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Comparison of the Exercises Performed on the Super Mini-Gym in Skylab II with Similar Exercises on the Universal Gym and Calisthenics

Harding College, Searcy, Arkansas
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PROGRESS REPORT

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This report covers Experiment I of two experiments to be conducted during a 12-month period beginning January 1, 1974. In Experiment I three groups trained twenty minutes a day, three days a week for ten weeks. One group trained on the Super Mini-Gym, a second group trained on the Universal Gym, and a third performed calisthenics. Cardiopulmonary gains were negligible but all training groups exhibited good gains in strength.

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Experiment I: Comparison of the Exercises Performed on the Super Mini-Gym in Skylab II with Similar Exercises on the Universal Gym and Calisthenics

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I. Introduction

A number of physiological changes, which are in general referred to as deconditioning, result from living in the environment of space. Two possible ways to minimize the effects of deconditioning in space are to achieve a very high level of conditioning immediately prior to flight and provide a regimen in the capsule which will conserve pre-flight physical fitness and maintain a moderate degree of fitness. This laboratory has been investigating methods and equipment to determine how these two goals might be efficiently attained.

It was determined in this laboratory that running and riding a bicycle ergometer at comparable heart rates produced similar gains in physical fitness variables. It was found that subjects who exercised at a 180 heart rate made greater gains in physical fitness than did those exercising at a 140 or 160 heart rate. When the length of the workout was varied, subjects exercising sixty minutes per day made greater gains than those exercising twenty or forty minutes per day. Greater gains on specified components of physical fitness also resulted in subjects who exercised twelve times per week when compared to those who exercised three or six times a week. Subjects who discontinued training slowly deconditioned, but a moderate level of fitness could be maintained by exercising at a pulse rate of 160 beats per minute for twenty-minute periods three times a week. Subjects who "overtrained" twice daily to near exhaustion increased in fitness.

Exercise programs involving two pieces of equipment, the Exer-Genie Exerciser and the Collins Pedal Mode Ergometer, have been investigated. It was found that neither six- nor twelve-minute training periods each day involving isometric and isotonic exercises with an Exer-Genie resulted in significant increases in selected physical fitness variables. Training in a supine position on the Exer-Genie at a 160 pulse rate for twenty minutes per day showed no significant change in fitness. Three training programs involving the Collins Ergometer have been examined. One group of subjects exercised for twelve minutes per day with the heart rate programmed to increase during the training period. Another group exercised for ten minutes a day at 85% of their maximum heart rate while a third group exercised at a 160 heart rate for ten minutes a day. Each of these groups showed moderate increases in fitness.

Moderate gains in physical fitness were produced in three exercise groups of men 30-45 years old who were initially in poor to fair condition. One group exercised for ten minutes a day, three times a week on a bicycle ergometer at 85% maximum pulse rate. Another group exercised for ten minutes a day, five times a week on a bicycle ergometer at 85% maximum pulse rate. The third group exercised for ten minutes a day, three times a week on the bicycle ergometer at 85% maximum pulse rate and two times a week on an Exer-Genie circuit. These three exercise groups made comparable gains in fitness.

A combination of exercises has been investigated. One group of subjects exercised for twenty minutes a day, three days a week, on a foot-mode ergometer at 85% maximum pulse rate and twenty minutes a day, two days a week, on a hand-mode ergometer at 70% maximum pulse rate. A second group had the same schedule but worked on the hand-mode ergometer at 85% maximum pulse rate. The third group exercised for twenty minutes a day, three days a week, on a foot-mode ergometer at 85% maximum pulse rate and two days a week on a seven-station Exer-Genie circuit. These groups made moderate gains in strength and cardiopulmonary fitness.

Another combination included endurance and strength training in the same workout. The three exercise groups worked fifteen minutes a day, three days a week on a foot-mode ergometer at 85% of their maximum heart rate. Each group immediately followed this with an additional fifteen minutes of exercise. One group completed two circuits on a seven-station Exer-Genie circuit at each exercise session. One group exercised on a hand-mode ergometer. The third group completed two circuits on a seven-station Super Mini-Gym circuit during each exercise session. All groups made moderate cardiopulmonary gains but only the Exer-Genie and the Mini-Gym were effective in increasing strength.

An experiment was performed to compare exercise on equipment designed solely to produce strength, exercise of the lower torso only to produce cardiopulmonary fitness and exercise of the upper torso only so as to produce cardiopulmonary fitness. One group worked thirty minutes a day, three days a week, on a Universal Gym. Another group worked thirty minutes a day, three days a week, on a foot-mode ergometer at 85% of their maximum pulse rate. A third group worked thirty minutes a day, three days a week, on a hand-mode ergometer at 85% of their maximum pulse rate. The group exercising on the Universal Gym gained in arm and shoulder girdle strength. The subjects exercising on the foot-mode ergometer gained in leg strength and all groups made moderate gains in cardiorespiratory fitness.

The effect of stress on highly trained subjects has been investigated by confining one group in bed for five days and depriving a second group of sleep for 50 hours. The pre-stress training, which lasted 12 weeks, consisted of a three-mile run three days a week and working on a Universal Gym for thirty minutes a day, twice a week. Good increases in strength and cardiopulmonary fitness were obtained. Both stresses caused negligible decreases in strength variables but drastic decreases in cardiopulmonary fitness. Two weeks post-stress the subjects had recovered about half of the conditioning they lost.

II. Purpose

The purposes of this experiment were to examine training programs necessary for development of optimal strength suitable for prolonged space flight and to compare the exercise performed on the Super Mini-Gym in Skylab II with similar exercises on the Universal Gym and calisthenics.

III. Methods

The subjects in this experiment were twenty college-age male volunteers whose physical work capacity was above average. Base lines were determined on specified variables by administering the following: (a) a medical examination, (b) anthropometric measurements, (c) the Physical Fitness

Index Test, (d) three selected strength measurements, and (e) a bicycle ergometer test.

The medical examination included a six-lead EKG, a vital capacity test (1), and serum and urine analysis. The following anthropometric measurements were taken: neck, chest, bicep, forearm, waist, thigh, and calf. A Physical Fitness Index (PFI) (2) was obtained for each subject based on his: age, height, weight, vital capacity, grip strength, back strength, leg strength, and arm strength. In addition to the PFI, a Strength Quotient was determined by the procedure of Clarke (3). The Strength Quotient is derived from cable-tension tests of shoulder extension, knee extension and ankle plantar flexion.

Each subject was given a bicycle test consisting of a five-minute rest period followed by five minutes of work at each of three work levels, 25, 50, and 75% of maximal load. Pulse rate and blood pressure, diastolic and systolic, were taken manually each minute during the resting, recovery, and working phases. Pulmonary ventilation was measured and expired gas samples were collected during the fourth and fifth minutes of the resting, recovery, and exercise phases of the test. Using a single-breath procedure developed by Kim, et al. (4) and modified by Buderer, et al. (5) at the Johnson Spacecraft Center Environmental Physiology Laboratory, measurements were made during the fourth minute of the resting, recovery, and exercise phases, with a Medspect Medical Mass Spectrometer and an X-Y plotter, from which cardiac output was estimated. Stroke volume was determined by dividing cardiac output by the pulse rate of the subject.

By using a table of random numbers the twenty subjects were divided into four groups of five each. Three groups were trained and the fourth served as a control, engaging in their normal daily activities without any specified training program. Group A trained on the Super Mini-Gym, Group B on the Universal Gym, and Group C performed calisthenics.

The training program lasted ten weeks and was modeled as closely as possible after the five exercises performed on the Super Mini-Gym by the Skylab II crew during flight. One exercise consisted of a leg press which is the first half of the "basic conditioner" (6). Another exercise combined a curl and military press, the second half of the "basic conditioner" (6). The remaining exercises were (a) stiff arm pull, (b) overhead pull, and (c) side bend (6). These exercises strengthen the major muscle groups of both the legs and trunk as well as the arms and shoulder girdle. The exercises for the experimental groups were chosen to correspond.

The exercise protocol of the three training groups is summarized in Table I. It was difficult to find calisthenics that exactly correspond to the exercises performed on the two Gyms. The advantage of calisthenics is that no equipment is needed and the exercises can be performed nearly anywhere. The Universal Gym and calisthenics would be effective only for pre-flight conditioning since they would be useless under conditions of zero gravity.

The training groups exercised for a twenty-minute period three times a week. During each exercise minute ten repetitions at maximum contraction were performed at a specific exercise station. This required approximately 30 seconds. During the remainder of the minute the subject rested. The total number of repetitions performed at a specific station during an exercise period can be determined from Table I by multiplying the number

TABLE I

THE TYPE AND NUMBER OF EXERCISES PERFORMED BY THE TRAINING GROUPS

GROUPS	A Mini-Gym			B Universal Gym			C Calisthenics		
	Exercise Station	Repetitions Per Set	Sets Per Day	Exercise Station	Repetitions Per Set	Sets Per Day	Exercise Station	Repetitions Per Set	Sets Per Day
Training	Leg Press	10	5	Leg Press	10	5	Squat Jumps	30 sec/min	5 min
	Curls[a]	10	5	Curls[a]	10	5	Squat Thrusts	30 sec/min	5 min
	Military Press	10	5	Military Press	10	5	Pullups	30 sec/min	5 min
	Stiff Arm Pull[b]	10	2	Stiff Arm Pull[b]	10	2	Dips	30 sec/min	2 min
	Triceps Pull	10	3	Triceps Pull	10	3	Pushups	30 sec/min	3 min

[a]Five of the ten were reverse curls.

[b]Of the ten five were performed with each arm.

of repetitions per set by the number of sets per day. Since the calisthenics group was not doing maximum contractions their exercise protocol was based on time rather than number of repetitions. They performed as many repetitions as possible during 30 seconds of each exercise minute. This corresponds to the time spent in exercise by the other training groups.

After five weeks of training, the bicycle ergometer test was administered. At the end of the training period, the effectiveness of the training programs was evaluated by administering the following tests to each subject: (a) anthropometric measurements, (b) the Physical Fitness Index Test, (c) three selected strength measurements, and (d) the bicycle ergometer test.

The data were analyzed by analysis of variance and Duncan's Multiple Range tests on selected contrasts where indicated. The following model was used for the analysis of variance: $Y_{ijkl} = U + A_i + B_{j(i)} + E_{l(ijk)}$, where A represents the groups and is considered fixed, B represents the subjects and is considered random, and C represents the tests and is considered fixed.

In the Anova Table the number of observations (N) is sixty for the bicycle ergometer test variables and forty for all other variables. The number of groups (n) is four, the number of subjects per group (p) is five and the number of tests (q) is three for the bicycle ergometer test variables and two for all other variables.

TABLE II

ANOVA TABLE

Source	Df	E(ms)	F
Total	N-1		
(A) Groups	n-1	(1) $\sigma_E^2 + q\ \sigma_{B(A)}^2 + pq\ \sigma_A^2$	1/2
B(A) Subjects in Groups	n(p-1)	(2) $\sigma_E^2 + q\ \sigma_{B(A)}^2$	
C Tests	(q-1)	(3) $\sigma_E^2 + \sigma_{[B(A)C]}^2 + np\ \sigma_C^2$	3/5
AC Groups, Tests Interaction	(n-1)(q-1)	(4) $\sigma_E^2 + \sigma_{[B(A)]C}^2\ P\ \sigma_{AC}^2$	4/5
[B(A)] C Subjects in Groups, Tests Interaction	n(p-1)(q-1)	(5) $\sigma_E^2 + \sigma_{[B(A)]\ C}^2$	

IV. Results

The average age, height, and weight for each group prior to the beginning of the training are given in Table III.

TABLE III

MEAN AGE, HEIGHT, AND WEIGHT OF SUBJECTS

GROUP	AGE (yr)	HEIGHT (cm)	WEIGHT (kg)
A - Mini-Gym	21.8	174.6	77.5
B - Universal Gym	21.8	173.8	68.5
C - Calisthenics	22.8	182.8	76.3
D - Control	23.0	177.6	73.6
ALL	22.3	177.2	74.0

The significant changes that were found for all variables that were measured pre- and post-training are listed in Table IV. The significance level is indicated (p = 0.1, 0.05, 0.01 or 0.001). A significant decrease is indicated by a minus sign in front of the significance level and a significant increase is indicated by the lack of a sign.

Table IV shows that the groups exercising on the Mini-Gym (Group A) and the Universal Gym (Group B) gained significantly in a number of anthropometric measurements. In past experiments we have failed to see a consistent pattern of change in anthropometric measurements with exercise. Possibly the explanation is that past experiments have involved submaximal rather than maximal strength-building exercises. Note that the calisthenics group (Group C) doing submaximal exercises had only one significant anthropometric increase.

It is apparent from Table IV that all training groups increased in strength. Group A had nine significant increases in strength measurements, Group B had eleven significant increases, Group C had nine, while the control group (D) had two increases and one decrease. The increases for Group A exhibit a lower level of significance than those for Groups B and C, however Group A had higher pre- and post-training values on nine of the thirteen strength variables than did Group B.

Group C, those training with calisthenics, had higher post-training values on ten of the thirteen strength variables than did either of the other two training groups. This seems to indicate that calisthenics is the best of the three training regimens for developing strength. However, strength development is rather specific and the fact that the calisthenics included pullups and dips, two of the test items in the Physical Fitness Index Test, may partially explain the superior improvement of Group C. Notice that Group C had no significant increase in leg strength.

TABLE IV

SIGNIFICANCE LEVELS OF CHANGES IN VARIABLES
MEASURED PRE- AND POST-TRAINING

VARIABLE	GROUP			
	A Mini-Gym	B Universal Gym	C Calisthenics	D Control
ANTHROPOMETRIC MEASUREMENTS				
Neck				
Chest		0.1	0.01	
Left Bicep	0.01	0.001		
Right Bicep				
Left Forearm	0.1	0.1		
Right Forearm	0.05			
Waist				
Left Thigh				
Right Thigh	0.05	0.1		
Left Calf				
Right Calf	0.05			
STRENGTH MEASUREMENTS				
Pullups	0.01	0.001	0.001	
Dips	0.05	0.001	0.001	
Arm Strength	0.01	0.001	0.001	
Left Hand Grip	0.05	0.01	0.05	
Right Hand Grip		0.01	0.01	
Leg Strength	0.05	0.01		
Back Strength		0.05	0.1	-0.05
Strength Index	0.01	0.01	0.001	

TABLE IV....SIGNIFICANCE LEVELS OF CHANGES IN VARIABLES MEASURED PRE- AND POST-TRAINING....CONTINUED

VARIABLE	GROUP			
	A Mini-Gym	B Universal Gym	C Calisthenics	D Control
Physical Fitness Index	0.05	0.001	0.001	0.05
Shoulder Extension	0.05	0.001	0.001	
Knee Extension				
Ankle Plantar Flexion	0.05	0.05		0.01
Strength Quotient				
<u>PHYSIOLOGICAL VARIABLES</u>				
Weight				
Vital Capacity				0.01
<u>BICYCLE TEST VARIABLES</u>				
Systolic Blood Pressure at Rest				
Systolic Blood Pressure at 25% Load	-0.1			
Systolic Blood Pressure at 50% Load		-0.05		
Systolic Blood Pressure at 75% Load				
Systolic Blood Pressure at Recovery			-0.1	
Diastolic Blood Pressure at Rest				
Diastolic Blood Pressure at 25% Load				
Diastolic Blood Pressure at 50% Load				
Diastolic Blood Pressure at 75% Load	-0.05			

TABLE IV....SIGNIFICANCE LEVELS OF CHANGES IN VARIABLES MEASURED PRE- AND POST-TRAINING....CONTINUED

VARIABLE	GROUP			
	A Mini-Gym	B Universal Gym	C Calisthenics	D Control
Diastolic Blood Pressure at Recovery				
Pulse Rate at Rest	-0.01			
Pulse Rate at 25% Load	-0.05			
Pulse Rate at 50% Load	-0.001			
Pulse Rate at 75% Load	-0.05			
Pulse Rate at Recovery	-0.05			
$\dot{V}_E$ BTPS at Rest				
$\dot{V}_E$ BTPS at 25% Load				
$\dot{V}_E$ BTPS at 50% Load				
$\dot{V}_E$ BTPS at 75% Load	0.05			
$\dot{V}_E$ BTPS at Recovery				
$\dot{V}_E$ STPD at Rest				
$\dot{V}_E$ STPD at 25% Load				
$\dot{V}_E$ STPD at 50% Load				0.1
$\dot{V}_E$ STPD at 75% Load	0.05			
$\dot{V}_E$ STPD at Recovery				
Respiratory Rate at Rest				
Respiratory Rate at 25% Load				
Respiratory Rate at 50% Load				
Respiratory Rate at 75% Load	0.05			
Respiratory Rate at Recovery				
Tidal Volume at Rest			0.05	

TABLE IV....SIGNIFICANCE LEVELS OF CHANGES IN VARIABLES MEASURED PRE- AND POST-TRAINING....CONTINUED

VARIABLE	GROUP			
	A Mini-Gym	B Universal Gym	C Calisthenics	D Control
Tidal Volume at 25% Load				0.1
Tidal Volume at 50% Load				
Tidal Volume at 75% Load				
Tidal Volume at Recovery				
$\dot{V}_{CO_2}$ at Rest				
$\dot{V}_{CO_2}$ at 25% Load				
$\dot{V}_{CO_2}$ at 50% Load				
$\dot{V}_{CO_2}$ at 75% Load				
$\dot{V}_{CO_2}$ at Recovery				0.1
$\dot{V}_{O_2}$ at Rest				
$\dot{V}_{O_2}$ at 25% Load				0.1
$\dot{V}_{O_2}$ at 50% Load				0.1
$\dot{V}_{O_2}$ at 75% Load				
$\dot{V}_{O_2}$ at Recovery	0.05			0.05
$\dot{V}_{O_2}$/pulse at Rest	0.05			
$\dot{V}_{O_2}$/pulse at 25% Load	0.1			
$\dot{V}_{O_2}$/pulse at 50% Load	0.001			
$\dot{V}_{O_2}$/pulse at 75% Load	0.05			0.05
$\dot{V}_{O_2}$/pulse at Recovery	0.01			0.01
$\dot{V}_{O_2}$/kgbw·min at Rest				
$\dot{V}_{O_2}$/kgbw·min at 25% Load				0.1
$\dot{V}_{O_2}$/kgbw·min at 50% Load				0.1

TABLE IV....SIGNIFICANCE LEVELS OF CHANGES IN VARIABLES MEASURED PRE- AND POST-TRAINING....CONTINUED

VARIABLE	GROUP			
	A	B	C	D
	Mini-Gym	Universal Gym	Calisthenics	Control
$\dot{V}_{O_2}$/kgbw·min at 75% Load				
$\dot{V}_{O_2}$/kgbw·min at Recovery	0.1			0.05
$\dot{V}_E/\dot{V}_{O_2}$ at Rest				
$\dot{V}_E/\dot{V}_{O_2}$ at 25% Load				
$\dot{V}_E/\dot{V}_{O_2}$ at 50% Load				
$\dot{V}_E/\dot{V}_{O_2}$ at 75% Load	0.1			
$\dot{V}_E/\dot{V}_{O_2}$ at Recovery			-0.1	-0.01
Cardiac Output at Rest				
Cardiac Output at 25% Load				0.05
Cardiac Output at 50% Load	0.05		0.05	
Cardiac Output at 75% Load		-0.05		
Cardiac Output at Recovery				
Stroke Volume at Rest	0.1			
Stroke Volume at 25% Load				0.05
Stroke Volume at 50% Load	0.001		0.01	
Stroke Volume at 75% Load		-0.05		
Stroke Volume at Recovery				
Respiratory Exchange Ratio at Rest	-0.1			
Respiratory Exchange Ratio at 25% Load	-0.1			
Respiratory Exchange Ratio at 50% Load	-0.05		0.1	

TABLE IV....SIGNIFICANCE LEVELS OF CHANGES IN VARIABLES MEASURED PRE- AND POST-TRAINING....CONTINUED

VARIABLE	GROUP			
	A Mini-Gym	B Universal Gym	C Calisthenics	D Control
Respiratory Exchange Ratio at 75% Load				
Respiratory Exchange Ratio at Recovery	-0.05			-0.05

Most bicycle ergometer tests are designed to measure cardiopulmonary fitness, but the test used in this study was not primarily for this purpose. Prior to the pre-training test period the maximal work load was determined for each subject. The bicycle test consisted of each subject working for five minutes at each of three work levels, 25, 50, and 75% of his maximal load. These same work levels were also used for the mid- and post-training bicycle tests. Cardiopulmonary measurements were made at rest, during each of the three work levels, and during recovery.

Since all cardiopulmonary measurements were made at the same levels of submaximal work at all three bicycle ergometer test periods, no significant changes were anticipated in most of the variables. In fact, the only variables in which a significant change would necessarily indicate an increase in cardiopulmonary fitness would be in pulse rate at the various levels of work or a calculated value involving the pulse rate, such as $\dot{V}_{O_2}$/pulse or stroke volume. Table IV shows that Group A, subjects training on the Mini-Gym, had significant decreases in pulse rate and significant increases in $\dot{V}_{O_2}$/pulse at all levels of work. These are the only consistent changes indicating an improvement of cardiopulmonary fitness among the training groups.

The primary purpose of the bicycle ergometer test as given was to estimate cardiac outputs at various work loads. Our previous experience in estimating a large number of cardiac outputs using the method of Buderer, et al. (5) caused us to suspect the reliability of the method. As Table IV indicates, significant changes in cardiac output at a constant work load were obtained but there was no apparent pattern. Since a constant energy expenditure is necessitated by a constant work load, a constant cardiac output would be predicted regardless of the subject's fitness.

In order to better determine the reliability of this method for estimating cardiac output, reliability coefficients have been calculated for all subjects at all work loads, comparing the bicycle test periods by pairs (Table V). Notice that the coefficients range from 0.061 to 0.767 (Table V). A perfect correlation would be 1.000. From this table, it appears that estimations of cardiac output are more reliable at rest and 75% work load than at moderate work. Further investigation will be necessary before firm conclusions can be made concerning the reliability of this method.

Table VI contains the mean pre- and post-training values of all the variables that were measured.

TABLE V

CARDIAC OUTPUT RELIABILITY COEFFICIENTS FOR ALL SUBJECTS AT ALL WORK LOADS COMPARING BICYCLE TEST PERIODS BY PAIRS

Work Load \ Test Periods	Test One-Test Two	Test One-Test Three	Test Two-Test Three
Rest	0.622	0.765	0.546
25% Work Load	0.572	0.699	0.243
50% Work Load	0.061	0.555	0.132
75% Work Load	0.767	0.624	0.740
Recovery	0.378	0.378	0.497

V. Conclusions

1. There were good increases in strength variables for all subjects due to the training programs of this experiment.

2. There were concommitant increases in anthropometric measurements in those subjects performing maximal or near-maximal contractions.

3. Subjects working on the Super Mini-Gym increased very slightly in cardiopulmonary fitness. No cardiopulmonary changes were observed in the subjects working on the Universal Gym or doing calisthenics.

4. The method being used to estimate cardiac outputs probably has low reliability.

TABLE VI

MEAN PRE- AND POST-TRAINING VALUES OF THE MEASURED VARIABLES BY GROUPS

VARIABLE		GROUP			
		A Mini-Gym	B Universal Gym	C Calis-thenics	D Control
ANTHROPOMETRIC MEASUREMENTS					
Neck (cm)	Pre	37.86	35.56	36.40	37.10
	Post	37.84	35.92	36.26	36.74
	Difference	-0.02	0.36	-0.14	-0.36
Chest (cm)	Pre	98.40	93.16	96.78	97.38
	Post	99.00	94.66	99.78	97.70
	Difference	0.60	1.50	3.00	0.32
Left Bicep (cm)	Pre	32.66	30.42	31.94	32.28
	Post	33.84	31.82	32.36	31.88
	Difference	1.18	1.40	0.42	-0.40
Right Bicep (cm)	Pre	33.74	31.32	33.14	33.16
	Post	34.48	31.98	33.26	32.78
	Difference	0.74	0.66	0.12	-0.38
Left Forearm (cm)	Pre	26.98	25.92	26.46	26.92
	Post	27.46	26.36	26.66	26.74
	Difference	0.48	0.44	0.20	-0.18
Right Forearm (cm)	Pre	28.02	26.92	27.30	27.22
	Post	28.44	27.16	27.30	27.22
	Difference	0.42	0.24	0.00	0.00
Waist (cm)	Pre	83.18	75.86	82.48	79.66
	Post	83.06	76.06	82.62	80.14
	Difference	-0.12	0.20	0.14	0.48
Left Thigh (cm)	Pre	54.80	51.56	53.78	54.26
	Post	55.70	52.54	53.82	53.72
	Difference	0.90	0.98	0.04	-0.54

TABLE VI....MEAN PRE- AND POST-TRAINING VALUES OF THE MEASURED VARIABLES BY GROUPS....Continued

VARIABLE		GROUP A Mini-Gym	GROUP B Universal Gym	GROUP C Calis-thenics	GROUP D Control
Right Thigh (cm)	Pre	55.54	51.76	53.76	53.92
	Post	56.96	52.78	53.96	54.02
	Difference	1.42	1.02	0.20	0.10
Left Calf (cm)	Pre	37.04	35.84	36.70	37.04
	Post	37.30	36.00	36.50	37.34
	Difference	0.26	0.16	-0.20	0.30
Right Calf (cm)	Pre	37.38	35.70	36.86	37.14
	Post	37.90	35.96	36.80	37.32
	Difference	0.52	0.26	-0.06	0.18
STRENGTH MEASUREMENTS					
Pullups	Pre	6.2	5.4	6.0	6.4
	Post	7.8	7.6	10.6	6.4
	Difference	1.6	2.2	4.6	0.0
Dips	Pre	11.0	9.0	9.2	10.0
	Post	14.2	14.4	16.4	11.0
	Difference	3.2	5.4	7.2	1.0
Arm Strength	Pre	423.8	346.6	426.0	429.8
	Post	554.2	526.4	738.6	433.0
	Difference	130.4	179.8	312.6	3.2
Left Hand Grip (lbs)	Pre	97.0	80.0	102.2	104.6
	Post	112.8	103.6	117.4	113.0
	Difference	15.8	23.6	15.2	8.4
Right Hand Grip (lbs)	Pre	114.8	91.2	110.2	120.0
	Post	126.0	123.2	135.8	128.4
	Difference	11.2	32.0	25.6	8.4
Leg Lift (lbs)	Pre	880	888	890	1012
	Post	1093	1062	998	1188
	Difference	213	174	108	176

TABLE VI....MEAN PRE- AND POST-TRAINING VALUES OF THE MEASURED VARIABLES BY GROUPS....Continued

VARIABLE		GROUP			
		A	B	C	D
		Mini-Gym	Universal Gym	Calis-thenics	Control
Back Lift (lbs)	Pre	387	314	360	378
	Post	368	350	386	350
	Difference	-19	36	26	-28
Strength Index	Pre	2214	2022	2203	2335
	Post	2565	2466	2708	2516
	Difference	351	444	505	181
Physical Fitness Index	Pre	73	74	74	81
	Post	86	92	95	91
	Difference	13	18	21	10
Shoulder Extension (lbs)	Pre	142	125	137	123
	Post	152	144	154	122
	Difference	10	19	17	-1
Knee Extension (lbs)	Pre	289	299	287	263
	Post	289	313	283	253
	Difference	0	14	-4	-10
Ankle Plantar Flexion (lbs)	Pre	333	298	384	314
	Post	353	319	393	339
	Difference	20	21	9	25
Strength Quotient	Pre	1.006	1.204	1.080	1.120
	Post	1.146	1.274	1.120	1.036
	Difference	0.140	0.070	0.040	-0.084
<u>PHYSIOLOGICAL VARIABLES</u>					
Weight (kg)	Pre	77.46	68.50	76.30	73.64
	Post	78.22	68.74	76.48	73.82
	Difference	0.76	0.24	0.18	0.18
Vital Capacity (l)	Pre	5.10	4.94	5.16	4.76
	Post	5.10	4.94	5.14	4.98
	Difference	0.00	0.00	-0.02	0.22

TABLE VI....MEAN PRE- AND POST-TRAINING VALUES OF THE MEASURED VARIABLES BY GROUPS....Continued

VARIABLE		GROUP A Mini-Gym	GROUP B Universal Gym	GROUP C Calis-thenics	GROUP D Control
BICYCLE TEST VARIABLES					
Systolic Blood Pressure at Rest (mm Hg)	Pre	124	120	131	120
	Post	121	121	125	117
	Difference	-3	1	-6	-3
Systolic Blood Pressure at 25% Load (mm Hg)	Pre	158	142	154	138
	Post	145	138	147	138
	Difference	-13	-4	-7	0
Systolic Blood Pressure at 50% Load (mm Hg)	Pre	165	157	169	155
	Post	157	146	166	149
	Difference	-8	-11	-3	-6
Systolic Blood Pressure at 75% Load (mm Hg)	Pre	183	173	194	173
	Post	179	173	184	167
	Difference	-4	0	-10	-6
Systolic Blood Pressure at Recovery (mm Hg)	Pre	126	131	138	126
	Post	125	126	128	129
	Difference	-1	-5	-10	3
Diastolic Blood Pressure at Rest (mm Hg)	Pre	79	73	73	77
	Post	79	78	73	76
	Difference	0	5	0	-1
Diastolic Blood Pressure at 25% Load (mm Hg)	Pre	73	68	72	72
	Post	72	66	68	71
	Difference	-1	-2	-4	-1
Diastolic Blood Pressure at 50% Load (mm Hg)	Pre	70	64	68	69
	Post	66	63	67	68
	Difference	-4	-1	-1	-1
Diastolic Blood Pressure at 75% Load (mm Hg)	Pre	65	62	64	66
	Post	61	60	63	65
	Difference	-4	-2	-1	-1

TABLE VI....MEAN PRE- AND POST-TRAINING VALUES OF THE MEASURED VARIABLES BY GROUPS....Continued

VARIABLE		GROUP			
		A Mini-Gym	B Universal Gym	C Calis-thenics	D Control
Diastolic Blood Pressure at Recovery (mm Hg)	Pre	80	78	76	84
	Post	80	77	76	79
	Difference	0	-1	0	-5
Pulse Rate at Rest (beats/min)	Pre	91.2	79.2	77.6	75.2
	Post	71.2	76.0	80.0	76.0
	Difference	-20.0	-3.2	2.4	0.8
Pulse Rate at 25% Load (beats/min)	Pre	117.6	105.6	108.0	102.4
	Post	103.2	106.4	103.2	104.8
	Difference	-14.4	0.8	-4.8	2.4
Pulse Rate at 50% Load (beats/min)	Pre	140.0	128.0	127.2	120.8
	Post	120.0	125.6	128.0	122.4
	Difference	-20.0	-2.4	0.8	1.6
Pulse Rate at 75% Load (beats/min)	Pre	164.0	153.6	156.8	153.6
	Post	152.8	156.8	153.6	146.4
	Difference	-11.2	3.2	-3.2	-7.2
Pulse Rate at Recovery (beats/min)	Pre	108.8	89.6	92.0	100.0
	Post	92.0	87.2	96.0	96.8
	Difference	-16.8	-2.4	4.0	-3.2
$\dot{V}_E$ BTPS at Rest (1)	Pre	11.4	10.2	16.4	11.6
	Post	14.2	9.6	17.4	10.8
	Difference	2.8	-0.6	1.0	-0.8
$\dot{V}_E$ BTPS at 25% Load (1)	Pre	30.6	25.4	30.2	25.4
	Post	31.2	27.2	29.0	28.6
	Difference	0.6	1.8	-1.2	3.2
$\dot{V}_E$ BTPS at 50% Load (1)	Pre	40.6	34.8	38.2	35.2
	Post	43.4	37.8	40.0	38.0
	Difference	2.8	3.0	1.8	2.8

TABLE VI....MEAN PRE- AND POST-TRAINING VALUES OF THE MEASURED VARIABLES BY GROUPS....Continued

VARIABLE		GROUP A Mini-Gym	B Universal Gym	C Calis-thenics	D Control
$\dot{V}_E$ BTPS at 75% Load (1)	Pre	57.2	54.4	54.8	50.0
	Post	64.8	54.8	57.4	52.0
	Difference	7.6	0.4	2.6	2.0
$\dot{V}_E$ BTPS at Recovery (1)	Pre	14.8	14.0	17.4	14.6
	Post	15.8	13.0	15.8	16.0
	Difference	1.0	-1.0	-1.6	1.4
$\dot{V}_E$ STPD at Rest (1)	Pre	9.4	8.6	13.6	9.4
	Post	11.6	8.6	14.4	8.8
	Difference	2.2	0.0	0.8	-0.6
$\dot{V}_E$ STPD at 25% Load (1)	Pre	25.6	21.0	24.8	21.2
	Post	26.0	22.8	24.2	23.8
	Difference	0.4	1.8	-0.6	2.6
$\dot{V}_E$ STPD at 50% Load (1)	Pre	33.4	28.8	31.4	29.0
	Post	36.0	31.6	33.0	32.0
	Difference	2.6	2.8	1.6	3.0
$\dot{V}_E$ STPD at 75% Load (1)	Pre	47.2	44.6	45.4	41.4
	Post	54.0	45.6	47.8	44.6
	Difference	6.8	1.0	2.4	3.2
$\dot{V}_E$ STPD at Recovery (1)	Pre	12.2	11.6	14.6	12.2
	Post	13.0	10.8	13.0	13.2
	Difference	0.8	-0.8	-1.6	1.0
Respiratory Rate at Rest (breaths/min)	Pre	12.8	13.2	14.8	13.4
	Post	15.2	12.4	14.4	13.6
	Difference	2.4	-0.8	-0.4	0.2
Respiratory Rate at 25% Load (breaths/min)	Pre	19.6	17.0	17.2	20.4
	Post	20.8	19.2	17.2	20.8
	Difference	1.2	2.2	0.0	0.4

TABLE VI....MEAN PRE- AND POST-TRAINING VALUES OF THE MEASURED VARIABLES BY GROUPS....Continued

VARIABLE		GROUP A Mini-Gym	GROUP B Universal Gym	GROUP C Calis-thenics	GROUP D Control
Respiratory Rate at 50% Load (breaths/min)	Pre	21.6	19.2	19.2	20.4
	Post	23.6	21.2	20.4	22.4
	Difference	2.0	2.0	1.2	2.0
Respiratory Rate at 75% Load (breaths/min)	Pre	25.2	23.6	24.4	23.6
	Post	30.4	24.8	27.2	26.0
	Difference	5.2	1.2	2.8	2.4
Respiratory Rate at Recovery (breaths/min)	Pre	12.8	15.6	15.0	16.8
	Post	14.0	13.2	15.4	16.0
	Difference	1.2	-2.4	0.4	-0.8
Tidal Volume at Rest (l)	Pre	0.88	0.78	1.10	0.84
	Post	0.96	0.82	1.30	0.84
	Difference	0.08	0.04	0.20	0.00
Tidal Volume at 25% Load (l)	Pre	1.58	1.52	1.78	1.50
	Post	1.56	1.44	1.74	1.84
	Difference	-0.02	-0.08	-0.04	0.34
Tidal Volume at 50% Load (l)	Pre	1.92	1.82	2.08	1.88
	Post	2.00	1.78	2.00	2.10
	Difference	0.08	-0.04	-0.08	0.22
Tidal Volume at 75% Load (l)	Pre	2.34	2.30	2.32	2.36
	Post	2.20	2.24	2.12	2.16
	Difference	-0.14	-0.06	-0.20	-0.20
Tidal Volume at Recovery (l)	Pre	1.26	0.88	1.22	0.90
	Post	1.22	1.04	1.12	1.22
	Difference	-0.04	0.16	-0.10	0.32
$\dot{V}_{CO_2}$ at Rest (l)	Pre	0.276	0.230	0.370	0.222
	Post	0.326	0.229	0.414	0.218
	Difference	0.050	-0.001	0.044	-0.004

TABLE VI....MEAN PRE- AND POST-TRAINING VALUES OF THE MEASURED VARIABLES BY GROUPS....Continued

VARIABLE		GROUP			
		A	B	C	D
		Mini-Gym	Universal Gym	Calis-thenics	Control
$\dot{V}_{CO_2}$ at 25% Load (1)	Pre	0.934	0.838	0.950	0.762
	Post	0.970	0.846	0.953	0.869
	Difference	0.036	0.008	0.003	0.107
$\dot{V}_{CO_2}$ at 50% Load (1)	Pre	1.400	1.254	1.338	1.178
	Post	1.413	1.317	1.393	1.266
	Difference	0.013	0.063	0.055	0.088
$\dot{V}_{CO_2}$ at 75% Load (1)	Pre	2.036	2.008	1.960	1.772
	Post	2.057	1.992	2.057	1.880
	Difference	0.021	-0.016	0.097	0.108
$\dot{V}_{CO_2}$ at Recovery (1)	Pre	0.368	0.358	0.408	0.316
	Post	0.411	0.330	0.414	0.401
	Difference	0.043	-0.028	0.006	0.085
$\dot{V}_{O_2}$ at Rest (1)	Pre	0.254	0.256	0.388	0.218
	Post	0.333	0.254	0.409	0.226
	Difference	0.079	-0.002	0.021	0.008
$\dot{V}_{O_2}$ at 25% Load (1)	Pre	1.040	0.990	1.040	0.840
	Post	1.076	1.025	1.042	0.951
	Difference	0.036	0.035	0.002	0.111
$\dot{V}_{O_2}$ at 50% Load (1)	Pre	1.440	1.382	1.454	1.234
	Post	1.512	1.418	1.462	1.354
	Difference	0.072	0.036	0.008	0.120
$\dot{V}_{O_2}$ at 75% Load (1)	Pre	2.016	2.120	2.008	1.752
	Post	2.098	2.035	2.107	1.853
	Difference	0.082	-0.085	0.099	0.101
$\dot{V}_{O_2}$ at Recovery (1)	Pre	0.332	0.350	0.376	0.302
	Post	0.418	0.335	0.413	0.408
	Difference	0.086	-0.015	0.037	0.106

TABLE VI....MEAN PRE- AND POST-TRAINING VALUES OF THE MEASURED VARIABLES BY GROUPS....Continued

VARIABLE		GROUP			
		A Mini-Gym	B Universal Gym	C Calis-thenics	D Control
$\dot{V}_{O_2}$/Pulse at Rest (ml)	Pre	2.84	3.70	5.00	3.12
	Post	4.82	3.42	5.10	2.96
	Difference	1.98	-0.28	0.10	-0.16
$\dot{V}_{O_2}$/Pulse at 25% Load (ml)	Pre	9.10	9.58	9.70	8.36
	Post	10.46	9.68	10.08	9.14
	Difference	1.36	0.10	0.38	0.78
$\dot{V}_{O_2}$/Pulse at 50% Load (ml)	Pre	10.56	10.96	11.54	10.34
	Post	12.66	11.52	11.48	11.16
	Difference	2.10	0.56	-0.06	0.82
$\dot{V}_{O_2}$/Pulse at 75% Load (ml)	Pre	12.48	13.64	12.92	11.52
	Post	13.76	13.10	13.74	12.84
	Difference	1.28	-0.54	0.82	1.32
$\dot{V}_{O_2}$/Pulse at Recovery (ml)	Pre	3.24	4.10	4.00	3.20
	Post	4.64	4.06	4.46	4.62
	Difference	1.40	-0.04	0.46	1.42
$\dot{V}_{O_2}$/kgbw·min at Rest (ml)	Pre	3.36	3.88	5.06	3.08
	Post	4.34	3.78	5.26	3.24
	Difference	0.98	-0.10	0.20	0.16
$\dot{V}_{O_2}$/kgbw·min at 25% Load (ml)	Pre	13.34	14.60	13.60	11.54
	Post	13.70	15.00	13.60	13.18
	Difference	0.36	0.40	0.00	1.64
$\dot{V}_{O_2}$/kgbw·min at 50% Load (ml)	Pre	18.50	20.36	18.90	17.06
	Post	19.22	20.84	19.06	18.80
	Difference	0.72	0.48	0.16	1.74
$\dot{V}_{O_2}$/kgbw·min at 75% Load (ml)	Pre	26.26	30.18	26.08	24.08
	Post	26.70	29.66	27.36	25.50
	Difference	0.44	-0.52	1.28	1.42

TABLE VI....MEAN PRE- AND POST-TRAINING VALUES OF THE MEASURED VARIABLES BY GROUPS....Continued

VARIABLE		GROUP			
		A	B	C	D
		Mini-Gym	Universal Gym	Calis-thenics	Control
$\dot{V}_{O_2}$/kgbw·min at Recovery (ml)	Pre	4.26	5.28	4.92	4.26
	Post	5.24	4.86	5.38	5.74
	Difference	0.98	-0.42	0.46	1.48
$\dot{V}_E/\dot{V}_{O_2}$ at Rest (l)	Pre	43.88	40.84	40.12	51.10
	Post	42.04	41.02	41.52	49.96
	Difference	-1.84	0.18	1.40	-1.14
$\dot{V}_E/\dot{V}_{O_2}$ at 25% Load (l)	Pre	29.94	25.62	28.66	31.50
	Post	29.52	26.94	27.88	29.84
	Difference	-0.42	1.32	-0.78	-1.66
$\dot{V}_E/\dot{V}_{O_2}$ at 50% Load (l)	Pre	28.68	25.34	26.10	28.72
	Post	29.28	26.96	27.24	28.24
	Difference	0.60	1.62	1.14	-0.48
$\dot{V}_E/\dot{V}_{O_2}$ at 75% Load (l)	Pre	28.76	26.24	27.34	29.10
	Post	31.64	27.28	27.14	29.14
	Difference	2.88	1.04	-0.20	0.04
$\dot{V}_E/\dot{V}_{O_2}$ at Recovery (l)	Pre	46.24	40.08	46.06	52.06
	Post	38.98	39.04	37.92	37.42
	Difference	-7.26	-1.04	-8.14	-14.64
Cardiac Output at Rest (l/min)	Pre	3.30	3.28	6.42	2.96
	Post	4.28	3.06	6.58	3.20
	Difference	0.98	-0.22	0.16	0.24
Cardiac Output at 25% Load (l/min)	Pre	9.40	9.34	8.84	7.60
	Post	9.32	8.78	9.58	9.64
	Difference	-0.08	-0.56	0.74	2.04
Cardiac Output at 50% Load (l/min)	Pre	10.24	11.70	10.34	10.74
	Post	13.14	10.30	13.18	11.70
	Difference	2.90	-1.40	2.84	0.96

TABLE VI....MEAN PRE- AND POST-TRAINING VALUES OF THE MEASURED VARIABLES BY GROUPS....Continued

VARIABLE		GROUP A Mini-Gym	GROUP B Universal Gym	GROUP C Calis-thenics	GROUP D Control
Cardiac Output at 75% Load (l/min)	Pre	13.72	16.74	12.90	13.68
	Post	15.64	13.40	14.76	14.62
	Difference	1.92	-3.34	1.86	0.94
Cardiac Output at Recovery (l/min)	Pre	6.16	5.46	6.66	4.60
	Post	5.50	5.74	6.44	5.28
	Difference	-0.66	0.28	-0.22	0.68
Stroke Volume at Rest (ml/beat)	Pre	35.80	50.40	77.80	43.60
	Post	63.40	41.40	81.80	42.20
	Difference	27.60	-9.00	4.00	-1.40
Stroke Volume at 25% Load (ml/beat)	Pre	82.40	89.40	81.80	74.80
	Post	89.80	83.80	91.40	92.00
	Difference	7.40	-5.60	9.60	17.20
Stroke Volume at 50% Load (ml/beat)	Pre	77.60	92.00	82.20	89.20
	Post	109.00	83.00	104.60	95.80
	Difference	31.40	-9.00	22.40	6.60
Stroke Volume at 75% Load (ml/beat)	Pre	87.60	111.00	82.40	88.60
	Post	101.60	86.20	97.40	101.00
	Difference	14.00	-24.80	15.00	12.40
Stroke Volume at Recovery (ml/beat)	Pre	56.60	60.00	69.60	48.20
	Post	58.60	63.40	63.40	57.20
	Difference	2.00	3.40	-6.20	9.00
Respiratory Exchange Ratio at Rest	Pre	1.062	0.904	0.984	1.008
	Post	0.974	0.890	1.014	0.956
	Difference	-0.088	-0.014	0.030	-0.052
Respiratory Exchange Ratio at 25% Load	Pre	0.946	0.844	0.900	0.906
	Post	0.898	0.874	0.910	0.912
	Difference	-0.048	0.030	0.010	0.006

TABLE VI....MEAN PRE- AND POST-TRAINING VALUES OF THE MEASURED VARIABLES BY GROUPS....Continued

VARIABLE		GROUP			
		A	B	C	D
		Mini-Gym	Universal Gym	Calis-thenics	Control
Respiratory Exchange Ratio at 50% Load	Pre	0.976	0.906	0.910	0.952
	Post	0.926	0.924	0.952	0.936
	Difference	-0.050	0.018	0.042	-0.016
Respiratory Exchange Ratio at 75% Load	Pre	1.016	0.972	0.966	1.008
	Post	0.964	0.980	0.970	1.014
	Difference	-0.052	0.008	0.004	0.006
Respiratory Exchange Ratio at Recovery	Pre	1.110	0.994	1.072	1.060
	Post	1.002	0.988	1.006	0.972
	Difference	-0.108	-0.006	-0.066	-0.088

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