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PHYSICAL FITNESS AND HUMAN PERFORMANCE

John Frederick Lambert, et al

Naval Postgraduate School
Monterey, California

September 1972

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PHYSICAL FITNESS AND HUMAN PERFORMANCE

by

John Frederick Lambert

and

Donald James Parrish

Thesis Advisor: R. N. Forrest

September 1972

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63

Security Classification

14. KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
psychomotor performance						
psychological state						
physical fitness						
aerobic exercise						
parametric statistics						
nonparametric statistics						
Maximal Oxygen Uptake (MOU)						
treadmill						
exer-genie						
life cycle						

II

DD FORM 1 NOV 65 1473 (BACK)

S/N 0101-807-6821

Security Classification

A-31409

Physical Fitness and Human Performance

by

John Frederick Lambert
LCDR, U.S. Navy
B.S., U.S. Naval Academy, 1964

and

Donald James Parrish
Cpt, U.S. Army
B.S., U.S. Military Academy, 1965

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
September 1972

Authors _____

_____

Approved by: _____ Thesis Advisor

_____ Second Reader

_____
Chairman, Department of Operations Research and Administrative Science

_____
Academic Dean

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Naval Postgraduate School Monterey, California 93940	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

Physical Fitness and Human Performance

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Master's Thesis; September 1972

5. AUTHOR(S) (First name, middle initial, last name)

John Frederick Lambert and

Donald James Parrish

6. REPORT DATE September, 1972	7a. TOTAL NO. OF PAGES 63	7b. NO. OF REFS 12
8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Naval Postgraduate School Monterey, California 93940

13. ABSTRACT

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The statistical tests used in this investigation suggest that the subjects in the exercise programs significantly lowered their psychomotor reaction times as a result of their exercise while the psychomotor reaction times of the control group were unchanged. No statistical evidence of a change in the psychological state of the subjects as a result of exercise was shown.

Details of illustrations in this document may be better studied on microfiche

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DD FORM 1 NOV 65 1473 (PAGE 1)

S/N 0101-807-6811

Security Classification

A-31408

ABSTRACT

The relationship between physical fitness and performance as determined by psychomotor reaction times and psychological state was investigated in an experiment using two different exercise programs and thirty subjects. There were ten subjects in each exercise group and the remaining ten were in a control group.

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I. INTRODUCTION

The relation between physical fitness and human performance is not completely understood. Frequent demanding work coupled with the requirement for alertness and quick response under potentially the most critical of circumstance in some military activities suggests that increasing the understanding of this relationship could be of interest to military decision makers.

To determine an individual's physical fitness, Cooper [Ref. 2] has used maximal oxygen uptake (MOU) as an indicator. MOU is a measure of the maximum rate of oxygen consumption of which an individual is capable. It is commonly measured in units of militers of oxygen per kilogram of body weight per minute (ml O_2/Kg/min). In order to obtain a subject's MOU, the subject must be placed under sufficient stress for a sufficient length of time so that oxygen will be consumed at the subjects maximum rate. In general, an increase in MOU is related to increased capability of the cardio vascular system. MOU is a measure of the body's capability to do work and was the measure of physical fitness used in this experiment.

To produce increased physical fitness, two exercise programs were used. One involved a stationary bicycle, the Lifecycle, and the other a rope tension exerciser, the Exer-Genie. The two programs were based on recommendations of

Phelan and Parodi [Ref. 4] on whose work part of this experiment is based.

To determine performance, measures of psychomotor reaction times and psychological state were used. Psychomotor reaction time is the time required to perform a muscular action which is cued by some observable signal. Psychological state was defined, for this experiment, as an individual's degree of anxiety, depression, and hostility.

An overview of the experiment is as follows: A group of subjects underwent initial testing to determine their initial MOU's, psychological states, and psychomotor reaction times. The subjects exercised for a fixed period of time with regular frequency. They, then, underwent final testing to determine their final MOU's, psychological states, and psychomotor reaction times. This initial and final data were statistically analyzed to determine changes in the subject population. A control group was established to isolate temporal effects, etc. The null hypothesis tested in this experiment was that increased physical fitness does not decrease psychomotor reaction time, anxiety, depression, and hostility.

II. THE EXPERIMENT

A. EXPERIMENTAL EQUIPMENT

The following equipment was used to measure physical fitness and performance parameters:

1. Physical Fitness Testing Equipment

A commercial treadmill, Quinton Instruments, Model 14-44A, was used to stress subjects for the MOU measurement. The treadmill consisted of a mechanically driven belt upon which the subject ran at a predetermined rate. By a control knob and speed indicator, the subject's speed could be varied from 0.0 to 4.5 miles per hour. Additionally the incline angle of the treadmill could be controlled by the experimenters from 0 to 20 degrees.

Oxygen consumption was determined with a respiration gasmeter in conjunction with a Beckman Oxygen Analyzer. The respiration gasmeter measured the total quantity of air exhaled by a subject in liters and siphoned a sample of air from each exhalation of the subject. The oxygen analyzer measured the percentage of oxygen in the exhalation sample as well as the percentage of oxygen at ambient room conditions.

Pulse rate was monotored by a pulse rate meter on the bicycle. It was measured by an ear clip which consisted of a light source and a small photoelectric cell which sensed the periodic change in transparency of the ear lobe resulting from changes in blood flow due to heart action.

The treadmill is shown in Figure 1.

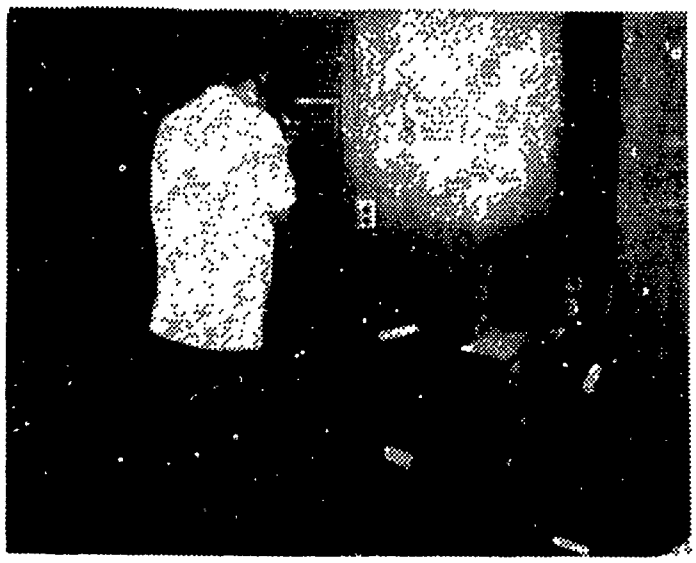

Figure 1

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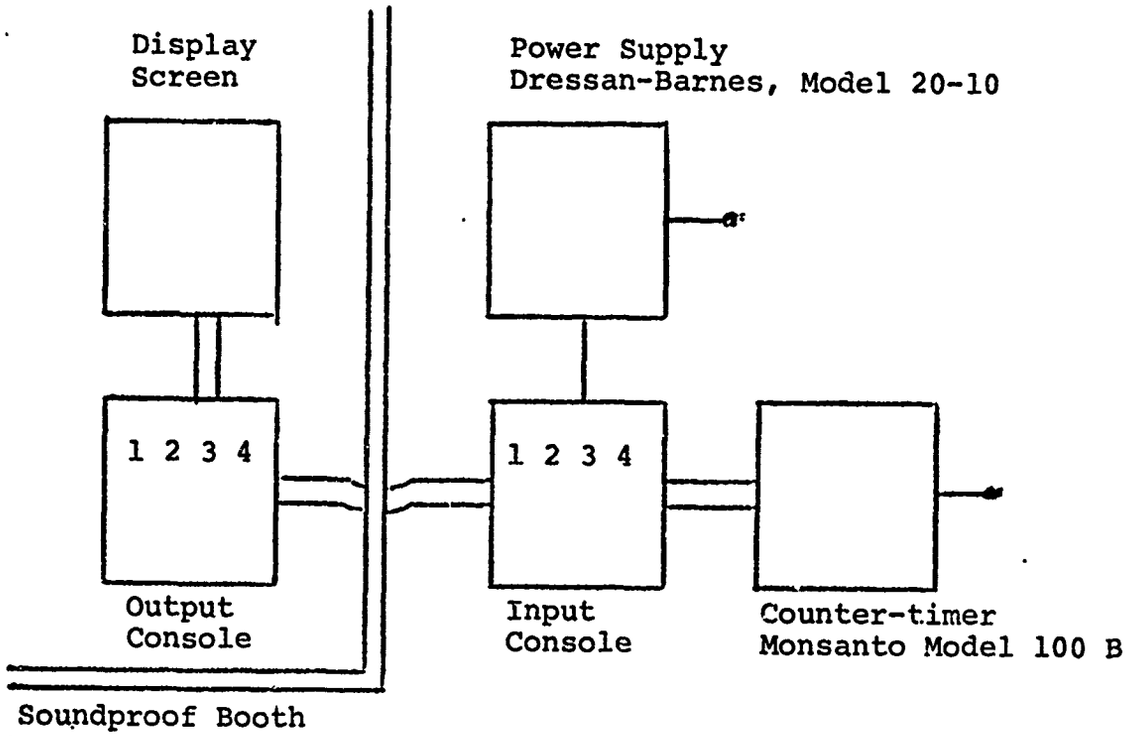
2. Psychomotor Performance Testing Equipment

The psychomotor performance testing equipment measured a subject's reaction time to a particular stimulus. This equipment consisted of a counter-timer, an input console, a three inch by two inch display screen, and an output console. The experimenters' input console consisted of four buttons numbered 1, 2, 3, and 4 which activated corresponding numbers 1, 2, 3, or 4 on the display screen and simultaneously started the counter-timer. The subject's output console was similar to the input console except that pushing the button whose number corresponding to the number appearing on the screen extinguished the displayed number and stopped the counter-timer. Unless reset to zero, the counter-timer

indicated the cumulative reaction times to a series of numbers. The subject's output console and display screen were placed in a soundproof booth to eliminate outside detractions. Figure 2 is a schematic of the equipment.



Test Equipment Schematic

Figure 2

3. Psychological Testing Equipment

The only special equipment was the soundproof booth, mentioned above, in which the test was administered. The psychological test is discussed under Testing Procedures.

B. EXPERIMENTAL SUBJECTS

The experimental subjects were volunteers from the student body of the U.S. Naval Postgraduate School, Monterey, California. Approximately 1000 circulars requesting volunteers for the program were distributed to the student body. Approximately sixty responses were received. Thirty-one subjects were selected after an interview. The subjects selected met the following criteria: no regular exercise patterns and no recent participation in any physical fitness program. This criteria suggested that some increase in physical fitness of a subject participating in one of the exercise programs should occur.

The Medical Staff of the school medically cleared all subjects prior to their participation, however, three of the exercise subjects developed medical problems and had to terminate their participation in the experiment prior to its completion.

A control group was selected from the students who had not responded to the initial request. This was done in order to reduce the possibility of a control group member undertaking an exercise program during the experiment. The control group was established to indicate temporal effects, etc. All subjects, control and exercise, agreed not to initiate any regular exercise program for the duration of the experiment.

C. DESCRIPTION OF EXERCISE PROGRAMS

The exercise programs used were the stationary bicycle program and the exerciser program. The entire program spanned a period of ten weeks. Both exercise programs were completed within the fourth quarter of academic year 1972 at the U.S. Naval Postgraduate School. The first week of the quarter was devoted to subject selection, orientation, and initial testing. The exercise programs continued from the second through tenth weeks. Final testing was conducted at the end of the tenth week. The exercise programs were not extended beyond the tenth week because it was felt that final exams and the quarterly break would constitute too large an interruption for the programs.

1. Stationary Bicycle Program

Participants in the bicycle program were required to ride the bicycle over a preprogrammed twelve minute course a minimum of four days per week. Ten load levels are available with the bicycle. Gradual increases of these load levels over the duration of the program should produce increased physical fitness. The amount and frequency of increase was determined by the subject's pulse rate. The program was essentially the program outlined by Cooper [Ref. 2]. The detailed program is contained in Appendix A.

To monitor progress, each subject recorded his pulse at selected time intervals on a preprinted form. Data from these daily forms was transcribed to a weekly summary

[Appendix A]. These forms provided the experimenters with information concerning each subject's progress and participation.

During the program, the stationary bicycle was inoperative during the fourth week for a loss of four exercise periods. Because of adjustments to the variable load mechanism, each participant had to refind his load level. It was felt that this readjustment and loss of exercise periods were accomplished without significant detriment to the overall program. Of the fourteen original subjects, 10 successfully completed the program. One stopped for medical reasons, one stopped for academic reasons, and two were judged by the experimenters not to have participated with satisfactory frequencies.

2. Exerciser Program

The exercising equipment used in this portion of the program is relatively new and therefore requires a brief discussion. The Exer-Genie exerciser, created in 1961, is a rope tension device which consists of a highly polished aluminum shaft inside an engineered cylinder and a nylon rope. Friction determines the tension of this device and is determined by the number of turns the nylon rope is wrapped around the shaft. The exerciser is shown in Appendix B.

The exerciser program was developed with the assistance of Ronald E. Useldinger, M.A., the Regional Director of American Physical Fitness of San Jose, California [Useldinger 1972].

Each subject was instructed to exercise with the exerciser a minimum of four times per week. Each workout

period consisted of the following exercises:

1. 3 - Big Fours
2. 3 - Floor Sit-ups or Standing Sit-ups
3. 3 - Rowing
4. 3 - Side Bends
5. 3 - 35 Second Runs in Running Harness

These exercises are shown in Appendix B.

Starting load levels were ascertained by having each subject individually make a subjective determination of his maximum capacity. Each subject was advised not to exceed this capacity as a measure to prevent injury. These load levels were maintained until the subject found the load too easy. At this point each subject would again adjust the load levels by determining his new capacities. To increase cardiovascular exercise, each subject was instructed to maintain a pulse count between 120 and 170 beats per minute for each exercise. The pulse was found by placing a finger on the throat at the end of the third repetition of each exercise. The pulse rate was then increased or decreased by varying the amount of exertion expended during the exercises. The subjects were instructed to move from one exercise directly to the next with less than one minute of delay. The subjects were further instructed to complete all exercises in less than twenty minutes. By the fifth week all subjects were completing all five exercises in under fifteen minutes.

The exerciser program results were monitored and displayed continuously throughout the ten week period. Each subject was instructed to record on the forms provided his

load levels and pulse rates for each exercise in addition to his total exercise time. These data were then transferred to his individual progress chart which was displayed in the exerciser room. Examples of the form and progress chart are contained in Appendix B.

The individual progress chart in Appendix B represents a hypothetical subject's progress throughout the ten week exerciser program. The left ordnant of the chart represents load levels used on the exerciser for all of the five exercises. On a weekly basis a data point for each of the five exercises was plotted on the chart. This point represented the highest load level achieved on the exerciser for the respective exercise during the preceding week. The weekly data points thus obtained for each exercise were then connected by straight lines containing the proper nomenclature symbols.

The right ordnant of the chart represents the average time per week to complete a workout, i.e., a set of the five required exercises. This average time was obtained by having the subject record the total time required to complete each workout during the week in question and then dividing the total time for all workouts by the number of workouts completed during the week.

Of the seventeen original subjects, ten successfully completed the exerciser program. No one dropped from the program for reasons directly attributed to the use of the exerciser.

D. TESTING PROCEDURES

1. Psychomotor Response Test

To obtain a measure of each subject's psychomotor performance the experimenters constructed a consecutive three-part test. Parts one and three were identical. Parts one and three consisted of a serial reaction time test. For these parts each subject was seated in the soundproof booth at a table furnished with the output console and display screen mentioned earlier. The subject was instructed to use either or both hands and any number of fingers to push the buttons on the output console. The only restrictions placed on the subject's individual technique were that he never use more than one finger simultaneously to extinguish a number on the screen and that he always use the same technique. A number was presented on the screen by the experimenter and was extinguished as rapidly as possible by the subject. The rate at which the numbers appeared on the screen was determined by the rate at which the subject extinguished them. As soon as the experimenter observed that the subject had correctly responded by noting that the counter-timer had stopped, he inputted another number. A total of 150 numbers were presented on the screen during a test segment. The numbers were obtained from a table of random numbers. Each subject was initially allowed 50 numbers to acquaint himself with the apparatus and to reduce the learning effects during the actual testing. This number

was considered sufficient due to the simplicity of the task involved.

After responding to the first set of 150 numbers, i.e., part one of the test, the subject commenced part two of the test without delay. Part two consisted of jogging on a treadmill for a total time of three minutes. The speed and incline angle of the treadmill were standardized for all subjects at four miles per hour and fifteen degrees respectively. Upon completion of the three minutes of jogging, the subject was immediately returned to the soundproof booth for part three of the test. The prosecution of the second set of 150 numbers commenced again without delay and unlike part one, no practice numbers were allowed. The average of the cumulated times obtained in parts one and three was the measure used for each subject's psychomotor response time. The psychomotor response test was given to every subject in our experiment, both at the beginning and end of the ten week physical conditioning program.

2. Physical Fitness Test

This test was actually performed during part two of the psychomotor response test. As described earlier, each subject jogged for a total of three minutes on the treadmill. Data for the physical fitness test was obtained by having the subject place the face mask of the previously described respiration gasmeter over his nose and mouth during the final minute of the three minute jogging period. The volume and oxygen percentage of the exhaled air were then obtained and recorded. These data plus the subject's

weight in kilograms were used to compute his physical fitness index. This index was called the maximal oxygen uptake (MOU).

3. Psychological Test

The psychological test utilized for this experiment was identical in every detail to the test used by Phelan and Parodi [Ref. 4] and the following discussion of the test was excerpted from their work.

"The psychological test utilized was the Multiple Affect Adjective Check List (Appendix C). Affect may be defined as the psychological aspects of emotion, or the emotional response which is assessed by means of verbal reports. Most psychological measures tend to evaluate affect as a trait rather than a state [Zuckerman 1965]. The MAACL, however, attempts to measure the state, as measuring the state specifies the time referant (e.g., now, last week).

The MAACL is a self-administered test which provides measures of three of the clinically relevant negative affects: anxiety, depression, and hostility. Two types of the test are available, the "today" form and the "general" form. In the "today" form, the subject responds positively or negatively to a series of adjectives describing how he has felt today only, and in the "general" form the subject responds to how he has felt in some specified time frame in the past. In this experiment, the subject was asked how he had felt during the past week.

Most words appearing on the check list were direct indicators of the affective state. The remaining words,

however, had no relationship to the affective state. The process by which words were selected to appear on the check list is discussed fully by Zuckerman [Ref. 10].

The scoring of the tests was based on the subject's response to certain words and lack of response to other words. These key words are shown in Appendix C, as well as the specific scoring procedures utilized.

The MAACL has not been investigated sufficiently to relate the raw scores obtained from the tests to a specific degree of clinical affect [Zuckerman 1965]".

In this experiment, the MAACL was given to all subjects both before the physical training program commenced and after its completion.

III. STATISTICAL RESULTS

Parametric and nonparametric statistics have been used to analyze results of the exercise program. Conclusions drawn by parametric tests have been rechecked by nonparametric tests. This redundancy was felt necessary because the underlying assumption of the test is normality of the random variables. A plot of the variables on normal probability paper did not indicate that they were not normal, however the plot did not strongly indicate normality. Hence, it was felt that it would be advisable to use the more conservative nonparametric tests as a check to prevent rejection of the null hypothesis when it should be accepted.

A. PARAMETRIC ANALYSIS

In this analysis, it is assumed that the five variables, maximal oxygen uptake, psychomotor reaction times, and anxiety, hostility, and depression, were approximately normally distributed. Zuckerman [Ref. 12] indicated that the three variables of the psychological test were normally distributed. Each subject has a before and after exercise score for each variable. These bivariate normal pairs were tested for equal means by the paired sample t test. The null hypothesis was that the means before and after were equal and the level of significance α was ten percent. If the null hypothesis was rejected, the direction of the inequality was determined by the sample means. Details of the analysis are as given in Appendix D. Table I summarizes the results.

	MOU	Psychomotor test	Psychological Test		
			Anxiety	Hostility	Depression
Bicycle	accept	accept	accept	accept	accept
Exerciser	reject	accept	accept	accept	accept
Control	accept	accept	accept	accept	accept

Table I Results of the t Test.

Results of the test indicated that no change had occurred in the subject populations because of the exercise program except in the case of the exerciser group in which it was concluded that the mean MOU had decreased.

B. NONPARAMETRIC ANALYSIS

Three nonparametric tests were used to analyze the data. The Kruskal-Wallis Test was used to determine if the populations of each group were the same initially with respect to each of the tested variables. The Wilcoxan Signed Rank Test and the Sign Test were used to determine differences in the populations after the exercise program.

As indicated by the Kruskal-Wallis Test, all groups were initially homogeneous with respect to the measured variables at a significance level α of ten percent. Details are provided in Appendix D.

The Wilcoxan Signed Rank Test was used to compare MOU's and psychomotor reaction times before and after the exercise program for the exercise and control groups. This test according to Conover [Ref. 1] is one of the "best" tests for determining distributional changes of the bivariate random sample. The test requires the following assumptions:

(1) Continuous random variables

(2) Symmetry of underlying distribution

(3) Independence of bivariate pairs.

Again the null hypothesis was that the population means before and after were equal and the level of significance α was ten percent. Details of the analysis are as given in Appendix D. To investigate the effects of both exercise programs on performance, the results of the bicycle and exerciser groups were pooled into a combined group. Table IV summarizes the results.

	MOU	Psychomotor Test
Bicycle	accept	reject
Exerciser	reject	reject
Combined	accept	reject
Control	accept	accept

Table II Results of the Wilcoxan Signed Rank Test.

Comparisons of means indicated that the psychomotor reaction times for the bicycle and exerciser groups decreased while the control group's psychomotor reaction times were not shown to have changed. The MOU results indicated no change for the combined group and the control group, but indicated a decrease in MOU for the exerciser group.

The Wilcoxan Signed Rank Test was not appropriate to analyze the results of the psychological testing because of the discreet nature of the data. The Sign Test which was used requires only the assumptions that each bivariate pair be independent and that the measurements be ordinal. Although

prescribed testing procedures [Zuckerman 1965] indicated the use of the t test, the small sample sizes in this experiment were not felt to be conducive to accurate results.

The null hypothesis tested was that the means before and after were equal. The alternate hypothesis was they were not equal with the direction of the inequality determined by the sample averages. Table V summarizes the results. Details of the analysis are given in Appendix D.

	Anxiety	Hostility	Depression
Bicycle	accept	accept	accept
Exerciser	reject	accept	reject
Combined	accept	accept	reject
Control	accept	accept	reject

Table III Results of the Sign Test.

Comparison of means indicated that anxiety increased in the exerciser group but it was not shown that anxiety changed for the combined group. Depression decreased for the exerciser, combined, and control groups. The null hypothesis that depression for the combined and control groups decreased by the same amount was tested by the Mann-Whitney Test and was accepted.

IV. DISCUSSION OF RESULTS

A. MAXIMAL OXYGEN UPTAKE

Central to the entire experiment was the requirement that the subjects improve in physical fitness. The measure of the physical fitness of a subject was the subject's maximal oxygen uptake (MOU) which was expected to increase over the duration of the exercise program. Moreover, the results of the experiment were that the exerciser group's average MOU's significantly decreased and the bicycle group's average MOU's were unchanged. Regardless of this fact, the experimenters believe that the physical fitness of all the exercising subjects was considerably increased. This belief is based on the following observations:

(1) During the initial testing phase, the heartbeat of each subject was monitored to prevent the possibility of any physical damage to the subjects. If the pulse rate exceeded 160 beats per minute, the treadmill was slowed until a pulse rate of 160 was achieved. Approximately four-fifths of the subjects required that the treadmill be slowed during the initial testing. During the final testing, not one of the subject's heartbeats exceeded 160 beats per minute. Shephard [Ref. 6] has indicated that due to inherent difficulties in measuring MOU, the pulse rate may be a better indicator of physical fitness for a constant effort task.

(2) At the conclusion of the experiment, each subject completed a questionnaire on the overall program. Nineteen

of the twenty stated that they personally felt in "better" condition. Of these nineteen, six stated that they felt in "much better" condition.

(3) The data from the exercise programs indicated that all of the subjects showed improvement in their capabilities to perform work.

Several potential explanations for the possible failure of the MOU to reflect this increased fitness have been listed below:

(1) Final testing did not place the improved subjects under as great a relative stress as the initial testing had and hence the final MOU's were less of a "maximal" measure than the initial MOU's.

(2) Oxygen uptake during the short test periods (0 - 3 minutes) was erratic. Cooper [Ref. 2] would claim that a much longer test period is required to determine MOU, no matter what the stress. In this experiment, it is possible that neither the stress nor the test period or possibly both were sufficient. The MOU formula at less than "maximal" efforts is extremely sensitive to the quantity of air exhaled, i.e., a person who hyperventilated would exhibit a higher oxygen uptake than a person who did not do so.

B. PSYCHOMOTOR TEST

The psychomotor reaction times for both the bicycle and exerciser groups decreased at a significance level α of ten percent. The times for the control group were not shown to change. The experimenters felt that effects of any learning

effects should have been minimized by the rather simple nature of the test. This feeling was reinforced by the result of no significant change in psychomotor reaction times for the control group. Hence, it was concluded that psychomotor reaction times decreased because of the exercise programs.

C. PSYCHOLOGICAL TEST

The psychological test produced mixed results. For the combined group and control groups, depression decreased at a ten percent significance level. No change was observed for anxiety and hostility. Between exercise groups, the exerciser group increased in anxiety. From this experiment, no change in the psychological state of the subjects was determined. The failure to detect any change could possibly have resulted from one or more of the following reasons:

(1) There was no change.

(2) The sample size was too small to detect a change at the ten percent level of significance.

(3) The student population from which the sample was drawn was not a representative one.

Of these three reasons, the second and third seem the most likely. In the case of the third reason, the test periods directly followed and preceded quarterly final examinations and this could have influenced the results of the psychological test.

In conclusion, the results of this experiment are that the subjects in the exercise programs decreased their

psychomotor reaction times. An increase in physical fitness of the subjects was not shown by measurements of the subject's MOU's. No psychological changes in the subjects were indicated by the MAACL test.

V. OTHER RESULTS

An interesting phenomenon was observed during the psychomotor response testing of this experiment. The experimenters had assumed that the response time of part three of the psychomotor response test would be greater than the response time of part one for all the subjects involved in the experiment. However, almost ninety-five percent of all the subjects had shorter response times for part three of this test. The experimenters thus concluded that the task of jogging for three minutes on the treadmill had stimulated the subject's circulatory and respiratory systems without noticeably fatiguing them. It was further concluded that the subjects would have to reach some level of fatigue before appreciable increases in response times for part three of the test would be observed.

VI. COMMENTS

Because of the difficulty in determining MOU's, the heartbeats per minute might have been a better index for measuring physical fitness.

A final comment concerns the population from which the subjects for this type of experiment might best be chosen. Our subjects were all young men under thirty-two years of age and of apparently good physical and mental health. For this reason, the experimenters felt that the sensitivity of the psychological test was somewhat minimized. The basis for this conjecture is that older and perhaps weaker subjects would have greater psychological gains as a result of a sustained period of physical conditioning.

Combined analysis of all individual progress records was not attempted. This was partly due to equipment breakdown in the case of the bicycle as mentioned earlier. Also, the ropes of the exercisers soiled easily. This rapidly led to fraying which made the ropes unacceptable for this experiment. Because of the fraying, the ropes were subsequently changed for new ones three times during the ten week exercise period. New ropes created less friction than the old frayed ones, thus the workloads varied radically during these rope replacement periods.

APPENDIX A

The specific instructions that were given to the bicycle program participants are contained below.

Exercise Program

This program is designed to be a progressive program. At the end of 10 weeks, you can expect a significant increase in your body's ability to consume oxygen. This increase, in turn, indicates physical improvement. Each participant will begin at load level 40 and increases or decreases in this level will be determined by your maximum pluse reading (expected during the 4th hill). Each participant will adjust his own daily load level using the following criteria:

Max Pulse Level	Action
150 & below	Increase load level by 10 at next session
150-160	Increase load level by 10 at next session if you feel that you can maintain the higher level
160 & above	Decrease level by the next session

Crank speed should be maintained at 80 rpm except during the 100 rpm portion. During the last minute of the program, the crank speed may gradually be reduced to zero.

If the initial load level of 40 is too high, i.e., your pulse exceeds 160, decrease (during the program) the load level by 10 and your crank speed to 60 rpm. When your pulse rate decreases to 150, increase your crank speed to 80 rpm.

If your pulse does not decrease to 150, decrease the load by an additional 10 units and proceed as above.

If the initial load level of 40 is too low, i.e., your pulse is below 160, follow the instructions for increasing your load level as given above.

Operating Instructions

1. Adjust seat height (leg should be slightly bent)

2. Turn on and set to PROG. (programmed mode).

3. Set load level (10-100).

4. Attach earclip to fleshy part of earlobe with light source to outside. Compute reading (blinking red light) with your heart beat after 5-15 second warmup. Occasionally there are fluctuations caused by such things as random outside light striking the photo cell, etc.

5. The timer should be at the 12 minute (zero time) mark when beginning. To start program, press start button for three seconds and begin pedaling. If you should stop before the program is completed, let the timer continue running until the program is completed. Then turn the off-on switch to off.

Caution

1) If your feet slip off the pedals, the pedals will continue to spin. Wait for crank revolutions to decrease prior to replacing feet.

2) If you stop pedaling during a heavy load, the pedals may lock. To correct, turn switch to manual mode, place load level on lowest setting, and press start button while attempting to turn pedals. This procedure should correct the locked pedals.

Program Mode

The program mode consists of 4 parts as follows:

a. Warm-up (0-2 minutes)

b. Test (2-4.5 minutes)

c. Cardio-vascular stimulation (4.5-9 minutes)

d. Warm down (9-12 minutes)

Record your pulse on the daily form when the yellow check pulse light comes on. This occurs at 5 minutes, the end of each hill, the end of the 100 rpm phase, and the conclusion of the entire program. Turn in this daily form.

LIFECYCLE

SCOREPAD

Name						
Date						
Level						
Test						
Hill 1						
2						
3						
4						
100 rpm						
Final 1						
2						
MOU						
Comments						

Record your pulse rate each time the "pulse check" indicator light goes on. You can then transfer figures to the LIFECYCLE progress card for a historical record of your progress.

FOR THE LIFE OF YOU !

LIFECYCLE INC., 1006 SHARY CIRCLE, CONCORD, CAL. 94520

Daily Form

LIFECYCLE

PROGRESS CARD

Date _____ Level _____ MOU _____
Wt _____ Hps _____ Wst _____

Pulse Rate	T 5	Hill 1	Hill 2	Hill 3	Hill 4	100 rpm	Final 1	Final 2
200								
196								
192								
188								
184								
180								
176								
172								
168								
164								
160								
156								
152								
148								
144								
140								
136								
132								
128								
124								
120								
116								
112								
108								
104								
100								
96								
92								
88								
84								
80								

Date _____ Level _____ MOU _____
Wt _____ Hps _____ Wst _____

Pulse Rate	T 5	Hill 1	Hill 2	Hill 3	Hill 4	100 rpm	Final 1	Final 2
200								
196								
192								
188								
184								
180								
176								
172								
168								
164								
160								
156								
152								
148								
144								
140								
136								
132								
128								
124								
120								
116								
112								
108								
104								
100								
96								
92								
88								
84								
80								

Date _____ Level _____ MOU _____
Wt _____ Hps _____ Wst _____

Pulse Rate	T 5	Hill 1	Hill 2	Hill 3	Hill 4	100 rpm	Final 1	Final 2
200								
196								
192								
188								
184								
180								
176								
172								
168								
164								
160								
156								
152								
148								
144								
140								
136								
132								
128								
124								
120								
116								
112								
108								
104								
100								
96								
92								
88								
84								
80								

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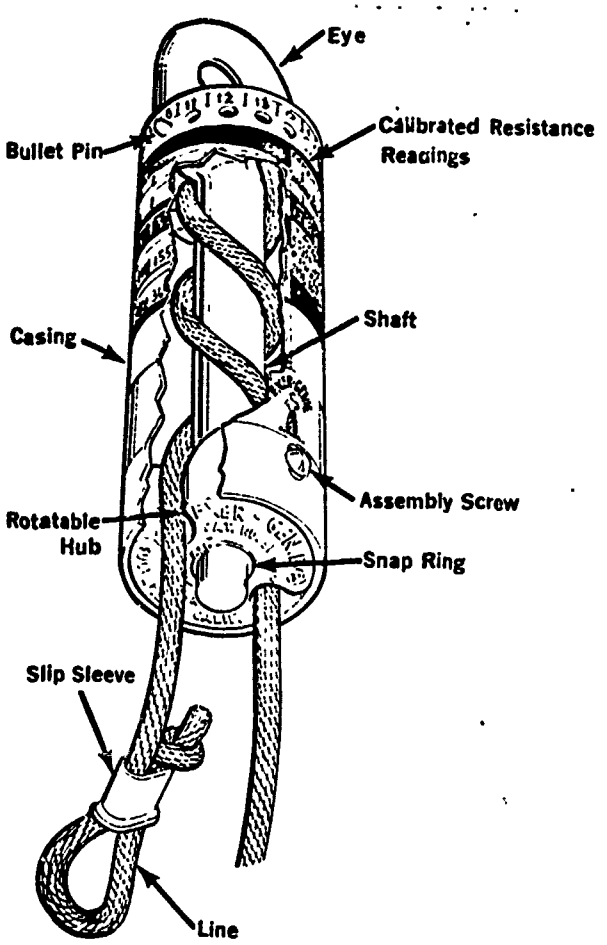
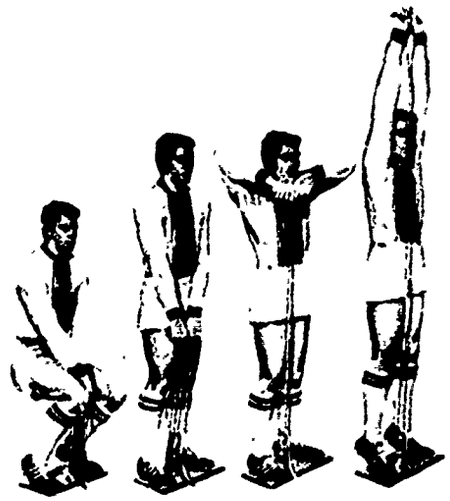
APPENDIX B


Eye
Calibrated Resistance Readings
Bullet Pin
Shaft
Casing
Assembly Screw
Rotatable Hub
Snap Ring
Slip Sleeve
Line

BIG FOUR



1. Anchor at ground level or to footboard.* Use double handle. Set resistance for 'clean'.
2. Assume deadlift position. Grasp handle and pull isometrically for 10 seconds, working all major muscle groups.
3. Keep arms straight, rotate hips forward, ease resistance and 'press' with legs to standing position (4 seconds). DO NOT LIFT WITH BACK.
4. Drop trail line, raise handle to chin — 'clean' (4 seconds).
5. Rotate hands, palms outward, and complete military press (4 seconds).
6. Stretch while completing heel raise (2 seconds).

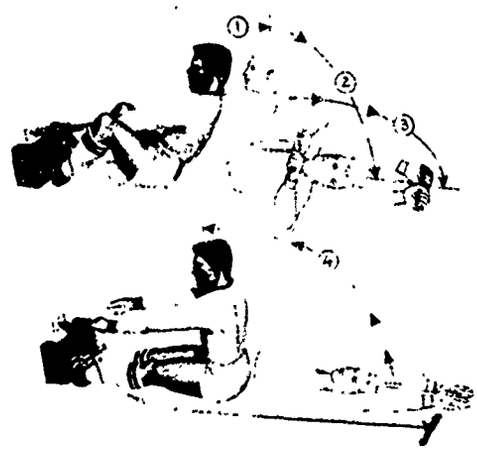
SIT UP - STANDING

1. Anchor at head level. Use double handles.
2. With knees bent, legs in stride position and head lowered, grasp handle behind neck with overhand grip. Keep elbows forward and pull isometrically for 10 seconds.
3. Ease resistance and bend downward, working abdominal muscles (12 seconds).

SIT UP - LYING

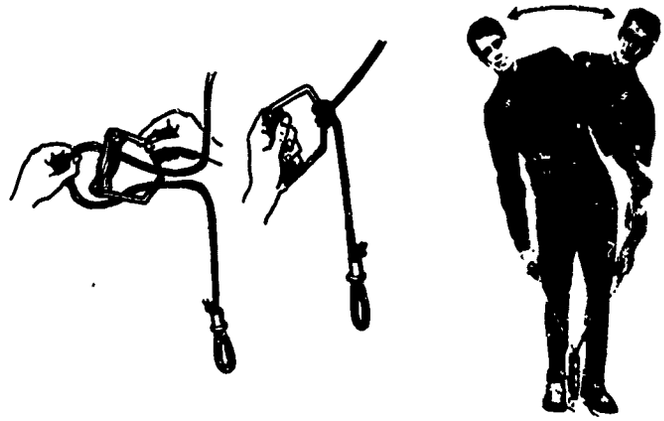
1. Anchor 6 inches above ground level. Use double handles.
2. Keep knees bent, feet flat on floor and grasp handle behind neck. With elbows forward and lower back on floor, raise shoulders and pull isometrically for 10 seconds.
3. Ease resistance and curl forward until elbows touch knees (12 seconds). DO NOT ARCH BACK.

ROWING EXERCISE



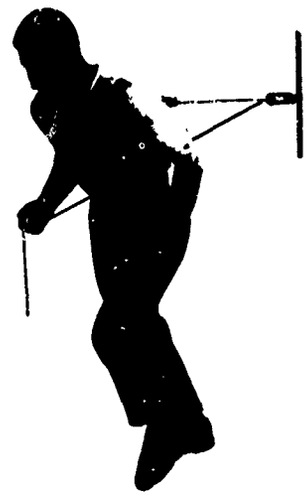
1. Anchor 18 inches above ground level. Use double handles.
2. With feet against block or wall, bend knees and assume rowing position. Extend arms forward, grasp handle and pull isometrically for 10 seconds.
3. Straighten legs (4 seconds). ① ⟶
4. Controlling resistance, row to chest as back is lowered to floor (4 seconds). ② ⟶
5. Drop trail line. 'Press' overhead to complete extension (4 seconds). ③ ⟶
6. Drop handle, reach forward, pull body to sitting position and repeat (2 seconds). ④ ⟵

SIDE BEND



1. Anchor to footboard. Use wire handles. Shorten line (diagram).
2. Keep shoulders back, bend directly to one side, grasp handles and pull isometrically for 10 seconds.
3. Ease resistance and bend to other side (12 seconds).
4. Again pull isometrically for 10 seconds.
5. Ease resistance and return (12 seconds).

35 SECOND RUN



NAME _____

DATE _____

EXERCISE	LOAD	PULSE
BIG FOURS:	_____	_____
SIT UPS		
Standing:	_____	_____
Lying:	_____	_____
ROWING:	_____	_____
SIDE BENDS:	_____	_____
35-SEC RUNS:	_____	_____
TOTAL TIME:	_____	_____

EXER-GENIE DAILY PROGRESS RECORD

INDIVIDUAL PROGRESS CHART

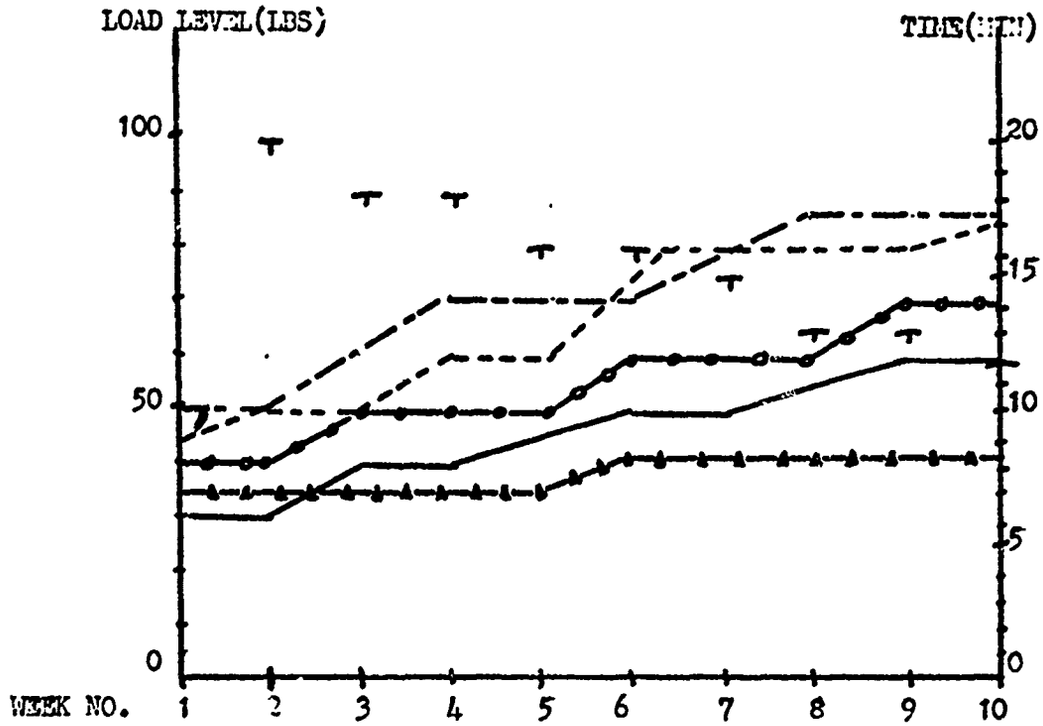


CHART NOMENCLATURE

: Time
: Sit Ups - Standing/Lying
: Big Four
: Rowing
: 35-Sec Run
: Side Bend

Note:

1. Load levels are the highest levels achieved during a week period.

2. Times are average times per week to complete all five exercises.

3. Complete explanation of this chart is contained in the text of this report.

APPENDIX C

The Appendix describes the scoring and lists the key words utilized in the Multiple Affect Adjective Check List. The scoring of the tests was based on the subject's response to certain words and lack of response to other words. The words are placed in plus columns or minus columns. A subject's checking of a word in the plus column tends to indicate that he is in a state of anxiety, depression, or hostility, while checking a word in the minus column tends to indicate a lack of anxiety, depression, or hostility. These key words are shown below.

Anxiety		Depression	
Plus	Minus	Plus	Minus
afraid	calm	alone	active
desperate	cheerful	awful	alive
fearful	contented	blue	clean
frightened	happy	destroyed	enthusiastic
nervous	joyful	discouraged	fine
panicky	loving	forlorn	fit
shaky	pleasant	gloomy	free
tense	secure	hopeless	gay
terrified	steady	lonely	glad
upset	thoughtful	lost	good
worrying		low	healthy
		miserable	inspired
		rejected	interested
		sad	lucky
		suffering	merry
		sunk	peaceful
		terrible	safe

Depression cont.

tormented	strong
unhappy	whole
wilted	young

Hostility

Plus	Minus
angry	agreeable
bitter	amiable
cruel	cooperative
disagreeable	friendly
discontented	good-natured
disgusted	kindly
enraged	polite
furious	sympathetic
irritated	tame
mad	tender
mean	understanding
offended	willful
outraged	warm
storym	devoted
unsociable	
vexed	

To obtain the raw score for the test add the number of words not checked on the minus list to the number of words that are checked on the plus list. An exact copy of the MAACL follows.

DATE TODAY_____

Last First Middle Initial

Below you will find words which describe different kinds of moods and feelings. Check the words which describe how you have felt during the past week, from _____ until now. Some of the words may sould alike, but we want you to ckeck all the words that describe your feelings during the past week. Work rapidly.

1.___active
2.___adventurous
3.___affectionate
4.___afraid
5.___agitated
6.___agreeable
7.___aggressive
8.___alive
9.___alone
10.__amiable
11.__amused
12.__angry
13.__annoyed
14.__awful
15.__bashful
16.__bitter
17.__blue
18.__bored
19.__calm
20.__cautious
21.__cheerful
22.__clean
23.__complaining
24.__contented
25.__contrary
26.__cool
27.__cooperative
28.__critical
29.__cross
30.__cruel
31.__daring
32.__desperate
33.__destroyed
34.__devoted
35.__disagreeable
36.__discontented
37.__discouraged
38.__disgusted
39.__displeased
40.__energetic
41.__enraged
42.__enthusiastic
43.__fearful
44.__fine
45.__fit
46.__forlorn
47.__frank
48.__free
49.__friendly
50.__frightened
51.__furious
52.__gay
53.__gentle
54.__glad
55.__gloomy
56.__good
57.__good-natured
58.__grim
59.__happy
60.__healthy
61.__hopeless
62.__hostile
63.__impatient
64.__incensed
65.__indignant
66.__inspired

67.__interested
68.__irritated
69.__jealous
70.__joyful
71.__kindly
72.__lonely
73.__lost
74.__loving
75.__low
76.__lucky
77.__mad
78.__mean
79.__meek
80.__merry
81.__mild
82.__miserable
83.__nervous
84.__obliging
85.__offended
86.__outraged
87.__panicky
88.__patient
89.__peaceful
90.__pleased
91.__pleasant
92.__polite
93.__powerful
94.__quiet
95.___reckless
96.___rejected
97.___rough
98.___sad
99.___safe
100.___satisfied
101.___secure
102.___shaky
103.___shy
104.___soothed
105.___steady
106.__stubborn
107.__stormy
108.__strong
109.__suffering
110.__sullen
111.__sunk
112.__sympathetic
113.__tame
114.__tender
115.__tense
116.__terrible
117.__terrified
118.__thoughtful
119.__timid
120.__tormented
121.__understanding
122.__unhappy
123.__unsociable
124.__upset
125.__vexed
126.__warm
127.__whole
128.__wild
129.__willful
130.__wilted
131.__worrying
132.__young

APPENDIX D

1. Paired Sample t Test

The paired sample t test was used to determine differences in the populations before and after the exercise programs for all the variables. The assumption of normality is required to use this test. The null hypothesis was that the means before and after were equal. If the null hypothesis was rejected, the direction of the inequality was determined by the sample means. Each t statistic had 18 degrees of freedom and the level of significance α chosen was ten percent. The null hypothesis that no change has occurred was accepted if the event,

$$-1.734 \leq T \leq 1.734 \quad \text{, occurred.}$$

The following table summarizes the values of the t statistic.

			Psychological Test		
	MOU	Psychomotor Test	Anxiety	Hostility	Depression
Bicycle	-0.042	0.685	0.053	0.325	0.909
Exerciser	2.568	0.405	-1.380	0.531	0.831
Control	-0.116	0.606	0.906	0.045	0.770

In all cases the null hypothesis was accepted except for the exerciser group in which it was concluded that the mean MOU had decreased.

2. Kruskal-Wallis Test

The Kruskal-Wallis test was used to determine if all the population distribution functions were identical i.e. the bicycle, exerciser, and control groups were from the same population. The test statistic

$$T = \frac{12}{N(N+1)} \sum_{i=1}^{k} \frac{Ri^2}{Ni} - 3(N+1)$$

where R_i is the sum of the ranks of the ith sample from the ranks of the pooled sample is distributed approximately chi-square with k-1 degrees of freedom. The null hypothesis tested for all variables was that each sample (bicycle, exerciser, and control groups) came from the same initial population. The level of significance α is ten percent and there are two degrees of freedom.

MOU Scores

Bicycle		Exercisor		Control	
Score	Rank	Score	Rank	Score	Rank
35.76	22	48.21	30	33.33	16
26.08	4	41.26	28	29.37	7
29.40	8	30.68	12	23.53	2
33.73	18	41.02	27	43.29	29
40.26	26	31.71	14	29.68	10
33.78	19	26.90	5	36.90	23
34.27	20	38.25	24	23.20	1
31.82	15	39.52	25	33.56	17
30.67	11	27.78	6	25.72	3
34.80	21	31.04	13	29.55	9
R_1 = 164		R_2 = 184		R_3 = 117	

Psychomotor Scores

224.93	30	127.79	1	148.67	8
209.07	29	181.19	23	171.93	20
154.59	12	148.77	9	159.88	15
189.26	25	131.15	2	165.35	16
167.97	17	156.34	13	145.23	5
171.81	19	153.17	11	138.52	4
175.65	21	137.27	3	147.67	7
149.82	10	200.80	28	192.66	26
145.89	6	158.87	14	171.52	18
181.79	24	180.12	22	194.27	27
R_1 = 193		R_2 = 126		R_3 = 146	

Depression Scores

Bicycle		Exercisor		Control	
Score	Rank	Score	Rank	Score	Rank
12	9.5	21	26.5	12	9.5
21	26.5	13	11.5	15	15
18	22	15	15	38	30
7	4	17	20	10	8
6	3	9	6	15	15
15	15	22	28.5	18	22
9	6	9	6	18	22
13	11.5	19	24.5	19	24.5
5	1.5	5	1.5	16	18.5
22	28.5	15	15	16	18.5
	$R_1 = 127.5$		$R_2 = 154.5$		$R_3 = 183$

Anxiety Scores

7	14	9	21	7	14
9	21	8	17.5	10	24.5
0	1.5	6	11.5	15	29.5
0	1.5	8	17.5	4	7
8	17.5	2	3.5	3	5
4	7	8	17.5	7	14
15	29.5	6	11.5	10	24.5
2	3.5	10	24.5	10	24.5
5	9.5	4	7	12	28
9	21	5	9.5	11	27
	$R_1 = 126$		$R_2 = 141$		$R_3 = 198$

Hostility Scores

11	17	14	23	10	13.5
14	23	12	18	5	4.5
14	23	7	7	15	27
6	6	18	29	10	13.5
10	13.5	5	4.5	4	2
10	13.5	14	23	14	23
10	13.5	10	13.5	13	19
9	9.5	14	23	9	9.5
4	12	4	2	22	30
17	28	8	8	4	23
$R_1 = 149$		$R_2 = 151$		$R_3 = 165$	

The null hypothesis is rejected if

$$T \leq \chi^2_{.10,2} = 4.6$$

The following table summarizes the results.

	T	Action
MOU	3.0	accept
Psychomotor	3.0	accept
Depression	2.0	accept
Anxiety	3.5	accept
Hostility	.3	accept

In all cases, the null hypothesis that all groups come from the same population was accepted.

3. Welcoxan Signed Rank Test

The Welcoxan Signed Rank Test was used to determine differences in a population before and after the exercise programs for MOU and psychomotor testing. The test statistic

$$T = \Sigma \text{ (Ranks of the positive differences, } X_i > Y_i)$$

is tabulated in tables [Conover 1971]. The null hypothesis tested was the means before and after exercise were the same. X is the variable before and Y is the variable after. Each bivariate pair (X,Y) came from one subject.

a. MOU Computations

Group	X_i	Y_i	X_i-Y_i	Rank	Combined Rank
	35.76	41.79	-6.03	6	12
	26.08	40.70	-14.62	9	19
	29.40	19.97	9.53	8	15
	33.73	36.80	-3.07	4	8
Bicycle	40.26	35.90	4.36	5	11
	33.78	34.54	-.76	1	1
	34.27	36.94	-2.67	3	7
	31.82	38.91	-7.09	7	14
	30.67	31.80	-1.13	2	4
	34.80	14.54	20.26	10	20
$\bar{X}$ =	33.06	$\bar{Y}$ = 33.19		T = 23	
	48.21	37.32	.89	1	2
	41.26	27.30	13.94	10	18
	30.68	26.79	3.89	6	10
	41.02	28.06	12.96	9	17
Exer-ciser	31.71	30.78	.93	2	3
	26.90	20.80	6.10	7	13
	38.25	34.95	3.30	5	9
	39.52	18.57	10.95	8	16
	27.78.	29.70	-1.92	3	5
	31.04.	29.05	1.99	4	5
$\bar{X}$ =	35.64	$\bar{Y}$ = 28.33		T = 52	

Combined $\bar{X}$ = 34.35 $\bar{Y}$ = 30.76 T = 145

Group	X_i	Y_i	$X_i - Y_i$	Rank
	33.33	26.06	7.27	10
	29.37	31.92	-2.55	6
	23.53	26.99	-3.46	7
	43.29	41.63	1.66	4
Control	29.68	32.11	-2.43	5
	36.90	36.56	.34	2
	23.20	29.15	-5.95	9
	33.56	29.83	3.73	8
	25.72	26.00	-.28	1
	29.55	30.79	-1.24	3
	$\bar{X}$ = 30.81	$\bar{Y}$ = 31.10		T = 24

Conclusions MOU Testing:

Bicycle: Accept Ho if 11 < T < 44 at α .10

T = 23

Accept Ho

Exerciser: Accept Ho if 11 < T < 44 at α = .10

T = 52

Reject Ho

Combined: Accept Ho if 61 < T < 149 at α = .10

T = 145

Accept Ho

Control: Accept Ho if 11 < T < 44 at α = .10

T = 24

Accept Ho

b. Psychomotor Computations

Group	X_i	Y_i	$W_i - Y_i$	Rank	Combined Rank
	224.93	220.59	4.34	2	5
	209.07	195.53	14.54	9	19
	154.59	143.90	10.69	5	14
	189.26	172.11	17.15	10	20
Bicycle	167.97	156.10	11.87	7	17
	171.81	165.98	5.83	3	7
	175.65	174.20	1.45	1	3
	149.82	141.80	8.02	4	12
	145.89	157.05	-11.16	-6	-15
	181.79	168.15	13.64	8	18
	$\bar{X}$ = 177.08	$\bar{Y}$ = 169.54		T = 49	
	127.79	134.41	-6.62	-7.5	-10.5
	181.19	169.49	11.70	10	16
	148.77	142.72	6.05	5	8
	131.15	131.72	-.57	-1	-1
Exerciser	156.34	146.57	9.77	9	13
	153.17	146.55	6.62	7.5	10.5
	137.27	131.19	6.08	6	9
	200.80	199.56	1.24	2	2
	158.87	157.08	1.79	3	4
	180.12	174.77	5.35	4	6
	$\bar{X}$ = 157.55	$\bar{Y}$ = 153.41		T = 46.5	

Combined $\bar{X}$ = 167.31 $\bar{Y}$ = 161.47 T = 183.5

Group	X_i	Y_i	$X_i - Y_i$	Rank
	148.67	147.96	.71	3
	171.93	157.43	14.50	9
	159.88	155.06	4.82	5
	165.35	168.25	-2.90	-4
Control	145.23	140.25	4.98	6
	138.52	130.87	7.65	7
	147.67	147.18	.49	2
	192.66	201.64	-8.98	-8
	171.52	171.80	-.28	-1
	194.13	162.43	31.70	10
	$\bar{X}$ = 163.56	$\bar{Y}$ = 158.29		T = 42

Conclusions Psychomotor Testing:

Bicycle: Accept Ho if $11 < T < 44$ at $\alpha = .10$

$T = 49$

Reject Ho

Exerciser: Accept Ho if $11 < T < 44$ at $\alpha = .10$

$T = 46.5$

Reject Ho

Combined: Accept Ho if $61 < T < 149$ at $\alpha = .10$

$T = 183.5$

Reject Ho

Control: Accept Ho if $11 < T < 4$ at $\alpha = .10$

$T = 42$

Accept Ho

4. Sign Test

The Sign Test was used to determine differences within a population before and after the exercise program for anxiety, depression and hostility, The test statistic is

Group	X_i	Y_i	X_i-Y_i	Rank
	148.67	147.96	.71	3
	171.93	157.43	14.50	9
	159.88	155.06	4.82	5
	165.35	168.25	-2.90	-4
Control	145.23	140.25	4.98	6
	138.52	130.87	7.65	7
	147.67	147.18	.49	2
	192.66	201.64	-8.98	-8
	171.52	171.80	-.28	-1
	194.13	162.43	31.70	10
	$\overline{X}$ = 163.56	$\overline{Y}$ = 158.29	T = 42	

Conclusions Psychomotor Testing:

Bicycle: Accept Ho if 11 < T < 44 at α = .10

T = 49

Reject Ho

Exerciser: Accept Ho if 11 < T < 44 at α = .10

T = 46.5

Reject Ho

Combined: Accept Ho if 61 < T < 149 at α = .10

T = 183.5

Reject Ho

Control: Accept Ho if 11 < T < 4 at α = .10

T = 42

Accept Ho

4. Sign Test

The Sign Test was used to determine differences within a population before and after the exercise program for anxiety, depression and hostility, The test statistic is

$$T = \Sigma +'s \quad \text{where } + = \begin{matrix} 1 & X_i > Y_i \\ 0 & X_i < Y_i \end{matrix}$$

The null hypothesis tested was that the means before and after the exercise programs were the same. Again X is the specified random variable before the exercise program; Y, after. Under the null hypothesis T is binomial (n, 1/2). The null hypothesis is rejected if T is too large or too small. At a level of significance α of ten percent reject the null hypothesis if

$$T \leq W_{\alpha/2} \quad \text{or } T \geq W_{1-\alpha/2}$$

where W is the critical value of T at the specified level of significance α.

	Depression			Anxiety			Hostility		
Group	X_i	Y_i	Sign	X_i	Y_i	Sign	X_i	Y_i	Sign
	12	19	-	7	8	-	11	13	-
	21	5	+	9	2	+	14	6	+
	18	18	0	9	7	+	14	10	+
	7	17	-	0	12	-	6	11	-
Bicycle	6	2	+	0	1	-	10	5	+
	15	14	+	8	6	+	10	8	+
	9	16	-	4	3	+	10	9	+
	13	4	+	15	8	+	9	10	-
	5	14	-	2	2	0	4	11	-
	22	10	+	5	9	-	17	9	+
	$\bar{X}$ = 12.8	$\bar{Y}$ = 11.9	T=5 n=9	$\bar{X}$ = 5.9	$\bar{Y}$ = 5.8	T=5 n=9	$\bar{X}$ = 10.5	$\bar{Y}$ = 9.2	T=6 n=10
	21	15	+	9	8	+	14	8	+
	13	13	0	8	8	0	12	8	+
	15	19	-	6	14	-	7	11	-
	17	11	+	8	10	-	18	7	+
	9	8	+	2	4	-	5	12	-
Exerciser									
	22	21	+	8	9	-	14	13	+
	9	7	+	6	8	-	10	6	+
	19	13	+	10	11	-	14	11	+
	5	9	-	4	4	0	4	7	-
	15	10	+	5	7	-	8	14	-
	$\bar{X}$ = 14.5	$\bar{Y}$ = 12.6	T=7 n=9	$\bar{X}$=6.6	$\bar{Y}$ = 8.3	T=1 n=8	$\bar{X}$ = 10.6	$\bar{Y}$ = 9.7	t=6 n=10
Combined									
	$\bar{X}$ = 13.6	$\bar{Y}$ = 12.2	T=12 n=18	$\bar{X}$ = 6.2	$\bar{Y}$ = 7.1	t=6 n=17	$\bar{X}$ = 10.5	$\bar{Y}$ = 9.5	T=12 n=20

X_i	Y_i	Sign	X_i	Y_i	Sign	X_i	Y_i	Sign
12	14	-	7	7	0	10	12	-
15	11	+	10	5	+	5	3	+
38	34	+	15	8	+	15	10	+
10	8	+	4	5	-	10	9	+
15	8	+	3	4	-	4	7	-
18	14	+	7	8	-	14	15	-
18	14	+	10	7	+	13	10	+
19	19	0	10	10	0	9	15	-
16	13	+	12	9	+	22	17	+
16	16	0	11	13	-	14	17	-
$\bar{X}$=17.7 $\bar{Y}$=15.1			$\bar{X}$=8.9 $\bar{Y}$=7.6			$\bar{X}$=11.6 $\bar{Y}$=11.5		
T=7 n=8			T=4 n=8			T=5 n=10		

n	$W_{\alpha/2}$	$W_{1-\alpha/2}$
8	1	6
9	1	7
10	1	8
17	4	12
18	5	12
20	5	14

Conclusions for psychological testing:

Bicycle: Accept all null hypothes

Exercise: Accept null hypotheses for hostility. Reject for depression and anxiety. Depression has significantly decreased and anxiety has significantly increased.

Combined: Accept null hypothesis for anxiety and hostility. Reject for depression which has significantly decreased.

Control: Accept null hypotheses for anxiety and hostility. Reject for depression which has significantly decreased.

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