing number of questions raised by the general public and researchers alike. Some of the questions most frequently asked are: How hard, how often, how long, and how much must one exercise to make aerobic gains? From these questions researchers have identified four factors to be considered in exercise prescriptions: intensity, frequency, duration, and total work.

In order to answer the questions, information must be obtained about intensity, frequency, duration, total work, and interactions among the four factors. Threshold values, the minimum amount of each factor needed to elicit a change in cardiovascular fitness, need to be identified for the four factors. These threshold values may then be used to intelligently prescribe exercise programs. Other useful information would include the identification of fitness ceilings, above which additional effort would be ineffectual. Then, quantified information concerning the middle ground between threshold and ceiling is needed.

Difficulties in Interpretation of Training Research

Although there have been many studies concerning the role of intensity, frequency, duration, and total work, it is still

not clear whether changes in fitness are largely the result of one of these factors, or mostly a combination of the factors. Logically, one would think that subjects training more intensely, more frequently, and for longer periods of time would make the greatest improvements. However, research indicates that even this statement is not completely true. The difficulty in the interpretation of studies involved with training is the lack of control of extraneous variables. Usually the lack of control involves the interaction of one of the four above mentioned factors

The most common problem appears to be the failure to control for total work. For instance, a study examining frequency of exercise might indicate that exercising four times a week is more effective than exercising twice a week. However, the data show that the work done by the four day per week group was twice as great as the work done by the two day per week group. Studies of exercise intensity often show a threshold value, and yet an examination of the findings reveals that the subjects working more intensely accomplished more total work. A study might point to duration as being the most important factor, when, in fact, the subjects working for longer periods of time did more total work.

The apparent weakness in the existing research is that the effect of total work was not controlled. This particular weakness becomes even more of a problem when a study by Kuntzlemen (20) indicates that total work is probably the most important of the factors influencing cardiovascular fitness. Also, in a position statement, the American College of Sports Medicine (1, p. 3) made

the following comment:

> Although more comprehensive inquiry is necessary, present evidence suggests that when exercise is performed above the minimal threshold of intensity, the total amount of work accomplished is the important factor in fitness development and maintenance.

In light of such statements, the fact that there was no control for total work in most of the training literature, makes it difficult to rely on the body of knowledge.

Therefore, it would seem that a study is needed that examines only the effects of total work on training. Such a study would not only add to the present body of knowledge by revealing the importance of total work, but would also be an aid in interpreting the existing literature.

Statement of the Problem

The study was undertaken to determine the effect of three different amounts of work [150, 300, and 450 kilocalories (kcal) per session] on various cardiorespiratory measures when intensity (80% of maximum heart rate), frequency (3 days per week), length of study (16 weeks), initial level of activity (sedentary), sex and age (college males), and type of activity (jogging) are held constant. The cardiorespiratory measures evaluated were maximal oxygen consumption, (VO_2 max), resting heart rate, maximal heart rate, and a heart rate response to a fixed submaximal task.

Definition of Terms

(1) Duration--Duration refers to the exercise session time (minutes per session). In order to achieve the specified caloric

expenditures for this study, duration per session varied. For instance, the 300 kcal group exercised longer per session than the 150 kcal group, and the 450 kcal group exercised longer than either of the other groups.

(2) Frequency--Frequency refers to the number of days per week that the subjects train. In this study the frequency was three times per week for all subjects in the experimental groups.

(3) Intensity--Intensity refers to the percentage of maximum heart rate at which subjects train. In this study subjects trained at 80% of their maximum heart rate (0.80 X max HR).

(4) Sedentary--A "sedentary" individual refers to a person who engages in vigorous physical activity (i.e. running, swimming, bike riding, etc.) not more than three times per month. The participants in this study had been sedentary for at least six months.

(5) Total Work--Total work refers to the approximate caloric expenditure of the assigned task. Total work may refer to total work per session, total work per week, or total work accomplished before testing.

CHAPTER II

REVIEW OF RELATED LITERATURE

It is common knowledge that a certain level of physical activity is needed to improve cardiovascular fitness. Although many investigators have shown that their training program produced the gains, they have less often shown that these gains were solely the result of the intensity, frequency, duration, or total work of the exercise program. Fewer studies have quantified these four factors or interactions between the factors.

Of the studies that have been involved in this quantification, many of them have not controlled for total work. In response to weaknesses in control evidenced in training studies, Franks and Deutsch (12) suggested that research be done to systematically identify the factors that cause improvements. By an examination of those studies that did not control for the effects of total work and those studies that did control for total work, one can glean some information concerning the factors that cause fitness improvements.

Intensity of Exercise

Karvonen, Kentala, and Mustala (18) were the first researchers to suggest there was a training threshold. Their experiment required the subjects (six sedentary male medical students) to run on a treadmill for half an hour. They trained four or five times a week for a period of four weeks. The researchers used heart rate as an estimate of cardiovascular fitness. The investigators concluded

that a heart rate of at least 60% of the range between resting and maximum was needed to achieve a training effect. This is in agreement with Astrand's (2) proposed threshold of 50% of maximal oxygen consumption and with the findings of Hollman and Venrath (16). Although the researchers held the exercise time constant, there was no specific control for total work.

Other studies followed a similar pattern. Sharkey and Holleman (36) trained subjects on a treadmill, walking at intensities of 120, 150, and 180 beats per minute for ten minutes. The 180 beats per minute group made the greatest improvements, but the 150 beats per minute group also made significant changes. Jackson (17) in a similar study concluded that training at 145 beats per minute or greater is necessary to improve cardiovascular fitness. VO_2 max and resting heart rate were used to estimate cardiovascular fitness in the Sharkey and Holleman experiment, and resting heart rate, heart rate response to exercise, and recovery heart rate were used by Jackson. Both experiments held exercise time constant, but failed to control for total work. In the three intensity studies cited, it is obvious that some subjects were required to do more total work than others to get heart rates up to specified levels. These studies are fairly typical of the work done concerning intensity where the effect of total work was not controlled.

Intensity of Exercise (Controlling for Total Work)

Using the bicycle ergometer, Burke and Franks (6) trained subjects at either 85%, 75%, or 65% of their maximum heart rates. Unlike Karvonen, Kentala, and Mustala (18), who measured intensity

by percentage of the range between resting and maximum heart rate (known as heart rate reserve), Burke and Franks determined intensity by percentage of maximum heart rate (% X maximum heart rate). All three groups were given the same amount of work, 12,000 kpm (approximately 150 kcal per session and 4500 kcal for all sessions combined). The groups trained three days a week for ten weeks. VO_2 max was used as a measure of cardiovascular fitness. The 85% and 75% groups made significantly greater improvements than the other two groups. There were no significant differences between the 65% group and the control group. Neither were there differences between the 85% and the 75% group. The researchers concluded that when total work was held constant, it was necessary to train at 75% of maximum heart rate in order to evoke changes in VO_2 max. These findings are in relatively close agreement with the findings of Karvonen, Kentala, and Mustala (18).

In another study that controlled for total work, Pollock et al. (32) examined the effects of 80% and 90% of maximum heart rate reserve on selected fitness measures. Groups trained forty-five minutes per session, two days per week for a total of twenty weeks. Twenty-two men (30-45 years old) and twelve controls were used. The findings revealed that after ten weeks and approximately a 9,000 kcal energy expenditure, both experimental groups made significant improvements in VO_2 max. Between group analysis showed no significant differences at 10 or 20 weeks. There were no significant changes in resting heart rate for the control group or the experimental groups. These results, along with the findings of Burke and Franks (6),

seem to suggest a ceiling effect for exercise intensity.

Sharkey (35) designed a study to observe the relationship between intensity and total work. In his study 36 college students were randomly assigned to three levels of intensity (130, 150, and 170 beats per minute) and two levels of work (7,500 and 15,000 kpm). Actual work time averaged about 15, 10, and 7 1/2 minutes for the 7,500 kpm--130, 150, and 170 groups and 30, 20, and 15 minutes for the 15,000 kpm--130, 150, and 170 groups, respectively. The subjects trained on bicycle ergometers three times a week for six weeks. Analysis of the data revealed no significant treatment or interaction effects for any of the test conditions. Energy expenditures were approximately 100 and 200 kcal per workout for the 7,500 and 15,000 kpm groups, respectively. Therefore, the total expenditures for the 7,500 and 15,000 kpm groups were approximately 1,800 and 3,600 kcal. Neither of these energy expenditures, at the intensities used, was sufficient to elicit significant changes in predicted VO_2 max scores by Astrand-Rhyming (3) test predictions.

Frequency of Exercise

Olree et al. (24) trained subjects on a bicycle ergometer at a heart rate of 160 beats per minute. They trained the subjects for 15 minutes a session over a period of 10 weeks. One group exercised 3 times a week, one exercised 6 times a week, and one exercised 12 times a week. Ninety different physiological measures were used to assess fitness changes including resting heart rate, resting blood pressures, and oxygen uptake. Results showed the 12

times a week group made the greatest changes. However, favorable changes were also made by the other two groups.

A study by Franks (11) used two frequencies, three and five days per week. The study used middle-aged men as subjects. The mode of training was running. He concluded that middle-aged sedentary men adapted better to three days of running than to five.

In another study, Pollock, Cureton, and Greninger (33) examined the effects of frequency on selected physiological variables. Nineteen male subjects (aged 28-39) were randomly assigned to exercise either two days or four days per week. A control group was used. Subjects trained for thirty minute sessions consisting of continuous walking, jogging, or running. The study lasted 20 weeks. Both experimental groups improved significantly from their initial values at 10 weeks and at 20 weeks. The between group analysis revealed no significant difference between experimental groups at 10 weeks, but did reveal a significantly greater improvement in the four days per week group at 20 weeks. At the 10 week point, the 2 days per week group had expended approximately 6,000 kcal and the 4 days per week group had expended approximately 12,000 kcal. At 20 weeks, caloric expenditures were about 13,000 and 26,000 kcal for the 2 and 4 days per week groups, respectively. The investigators concluded that over a period of 20 weeks, a four days per week program is more effective for improving VO_2 max than a two days per week program. Like the above studies, this study did not control for total work.

In order to control for total work, Hill, Wearring, and Eynon (15) conducted a study examining the effects of two frequencies--

three times a week and five times a week. They trained at a set workload--65% of maximum workload derived from an "all out" Balke bicycle ergometer test. Subjects were tested after eight weeks and again after 40 exercise sessions. At the end of the eight weeks, the five times a week group showed a significantly greater increase in VO_2 max. The groups were equal in increasing time to exhaustion on the bicycle ergometer. The groups were also equal in resting pulse values. However, after an equal number of exercise sessions, the three times a week group showed greater improvements in time to exhaustion and heart rate response to a fixed submaximal task. Concerning increases in VO_2 max, the groups were the same after an equal number of sessions.

Duration of Exercise

Using young men (18-22 years old) as subjects, Durnin, Brockway, and Whitcher (10) conducted a study which observed the effects of a combination of total work and duration. Four groups were used: one walking 3 kilometers, one walking 10 kilometers, one walking 20 kilometers, and one walking 30 kilometers daily. The study lasted 10 days. In the between group analyses, the 20 kilometer group showed significantly greater improvements than the other groups in pulmonary ventilation, oxygen consumption, oxygen extraction, and heart rate during a treadmill test. No other between group differences were noted. The researchers noted that it was unlikely that the heart rates exceeded 120 beats per minute during the exercise sessions. The

results suggested that gains could be made with intensities lower than the proposed training thresholds.

Yeager and Bryntson (39) conducted a study in which 3 experimental groups composed of female volunteers trained for 10, 20, and 30 minutes a day. They trained three times per week at a heart rate of 144 beats per minute. The study lasted six weeks. Once again the subjects were tested before and after the training period. The results showed that all groups made signficant improvements in predicted VO_2 max scores determined by the Astrand-Rhyming (3) test. However, there were no between group differences.

Milesis et al. (23) designed a study to examine the effects of 3 different durations (15, 30, and 45 minutes) on 59 subjects (20-35 years old). Frequency (3 days per week), intensity (85%-90% of maximum heart rate reserve), and total duration (20 weeks) were held constant. Results showed improvements to be directly proportional to the duration of exercise. However, examination of the data revealed that the 3 groups accomplished very different amounts of total work. The 15, 30, and 45 minute groups expended approximately 11,000 kcal, 20,000 kcal, and 30,000 kcal, respectively. Both the 15 and 30 minute groups showed significant increases in VO_2 max and significant decreases in resting heart rate as compared to the control group. No significant differences were noted between the 15 and 30 minute per session groups on any variable. The 45 minute group improved significantly more than the 15 minute group in VO_2 max and resting systolic and diastolic blood pressures. The 45 minute group also made significantly greater improvements than the 30 minute group in resting diastolic pressure. In general, comparisons

between the 15 and 30 minute groups and between the 30 and 45 minute groups failed to yield significant differences. Most of the significant differences were noted between the 15 and 45 minute groups. This study, like the two preceding studies of exercise duration, did not control for total work.

Total Work of Exercise

Very little research has been conducted to measure the effect of total work directly. Probably the most significant study involving total work was done by Kuntzlemen (21).

Kuntzlemen conducted a study involving a bench stepping task. There were two intensitities (15 and 30 steps per minute), two amounts of external work (120 and 240 steps), and two frequencies (two and four times a week). In his eighteen week study, Kuntzlemen used sedentary men as subjects. There were 3 testing periods: the initial test, after 9 weeks, and after 18 weeks. Training effect was measured by changes in resting heart rate, heart rate for same work rate, working duration until PWC 150 was reached, heart rate recovery after submaximal exercise, a submaximal VO_2 measure obtained when PWC 150 was reached, and blood pressures. VO_2 max was estimated. Kuntzlemen concluded that after 9 weeks, intensity and total work were the most important factors in the development of cardiorespiratory efficiency. After 18 weeks he concluded that total work played the most important role. However, it should be noted that he found no significant differences in the submaximal VO_2 measure at either 9 or 18 weeks.

Conclusions

Of the studies that failed to control for total work, the trend was that the variable being controlled produced a significant effect. This was true of the intensity, frequency, and duration studies. Perhaps it was the interaction of the factor with total work causing the effect, or maybe it was total work alone.

In the few studies available that controlled for total work, the trend was often different. For example, the study conducted by Hill, Wearring, and Eynon (15) revealed that frequencies of three and five days per week made no significant difference in training effect. Also Burke and Franks (6) found no significant difference between the 75% of max HR group and the 85% of max HR group. Other research (10) indicates that gains can be made with low intensity and large amounts of total work.

The study by Kuntzlemen (21) sheds more light on the confusing situation. He argued that a basic mistake had been made in the bulk of the studies. This mistake was equating duration and total work. Kuntzlemen considered total work a more inclusive term than duration, the former being influenced by activity type, intensity, duration, and frequency, and the latter only referring to exercise time or length of the study. Kuntzlemen's study indicated that total work was the most important of the factors.

However, Kuntzlemen's study also had some limitations. First of all, the only task he used was stepping. Perhaps the findings would differ if a different mode of training were used. Next he measured intensity by steps per minute rather than by percentage of maximum heart rate.

He also used an external measure of total work (number of steps) rather than an internal measure (kilocalories expended). Finally, Kuntzlemen did not directly measure VO_2 max which is widely accepted as the best single measure of cardiorespiratory fitness (4,8,22,27,38).

It follows then, that there is a need for further research concerning total work. Such a study would involve the use of a different mode of training. The intensity and frequency would logically be held constant above proposed threshold levels in order to observe the isolated importance of total work. Next, kilocalories would be used as the measure of total work. This measure is supported by Pollock:

> . . . present studies do appear to point to the importance of the total amount of work (energy cost) accomplished as the important criteria for cardiovascular improvement (26, p. 162).

Finally VO_2 max would be measured and used as the criterion for cardiovascular improvements.

CHAPTER III

METHODS

Subjects

In this 16 week investigation, 34 males (ages 18-24) were placed into one of three groups involved in expending a prescribed number of kiocalories each exercise session. The three groups were: (1) a 450 kilocalorie per session group, (2) a 300 kilocalorie per session group, and (3) a 150 kilocalorie per session group. In order to ensure for homogeneity of variance, subjects were stratified into three levels (high, medium, and low) on the basis of VO_2 max scores on the pretest, and then randomly placed in groups. By this method, each experimental group was given the same number of subjects with the high, medium, and low classifications. A control group of 10 subjects, chosen from the same general population as the experimental subjects (classes at the University of Tennessee, Knoxville), was also used in the experiment. See Table III-1 for selected initial values for each group. Only individuals who had not actively participated in any type of training program for at least six months prior to the study were used as subjects.

All subjects in the experimental groups exercised three times per week at an intensity of 80% of maximum heart rate. This intensity level was determined as a percentage of maximum heart rate attained on the initial maximal treadmill test. The mode of training for all experimental groups was jogging. The control group was advised not to begin any vigorous conditioning program and instructed to maintain their current physical activity level for the entire length of the study.

TABLE III-1

MEANS AND STANDARD DEVIATIONS FOR AGE AND WEIGHT

Group	Weight (kg)	Age (yrs)
Control (n=10)	77.9 ± 9.6	20.4 ± 1.9
150 kcal/session (n=10)	77.6 ± 9.4	21.3 ± 2.1
300 kcal/session (n=11)	81.5 ± 10.5	20.3 ± 1.5
450 kcal session (n=12)	79.4 ± 12.4	20.4 ± 1.9

Testing Schedule

All the experimental groups and the control group were given a pretest (T_1). At this time an informed consent form (Appendix A) was signed by all subjects. All subjects were retested at the end of eight weeks (T_2) and again after 16 weeks (T_3) of training. See Table III-2 for caloric expenditures for each group at each testing period.

Testing Procedure and Equipment

Resting heart rate. Resting heart rate was taken by the palpation technique from the subject's radial artery after the subject had rested for 10 minutes in a sitting position. The pulse was taken in 15 second intervals until a constant rate was measured.

Skinfold measurements. Following the measurement of resting

TABLE III-2

ENERGY EXPENDITURES FOR ALL GROUPS (KCAL)

Group	Per Week	For 8 Weeks	For 16 Weeks
Control	0	0	0
150 kcal/session	450	3,600	7,200
300 kcal/session	900	7,200	14,400
450 kcal/session	1,350	10,800	21,600

pulse, skinfold measurements were taken from the subject at selected sites (biceps, triceps, umbilical, suprailiac, subscapular, and mid-axillary) using Lange skinfold calipers. The locations for these sites are shown and described by Behnke and Wilmore (5). The sum of these skinfolds was used to evaluate changes in body fatness. No determination of body fat percentages was attempted.

Submaximal heart rate. After the above measurement, the subject was allowed to stretch and "loosen up" until comfortable. Then the subject performed a five minute warm-up on a Quinton treadmill at a constant speed of 161 meters per minute (6 miles per hour) and 0% elevation. Before the warm-up the speed of the treadmill was calibrated to ensure that the speed was identical for all subjects. The subject's heart rate was recorded on a Narco Biosystems DMP-4A recorder by means of skin electrodes. The heart rate obtained during the fifth minute of the warm-up was considered the subject's submaximal heart rate. A note should be made here. During several tests,

primarily at the 16 week point, carotid pulse readings taken immediately after the cessation of work were used. The reason for this change in the method of obtaining submaximal heart rate was that mechanical problems were encountered with the electrode recording system. Whenever this method was used, the heart rate was taken during the 15 seconds immediately following the submaximal test.

Maximum oxygen consumption test. The testing procedure used for obtaining VO_2 max was similar to that of Saltin and Astrand (34). During the test, speed remained constant at 201 meters per minute (7 1/2 miles per hour) and elevation was increased 2 1/2% every 2 minutes. Initial elevation was 0%. The speed of the treadmill was calibrated before each test. Oxygen consumption was measured by the open circuit method, using a Daniels' valve and metereological balloon for the collection of expired air samples. Expired gases were analyzed by an Applied Electrochemistry model S-3A O_2 analyzer and a Beckman model LB2 CO_2 analyzer. The analyzers were calibrated with standardized gases which had been measured by the Scholander (37) method. Inspired ventilation (VI) was measured by a Parkinson-Cowan CD4 dry gas meter and recorded with a Narco Biosystems DMP-4A recorder. Oxygen consumption was calculated according to Haldane (14). Finally, maximum heart rate was obtained during the last minute of the VO_2 max test. As with submaximal heart rate, it was necessary to use carotid pulse taken immediately after the test on several tests during the last testing period.

Training Procedure

Based on his body weight and the group to which he was assigned, each subject jogged a prescribed distance three times per week in a supervised setting. This prescribed distance was determined from tables by Katch and McArdle (19). Each subject regularly checked his pulse to ensure that he was exercising at 80% of his maximum heart rate. In order to allow for adaptation to training, the subjects expended 70% and 85% of their daily caloric prescriptions during the first and second weeks, respectively. All experimental groups were expending the appropriate number of kilocalories each session beginning with the third week of training. Caloric expenditures in this study were computed as gross expenditures, rater than as net expenditures.

Statistics

An analysis of covariance was done on the test scores at eight weeks and at 16 weeks using pretest scores as the covariate. Tests of homogeneity of regression were performed on each variable to ensure that all assumptions for the ANCOVA were met. Where significant differences were found using a .05 alpha level, Duncan's New Multiple Range Test (9) with Kramer's adjustment for unequal cell size (20) was performed. For the Duncan test a p value equal to or less than 0.05 was accepted as significant. This mode of analysis was used by Gettman (13) and Pollock, Ward, and Ayres (28).

CHAPTER IV

RESULTS

Maximum Oxygen Consumption [VO_2 max(ℓ/min)]

Mean scores for each group at each testing period can be found in Table IV-1. An analysis of covariance on values at T_2, using T_1 as the covariate, revealed a significant intergroup difference in VO_2 max(ℓ/min). The Duncan post hoc test performed on adjusted means showed the 450 kcal/session group to be significantly higher than the control group at T_2. No other significant differences were found between groups at T_2. Using the same mode of analysis for T_3, no significant differences were observed among the four groups. See Tables B-1 and B-2, Appendix B, and Tables B-3 and B-4, Appendix B for tests for homogeneity of regression.

TABLE IV-1

MEANS AND STANDARD DEVIATIONS FOR MAXIMUM OXYGEN CONSUMPTION [VO_2 max(ℓ/min)]

Group	T_1	T_2	T_3
Control	3.94 ± 0.46	3.95 ± 0.54	4.00 ± 0.55
150	3.77 ± 0.45	3.89 ± 0.53	3.83 ± 0.31
300	4.05 ± 0.56	4.16 ± 0.52	4.18 ± 0.54
450	3.82 ± 0.32	4.09 ± 0.31	4.08 ± 0.33

Maximum Oxygen Consumption {VO_2 max [ml $(kg \cdot min)^{-1}$]}

Mean scores for all groups at each testing period are available in Table IV-2. The analysis of covariance revealed intergroup differences in VO_2 max $[ml(kg \cdot min)^{-1}]$ at T_2 and T_3. The post hoc analysis on adjusted means showed the 450 kcal/session group to be superior to the control group on this measure at both T_2 and T_3. No other differences were noted between groups. See Tables B-1 and B-2, Appendix B for analysis of covariance tables and Tables B-3 and B-4, Appendix B for tests for homgeneity of regression.

TABLE IV-2

MEANS AND STANDARD DEVIATIONS FOR VO_2 MAX $[ml(kg \cdot min)^{-1}]$

Group	T_1	T_2	T_3
Control	50.8 ± 3.8	50.7 ± 4.7	51.5 ± 3.8
150	48.9 ± 5.3	50.6 ± 5.6	51.5 ± 4.7
300	49.9 ± 4.2	52.1 ± 5.4	52.4 ± 5.0
450	48.8 ± 6.2	52.3 ± 6.2	54.2 ± 5.6

Weight (kg)

Mean scores for the variable weight can be found in Table IV-3. Weight change values and expected weight change values (assuming subjects did not increase caloric intake) are available in Table IV-4. Significant intergroup differences in weight were observed at T_3, but not at T_2 with the analysis of covariance. Post hoc tests on adjusted means revealed a significant weight reduction for the

450 kcal/session group as compared to the control group at T_3. No other differences were noted. See Tables B-1 and B-2, Appendix B for analysis of covariance tables and Tables B-3 and B-4, Appendix B for homogeneity of regression tests.

TABLE IV-3

MEANS AND STANDARD DEVIATIONS FOR WEIGHT (KG)

Group	T_1	T_2	T_3
Control	77.9 ± 9.6	78.0 ± 9.1	77.7 ± 9.0
150	77.6 ± 9.4	77.2 ± 9.4	74.7 ± 7.5
300	81.5 ± 10.5	80.5 ± 10.9	80.1 ± 10.9
450	79.4 ± 11.9	79.3 ± 11.9	76.1 ± 11.0

TABLE IV-4

WEIGHT CHANGE AND EXPECTED WEIGHT CHANGE (KG) AT 8 AND 16 WEEKS

Group	T_2 Actual	T_2 Expected	T_3 Actual	T_3 Expected
Control	+ 0.1	0.0	- 0.2	0.0
150	- 0.4	- 0.5	- 2.9	- 0.9
300	- 1.0	- 0.9	- 1.4	- 1.9
450	- 0.1	- 1.4	- 3.2	- 2.8

Resting Heart Rate (beats/min)

Mean scores for all groups and all testing periods are available in Table IV-5. The analysis of covariance was performed on values for resting heart rate at T_2 and T_3, using the pretest as the covariate. Significant differences were observed at T_3, but not at T_2. Post hoc analysis on adjusted means revealed a significant reduction in resting pulse for the 450 kcal/session group as compared to the control group. No other differences were found. See Tables B-1 and B-2, Appendix B for analysis of covariance tables and Tables B-3 and B-4, Appendix B for tests for homogeneity of regression.

TABLE IV-5

MEANS AND STANDARD DEVIATIONS
FOR RESTING HEART RATE

Group	T_1	T_2	T_3
Control	70 ± 9	72 ± 11	70 ± 11
150	77 ± 12	71 ± 7	67 ± 5
300	74 ± 13	72 ± 11	68 ± 13
450	75 ± 12	68 ± 12	61 ± 8

Other Variables

Mean scores for skinfolds, maximum heart rate, and submaximal heart rate are available in Tables IV-6, IV-7, and IV-8, respectively. An analysis of covariance was also used to evaluate all other variables: skinfolds, maximum heart rate, and submaximal heart rate. However, no

significant differences among groups were found for these variables. See Tables B-1 and B-2, Appendix B for analysis of covariance tables for skinfolds, maximum heart rate, and submaximal heart rate. See Tables B-3 and B-4, Appendix B for tests of homogeneity of regression.

TABLE IV-6

MEANS AND STANDARD DEVIATIONS FOR SKINFOLDS

Group	T_1	T_2	T_3
Control	64 ± 25	64 ± 25	64 ± 26
150	74 ± 32	71 ± 34	65 ± 29
300	74 ± 31	71 ± 31	66 ± 27
450	74 ± 29	69 ± 26	60 ± 28

TABLE IV-7

MEANS AND STANDARD DEVIATIONS FOR MAXIMAL HEART RATE

Group	T_1	T_2	T_3
Control	198 ± 14	196 ± 12	195 ± 12
150	205 ± 9	201 ± 6	197 ± 5
300	193 ± 9	192 ± 7	193 ± 8
450	199 ± 6	195 ± 4	191 ± 9

TABLE IV-8

MEANS AND STANDARD DEVIATIONS
FOR SUBMAXIMAL HEART RATE

Group	T_1	T_2	T_3
Control	165 ± 20	159 ± 19	156 ± 21
150	172 ± 16	164 ± 12	155 ± 12
300	157 ± 15	152 ± 10	145 ± 11
450	168 ± 14	155 ± 14	143 ± 16

CHAPTER V

DISCUSSION OF RESULTS

By examining the total work accomplished over 8 and 16 weeks and the changes made in selected fitness measures, one can see that the number of kilocalories required in this investigation to elicit training changes was relatively high as compared to the findings of certain other researchers. For instance, Pollock, Cureton, and Greninger (33) found changes in VO_2 max when expenditures were as low as 6,000 kcal. Burke and Franks (6) found significant differences in VO_2 max with total expenditures as low as 4,500 kcal. However, the lowest expenditure found effective in producing training changes in this investigation was 10,800 kcal.

The results of this investigation showed improvements in VO_2 max, resting heart rate, and weight loss for the 450 kcal/session group only. Judging from these results, training changes appear to be more the result of total work per exercise session than total work for the entire study. For example, the 450 kcal/session made significant changes in VO_2 max(ℓ/min) and VO_2 max [ml(kg·min)$^{-1}$] at 8 weeks, with a total expenditure of 10,800 kcal. However, the 300 kcal/session group failed to make any significant changes at 16 weeks with a total expenditure of 14,400 kcal. These findings are in agreement with Cureton (7) who proposed that a minimum of 300-500 kcal per session is necessary to improve cardiovascular fitness and make changes in body composition. These findings are also in fairly close agreement with Pollock (25,27) who suggested that 300 kcal

per session is a threshold for showing cardiovascular fitness changes.

It should be noted that the 150 kcal/session group and 300 kcal/session group did show changes in the expected directions, but that none of these changes were significant. It should also be noted that these nonsignificant changes were very similar for the 150 kcal/session group and the 300 kcal/session group. In some instances the 150 kcal/session group showed larger improvements than the 300 kcal/session group. These findings suggest that an energy expenditure of 300 kcal/session is no more effective in improving cardiovascular fitness than an expenditure of 150 kcal/session for college-aged men.

The fact that significant changes were not found in this study for certain variables might be explained by sources of measurement error. As stated earlier, two methods, palpation and electrode recording system, were used for obtaining submaximal heart rate response and maximum heart rate. This certainly introduced some variation into the measurements. Furthermore, due to a failure in the air conditioning system during the last testing session, all of the experimental groups were tested in an environment averaging 25-26° Celsius and 60% relative humidity. On all other tests average conditions were 20-21° and 30% relative humidity. There is ample support in the literature to say that such an environment could lead to a higher heart rate at a given submaximal work rate (4,22).

However, the findings of this study are enough different from other similar studies to warrant further explanation. Many training studies in which significant differences were found with energy

expenditures of less than 400 kcal/session used middle-aged men as subjects. Such studies include Pollock, Cureton, and Greninger (33), Pollock, Ward and Ayres (28), Pollock et al. (30), Pollock et al. (29), Pollock et al. (31), and Pollock et al. (32). These studies found mean increases in VO_2 max ranging from 15.5% to 35%, whereas the largest mean increase in the present study was 11%. It should be noted that VO_2 max in all of the above studies except Pollock et al. (31) was measured as $ml(kg \cdot min)^{-1}$. All of the above found significant differences in resting heart rate, with the exception of Pollock et al. (31) and Pollock et al. (32). All of the above studies found decreases in body weight and body fat (measured by skinfolds) except Pollock et al. (32). Those studies using a submaximal heart rate measure (31,32,33) found significant decreases in each case. See Tables V-1 and V-2 for information concerning percent improvements for all variables.

The fact that this investigator found fewer fitness changes might be explained by the age factor. All of the above studies were conducted on middle-aged men, whereas this study utilized college-aged men. It could be argued that levels of activity for a "sedentary" male college student and a "sedentary" middle-aged man are quite different. One would logically expect the younger college student to be nearer to his maximum physical potential than the older man. This does appear to be the case since initial VO_2 max scores were much lower in the above mentioned studies (28,29,30,31,32,33) than in the present study. For the studies using middle-aged subjects, initial group means for VO_2 max never exceeded 44 $ml(kg\ min)^{-1}$. In the present study the lowest of the group means for VO_2 max on the initial test was 48 $ml(kg \cdot min)^{-1}$. This difference in

TABLE V-1

PERCENT CHANGES IN VARIABLES AT 8 WEEKS

Group	Weight(kg)	Skinfolds	Heart Rates			VO_2 (ℓ/min)	VO_2 max $ml(kg \cdot min)^{-1}$
			Resting	Submaximum	Maximum		
Control	0.13%	- 3.74%	1.99%	- 3.40%	- 1.11%	0.25%	- 0.10%
150	- 0.51%	- 4.17%	- 8.68%	- 4.66%	- 1.78%	3.18%	3.56%
300	- 1.17%	- 2.86%	- 3.24%	- 3.05%	- 0.83%	2.72%	4.35%
450	- 0.15%	- 6.67%	- 8.69%	- 7.75%	- 2.01%	7.07%	7.26%

TABLE V-2

PERCENT CHANGES IN VARIABLES AT 16 WEEKS

Group	Weight(kg)	Skinfolds	Heart Rates			VO_2 (ℓ/min)	VO_2 max $ml(kg \cdot min)^{-1}$
			Resting	Submaximum	Maximum		
Control	- 0.22	- 3.59%	- 1.14%	- 5.58%	- 1.31%	1.52%	1.50%
150	- 3.69%	- 11.50%	- 13.23%	- 9.81%	- 3.79%	1.59%	5.32%
300	- 1.66%	- 9.90%	- 8.70%	- 7.55%	0.07%	3.21%	5.03%
450	- 4.17%	- 18.52%	- 17.85%	- 14.55%	- 3.97%	6.81%	11.01%

initial fitness level could explain the lesser improvements shown in this investigation.

Another reason fewer significant results were found in the present study than in most other similar studies, concerns the mode of analysis used. Many of the significant differences reported by Pollock's research (28,29,30,31,32,33) were differences found between pretest and posttest scores. The differences found in the present study were differences found between groups as compared to the control group at the same point in time.

As a supplement to the paired analyses mentioned above, the Pollock studies (28,29,30,31,32,33) employed the analyses of covariance to evaluate intergroup differences, but when this mode of analysis was used more modest results were noted. For example, the analysis of covariance revealed no significant intergroup differences in VO_2 max in Pollock et al. (32). The same analysis showed similar findings in the study by Pollock, Cureton, and Greninger (33) where there were no intergroup differences at 10 weeks in VO_2 max. In some of Pollock's research (28,30,31,32,33) it is apparent that the investigators made the assumption that since the control group "remained constant" that the analyses performed against pretest scores were valid comparisons.

It is the contention of this investigator that this assumption cannot be made on the grounds that the control group failed to make significant changes. In order to demonstrate the differences between the paired T-test analysis based on the above assumption and the more conservative ANCOVA (where the control group was included),

a paired T-test was performed on the data in the present study. It revealed that the control group changed significantly only in submaximal heart rate measures. However, the results revealed that this method of analysis was far more liberal than the ANCOVA on all variables. Results for this analysis are available in Tables V-3, V-4, V-5, and V-6.

Yet another analysis, a repeated measures ANOVA was performed on this data. This analysis appeared to be the most logical choice since the design of the experiment corresponded directly to a classic repeated measure design, evaluating group differences over time. However, the results of this analysis were largely influenced by the initial intergroup differences, rather than differences caused by training. Therefore, it was concluded that the ANCOVA, which provides an adjustment for initial differences, was a preferable analysis for the data.

TABLE V-3

T-TEST RESULTS FOR CONTROL GROUP

Variables		T	p
Resting Heart Rate	$T_1 - T_2$	0.63	0.5461
Resting Heart Rate	$T_1 - T_3$	- 0.24	0.8144
Skinfolds	$T_1 - T_2$	- 1.83	0.1010
Skinfolds	$T_1 - T_3$	- 1.09	0.3051
Submax Heart Rate	$T_1 - T_2$	- 3.28	0.0095*
Submax Heart Rate	$T_1 - T_3$	- 2.44	0.0375*
Max Heart Rate	$T_1 - T_2$	- 2.09	0.0660
Max Heart Rate	$T_1 - T_3$	- 1.26	0.2400
VO_2 Max (ℓ/min)	$T_1 - T_2$	0.12	0.9056
VO_2 Max (ℓ/min)	$T_1 - T_3$	1.11	0.2973
VO_2 Max ml$(kg \cdot min)^{-1}$	$T_1 - T_2$	- 0.06	0.9518
VO_2 Max ml$(kg \cdot min)^{-1}$	$T_1 - T_3$	1.01	0.3373
Weight	$T_1 - T_2$	0.23	0.8211
Weight	$T_1 - T_3$	- 0.27	0.7936

*Significant at the 0.05 level.

TABLE V-4

T-TEST RESULTS FOR 150 GROUP

Variables		T	p
Reting Heart Rate	T_1- T_2	- 2.00	0.0739
Resting Heart Rate	T_1- T_3	- 3.42	0.0077*
Skinfolds	T_1- T_2	- 1.74	0.1133
Skinfolds	T_1- T_3	- 3.18	0.0111*
Submax Heart Rate	T_1- T_2	- 2.06	0.0667
Submax Heart Rate	T_2- T_2	- 3.23	0.0103*
Max Heart Rate	T_1- T_2	- 2.47	0.0331*
Max Heart Rate	T_1- T_3	- 2.85	0.0192*
VO_2 Max (ℓ/min)	T_1- T_2	2.19	0.0534
VO_2 Max (ℓ/min)	T_1- T_3	1.79	0.1070
VO_2 Max ml$(kg \cdot min)^{-1}$	T_1- T_2	2.82	0.0182*
VO_2 Max ml$(kg \cdot min)^{-1}$	T_1- T_3	3.20	0.0109*
Weight	T_1- T_2	- 0.86	0.4102
Weight	T_1- T_3	- 2.89	0.0109*

*Significant at the 0.05 level.

TABLE V-5

T-TEST RESULTS FOR 300 GROUP

Variables		T	p
Resting Heart Rate	$T_1 - T_2$	- 1.96	0.0811
Resting Heart Rate	$T_1 - T_3$	- 2.57	0.0331*
Skinfolds	$T_1 - T_2$	- 1.31	0.2241
Skinfolds	$T_1 - T_3$	- 1.70	0.1270
Submax Heart Rate	$T_1 - T_2$	- 1.96	0.0811
Submax Heart Rate	$T_1 - T_3$	- 2.85	0.0216*
Max Heart Rate	$T_1 - T_2$	- 0.94	0.3732
Max Heart Rate	$T_1 - T_3$	0.19	0.8548
VO_2 Max (ℓ/min)	$T_1 - T_2$	2.20	0.0551
VO_2 Max (ℓ/min)	$T_1 - T_3$	1.24	0.2509
VO_2 Max ml$(kg \cdot min)^{-1}$	$T_1 - T_2$	2.82	0.0199*
VO_2 Max ml$(kg \cdot min)^{-1}$	$T_1 - T_3$	2.12	0.0669
Weight	$T_1 - T_2$	- 1.67	0.1283
Weight	$T_1 - T_3$	- 3.32	0.0106

*Significant at the .05 level.

TABLE V-6

T-TEST RESULTS FOR 450 GROUP

Variables		T	p
Resting Heart Rate	$T_1 - T_2$	- 2.86	0.0155*
Resting Heart Rate	$T_1 - T_3$	- 7.96	0.0001*
Skinfolds	$T_1 - T_2$	- 1.75	0.1087
Skinfolds	$T_1 - T_3$	- 3.50	0.0057*
Submax Heart Rate	$T_1 - T_2$	- 5.61	0.0002*
Submax Heart Rate	$T_1 - T_3$	- 4.39	0.0013*
Max Heart Rate	$T_1 - T_2$	- 2.75	0.0190*
Max Heart Rate	$T_1 - T_3$	- 2.59	0.0270*
VO_2 Max (ℓ/min)	$T_1 - T_2$	3.82	0.0029*
VO_2 Max (ℓ/min)	$T_1 - T_3$	5.01	0.0005*
VO_2 Max ml$(kg \cdot min)^{-1}$	$T_1 - T_2$	4.10	0.0018*
VO_2 Max ml$(kg \cdot min)^{-1}$	$T_1 - T_3$	5.38	0.0003*
Weight	$T_1 - T_2$	- 0.21	0.8396
Weight	$T_1 - T_3$	- 3.16	0.0101

*Significant at the 0.05 level.

CHAPTER VI

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The effects of jogging at three levels of kilocalorie expenditure (150, 300, and 450 kcal per session) on selected fitness measures, when intensity (80% of max HR) and frequency (3 days per week) were held constant, were studied in college-aged men. The results of the sixteen week training program revealed that only the 450 kcal per session group showed significant improvements when compared to the control group. At eight weeks the 450 kcal group was found to be higher than the control group in absolute VO_2 max (ℓ/min) and relative VO_2 max [$ml(kg \cdot min)^{-1}$]. At 16 weeks the same group was significantly higher than the control group in relative VO_2 max, but not in absolute VO_2 max. Also, at 16 weeks, the 450 kcal group showed significantly greater reductions in resting heart rate and weight than the control group. No other significant intergroup differences were observed.

Conclusions

Within the parameters of this investigation, where subjects trained three days per week at 80% of maximum heart rate for 16 weeks, the following conclusions were made.

1. Total work per session appears to be the important factor for improving cardiovascular fitness, rather than total work for the entire program.

2. The proposed total work training threshold of 300 kcal per

session is probably insufficient to elicit fitness changes in college-aged men.

3. Four hundred and fifty kilocalories per session was found to be a sufficient amount of total work to cause fitness improvements in college-aged males.

4. The fact that the 450 kcal group showed more changes at 16 weeks than at 8 weeks suggests that when total work per session is sufficiently high, the length of the training program is also an important factor in affecting fitness changes.

Recommendations

1. The investigation should be repeated using higher amounts of total work per session.

2. A similar study should be done using the bicycle ergometer for training and testing. Such a study would provide for more accurate determination of energy expenditures.

3. A similar study should be conducted for a longer period of time (over 20 weeks) to determine if gains might be made with smaller caloric expenditures.

4. Studies of exercise intensity controlling for total work, should be performed using large amounts of total work (over 450 kcal/session).

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APPENDIXES

APPENDIX A

INFORMED CONSENT FORM

I, _____, hereby volunteer to participate in a research study designed to determine the effects of total work on cardiorespiratory fitness.

I realize that I will train three days per week for sixteen weeks. I am aware that unless I am assigned to the minimal activity group, I will exercise at eighty percent of my maximum heart rate until I expend either 150, 300, or 450 kilocalories.

I realize I will take three maximum work capacity tests in which I will run on a treadmill until voluntary exhaustion.

The rate of work required in the later stages of the maximum work capacity test is sufficient to produce some degree of fatigue. The risks involved with exercise include the possibility of heart attack, but this risk is very small for someone who is young and relatively fit. Exercise of this type sometimes produces soreness and slight muscular discomfort for a day or two after the experiment.

I understand that I will receive two hours of satisfactory credit in the Spring quarter. I realize that class credit will be awarded only upon completion of the requirements for the study; however, I am aware that I may withdraw my consent and discontinue participation at any time.

I have had the procedures and requirements of the study explained to me and I understand my role in the experiment.

Signature: _____

Date: _____

Witness: _____

APPENDIX B

TABLE B-1

ANALYSIS OF COVARIANCE SUMMARIES FOR ALL VARIABLES AT T_2

Source	D.F.	S.S.	M.S.	F	p
VO_2 (ℓ/min)					
Group	3	0.38	0.13	2.99	0.0428
T_1	1	7.28	7.28	171.90	0.0001
Error	38	1.61	0.04		
Corrected Total	42	9.40			
VO_2/kg					
Group	3	68.72	22.91	3.43	0.0265
T_1	1	953.20	953.20	142.71	0.0001
Error	38	253.81	6.68		
Corrected Total	42	1232.79			
Weight					
Group	3	5.25	1.75	0.62	0.6063
T_1	1	4141.50	4141.50	1467.82	0.0001
Error	38	107.22	2.82		
Corrected Total	42	4316.08			
Resting Pulse					
Group	3	274.86	91.86	1.80	0.1642
T_1	1	2353.23	2353.23	46.15	0.0001
Error	38	1937.62	50.99		
Corrected Total	42	4376.74			
Skinfold					
Group	3	49.00	16.33	0.35	0.7863
T_1	1	31755.64	31755.64	688.70	0.0001
Error	38	1752.16	46.11		
Corrected Total	42	33822.12			
Maximum HR					
Group	3	26.80	8.93	0.67	0.5732
T_1	1	1723.93	1723.93	130.12	0.0001
Error	38	503.45	13.25		
Corrected Total	42	2695.28			
Submaximum HR					
Group	3	317.06	105.69	1.81	0.1626
T_1	1	5264.98	5264.98	89.95	0.0001
Error	38	2224.23	58.53		
Corrected Total	42	8288.74			

TABLE B-2

ANALYSIS OF COVARIANCE SUMMARIES FOR ALL VARIABLES AT T_3

Source	D.F.	S.S.	M.S.	F	p
VO_2 (ℓ/min)					
Group	3	0.22	0.07	1.74	0.1774
T_1	1	5.53	5.53	133.24	0.0001
Error	35	1.45	0.04		
Corrected Total	39	7.61			
VO_2/kg					
Group	3	70.44	23.48	3.14	0.0375
T_1	1	574.72	574.72	76.81	0.0001
Error	35	261.89	7.48		
Corrected Total	39	886.14			
Weight					
Group	3	27.09	9.03	3.23	0.0342
T_1	1	3290.57	3290.57	1175.53	0.0001
Error	35	97.97	2.80		
Corrected Total	39	3539.80			
Resting Pulse					
Group	3	588.47	196.16	3.57	0.0235
T_1	1	1461.41	1461.41	26.62	0.0001
Error	35	1921.54	54.90		
Correct Total	39	3772.40			
Skinfold					
Group	3	537.23	179.08	2.11	0.1163
T_1	1	24236.24	24236.24	285.90	0.0001
Error	35	2967.03	84.77		
Corrected Total	39	27436.38			
Maximum HR					
Group	3	174.07	58.02	1.17	0.3347
T_1	1	1254.97	1254.97	25.33	0.0001
Error	35	1734.41	49.55		
Corrected Total	39	3167.60			
Submaximum HR					
Group	3	971.61	323,87	1.90	0.1475
T_1	1	2654.71	2654.71	15.58	0.0004
Error	35	5963.48	170.39		
Corrected Total	39	9852.40			

TABLE B-3

TESTS FOR HOMOGENEITY OF REGRESSION FOR ALL VARIABLES AT T_2

Source	D.F.	S.S.	M.S.	F	p
VO_2(ℓ/min)					
Group	3	0.22	0.08	1.83	0.1598
T_1	1	6.15	6.15	150.46	0.0001
T_1•Group	3	0.18	0.06	1.49	0.2346
Error	35	1.43	0.04		
Corrected Total	42	9.40			
VO_2/kg					
Group	3	12.79	4.26	0.61	0.6126
T_1	1	835.90	835.90	119.75	0.0001
T_1•Group	3	9.49	3.16	0.45	0.7167
Error	35	244.32	6.98		
Corrected Total	42	1232.79			
Weight					
Group	3	5.50	1.83	0.62	0.0644
T_1	1	3858.39	3858.39	1312.47	0.0001
T_1•Group	3	4.33	1.44	0.49	0.6912
Error	35	102.89	2.94		
Corrected Total	42	4316.08			
Resting Pulse					
Group	3	300.76	100.25	2.21	0.1039
T_1	1	2331.72	2331.72	51.47	0.0001
T_1•Group	3	351.96	117.32	2.59	0.0684
Error	35	1585.66	45.30		
Corrected Total	42	4376.74			
Skinfold					
Group	3	87.55	29.18	0.64	0.5968
T_1	1	30204.61	30204.61	658.30	0.0001
T_1•Group	3	146.26	48.75	1.06	0.3774
Error	35	1605.90	45.88		
Corrected Total	42	33822.42			
Maximum HR					
Group	3	90.20	30.07	2.56	0.0707
T_1	1	1067.30	1067.30	90.83	0.0001
T_1•Group	3	92.19	30.73	2.62	0.0665
Error	35	411.26	11.75		
Corrected Total	42	2695.63			

TABLE B-3 (Continued)

Source	D.F.	S.S.	M.S.	F	p
Submaximum HR					
Group	3	386.49	128.83	2.44	0.0805
T_1	1	4684.30	4684.30	88.78	0.0001
T_1•Group	3	377.56	125.85	2.39	0.0858
Error	35	1846.67	52.76		
Corrected Total	42	8288.74			

TABLE B-4

TESTS FOR HOMOGENEITY OF REGRESSION FOR ALL VARIABLES AT T_3

Source	D.F.	S.S.	M.S.	F	p
VO_2 (ℓ/min)					
Group	3	0.25	0.08	2.16	0.1115
T_1	1	4.87	4.87	128.02	0.0001
T_1•Group	3	0.24	0.08	2.07	0.1238
Error	32	1.22	0.04		
Corrected Total	39	7.61			
VO_2/kg					
Group	3	2.05	0.68	0.08	0.9683
T_1	1	496.71	496.71	61.14	0.0001
T_1•Group	3	1.93	0.64	0.08	0.9709
Error	32	259.96	8.12		
Corrected Total	39	886.14			
Weight					
Group	3	16.60	5.53	2.27	0.0991
T_1	1	3102.17	3102.17	1273.86	0.0001
T_1•Group	3	20.05	6.68	2.74	0.0592
Error	32	77.93	2.44		
Corrected Total	39	3593.08			
Resting Pulse					
Group	3	275.87	91.96	1.79	0.1687
T_1	1	1282.99	1282.99	24.99	0.0001
T_1•Group	3	278.81	92.94	1.81	0.1651
Error	32	1642.73	51.34		
Corrected Total	39	3772.40			
Skinfold					
Group	3	118.16	39.39	0.45	0.7185
T_1	1	23868.87	23868.87	273.32	0.0001
T_1•Group	3	171.43	57.14	0.65	0.5863
Error	32	2795.59	87.36		
Corrected Total	39	27456.38			
Maximum HR					
Group	3	170.92	56.98	1.17	0.3353
T_1	1	733.22	733.22	15.10	0.0005
T_1•Group	3	180.48	60.16	1.24	0.3118
Error	32	1553.92	48.56		
Corrected Total	39	3167.60			

TABLE B-4 (Continued)

Source	D.F.	S.S.	M.S.	F	p
Submaximum HR					
Group	3	580.33	193.44	1.17	0.3348
T	1	2061.00	2061.00	12.51	0.0013
T Group	3	693.27	231.09	1.40	0.2598
Error	32	5270.20	164.69		
Corrected Total	39	9852.40			

VITA

Kim Thomas Meeker was born in Dothan, Alabama on May 28, 1955. He went to school in Dothan and graduated from Dothan High School in June 1973. The following September he entered George C. Wallace Community College on a scholarship awarded by the Dixie Youth Baseball Association. In the fall of 1974 he entered Troy State University on a partial tennis scholarship. At Troy State he became a member of the Gamma Beta Phi and Kappa Delta Pi honor societies. He graduated cum laude with a B.S. in physical education in the spring of 1978.

Kim began work on a Master's degree in physical education at the University of Tennessee in the fall of 1978 when he accepted a graduate assistantship with the Knoxville City Schools. The degree was awarded in August 1980.

Kim is married to the former Robin Kendall of Dothan, Alabama.