

Integrating Physical Fitness Research into the Ergonomics Classroom

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Abstract

The intent of this paper is to describe the integration of a research project into the ergonomics classroom. The class evaluated a personal strength assistant device that is meant to increase core and upper body strength. The entire ergonomics class of 19 students worked on the group research project and final write-up. The experimental group in the research project was comprised of members of the ergonomics class while a control group was assembled consisting of students outside the class. A strength improvement device was used for a maximum of five minutes, three days per week for three weeks by the experimental group. The control group maintained their regular fitness and strength activities. A general fitness assessment and a strength specific assessment were administered and rated before and after the three-week testing period for both the experimental and the control groups. The data will show that general fitness levels did not change significantly for the experimental group, or the control group. However, the strength specific measurement did statistically increase in the experimental group while strength was unchanged in the control group. Details of the project procedure as well as ergonomic applications are presented.

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Problem and Hypothesis

Physical fitness is the measurement of how well a person's body reacts to physical activity over a certain period of time. Some assessments, like number of push-ups and sit-ups, measure both fitness and strength. During the testing procedure, the students of Kettering University's Ergonomics class assessed general fitness levels (heart rate, blood pressure, body composition, cardiorespiratory endurance, muscular endurance and flexibility) and strength specific levels (muscular strength via hand grip, arm, and low back strength).

Strength determines the ability of a person to exert a force on a physical object using muscles¹. The students in this class (the experimental group) completed movements

provided and formulated by the company My Loving Works². This company specializes in a rehabilitation product for increasing the strength of disabled persons.

Physical fitness, including strength training, has significant benefits that have been proven by earlier research³. These benefits include:

- Increased muscular strength
- Increased strength of tendons and ligaments
- Potential to improve flexibility (range of motion of joints)
- Reduced body fat and increased lean body mass (muscle mass)
- Potential to decrease resting systolic and diastolic blood pressure
- Positive changes in blood cholesterol
- Improved glucose tolerance and insulin sensitivity
- Improved strength, balance, and functional ability in older adults

In this experiment, the objective was to have subjects conduct four basic strength specific movements in an effort to increase strength over a specified period of time. Upon completion of the testing regimen, the results were analyzed and compared to pre-test strength data for each subject. Testing was done in reference to the American College Sports Medicine's Guidelines⁴ and to the guidelines of The Perfect Start: Assessment manual⁵. In addition, each subject was required to complete and sign a Physical Activity Readiness Questionnaire^{4,7} ("PAR-Q & You") which assessed the subject's general health level prior to testing.

The goal of the experiment was to assess whether doing a set of strength specific movements three times a week for three weeks would significantly increase a subject's strength. "Muscles (and strength) can be quickly and dramatically changed by a single environmental variable, exercise training⁷." For this experiment, the dependent variable was the subject's strength and fitness level. The independent variable was performing each of the four strength movements.

Experimental Procedure

There were 29 subjects from Kettering University in Flint, MI ranging from 18 to 23 years of age. The control group was comprised of 12 students and the experimental group was comprised of 17 students. All subjects were of normal health for their age group. There were 14 males and 15 females. Two members of the initial control group did not perform the week 3 follow-up and were subsequently dropped from the analysis. One member of the initial experimental group did not complete all movement repetitions and was subsequently dropped from the analysis.

Several pieces of equipment were used for the testing. The equipment used to perform the experimental movements included the Strength Assistant, gloves, cushioned floor mat, and height regulator. The equipment used to measure the strength and fitness of all subjects included: the Jackson Strength Evaluation Apparatus, IVAC Vital-Check Model 4000 blood pressure monitor, bioelectric impedance monitor, Life Cycle Aerobic Trainer

9500HR, cushioned floor mat with set markers, stopwatch and an Acuflex I flexibility measuring device.

Several attempts were made to control variation in the experiment including:

- The Control Group did not use the Strength Assistant product
- The Control Group met at the beginning of Week 1 and end of Week 3 for pre and post test strength and fitness assessments
- All subjects continued with their usual lifestyle (diet and exercise)
- All subjects were encouraged to avoid weight training 2-3 hours before the strength trials
- All Strength Assistant use occurred on the same day of the week and approximately the same time of day for the 3 week duration
- The same prototype of the Strength Assistant was used by each subject
- Each of the 4 movements had specific guidelines for execution
- All four movements combined were to last no more than 5 minutes
- The order of the movements remained consistent

To determine the strength of each subject before and after the three-week duration the Jackson strength evaluation apparatus was used. This measured average force exerted over a five second time period. In all testing positions a supine palm grip was used. When the subject was ready, the experimenter pressed the initiate button. At the beep, the subject exerted effort until the second beep sounded. A warm-up trial was conducted at half effort followed by two test trials using maximum effort. The experimenter recorded the average of the two test trials. The following measurements were taken: grip strength of the dominant hand and non-dominant hand, strength of arms, and strength of back. In order to measure grip strength, the grip device was laid flat on the table and the subject seated with arm bent at 90 degrees. When measuring arm strength the subject stood and the cable and bar apparatus was lifted with the arms at a 90 degree angle. The back strength was measured by bending at the waist with the cable and bar approximately at knee level and the back straight while pulling upward.

To determine the subjects' fitness level before and after the three-week duration several fitness scores were gathered for each participant. General fitness scores included initial resting heart rate (RHR) and resting blood pressure (systolic, diastolic, MAP). Both were measured using the IVAC Vital-Check Model 4000 Blood Pressure Monitor. Body weight was measured in pounds and height was measured in inches. Percent Body Fat test was assessed on each subject using the Omron Body Fat Analyzer. Aerobic Capacity was measured using the Life Cycle Aerobic Trainer 9500HR Fit Test Program. The test was five minutes in duration and intensity level was based on predetermined activity level charts. Initial Heart Rate, ending Heart Rate, and Fit Test Scores were recorded.

The sit-up test and the push-up test both indicate a measure of fitness based on muscular endurance. The half sit-up test was performed using a cushioned floor mat with markers set 3½ inches apart to indicate the starting point and stopping points. Each subject was expected to do as many sit-ups as possible in a controlled, consistent manner over a one-minute period of time. A sit-up was only counted if the subject reached the set marker.

The push-up test protocol was different for males than females. Males performed standard push-ups on their toes and females performed modified push-ups on their knees. The subjects were instructed to do as many push-ups as possible in a controlled, consistent manner. There was no time limit on this particular test.

Flexibility was measured using a modified sit and reach test with an Acuflex I flexibility measuring device. The subject was asked to remove shoes, sit on the floor with hips, back, and shoulders flat against the wall and legs straight. The experimenter aligned the sit-and-reach box against the subject's flexed feet. The subject was asked to extend their arms in front of their body with one hand over the other and their middle finger tips touching. The experimenter then aligned the touching device and the reach indicator of the sit-and-reach box to touch the end of the subject's finger tips. The subject was then asked to push the touching device of the sit-and-reach box as far as possible without using momentum. The test was repeated three times with the best of the three trials being recorded. Flexibility measurements were recorded in inches.

The Strength Assistant device was used by the experimental group. The experimental procedure was followed for a three week duration, three days per week, for no more than five minutes each day. Proper use of the device was demonstrated at the beginning of the study. Proper instruction included keeping the elbows close to the body while performing movements and exhaling when pushing up. The subject was also instructed to execute movements on their knees and progress to their feet once ten repetitions were performed regularly. A representative from Loving Works was present during each of the movement trials. Subjects were given instruction to perform as many repetitions as possible without fatigue or pain. They were further instructed to increase their repetitions as they felt comfortable. The following is a description of each movement:

- Chest Push-up (feet or knees): The Strength Assistant was set-up perpendicular to the body. Both hands were placed on one side of the Strength Assistant. The subject lowered their body until their chest touched the bar, then raised their body up to the starting position. Subjects were instructed to breathe out while pushing up.
- Chest Extender (feet or knees): The Strength Assistant was set-up perpendicular to the body. Each hand was placed on one side of the Strength Assistant. The subject lowered their body until their chest was at bar level, then raised up to the starting position. Subjects were instructed to breathe out while pushing up.
- Back Builder (feet or knees): The Strength Assistant was set-up parallel to the body. Each hand was placed on one side of the Strength Assistant. Subjects lowered their body until the chest was just below the bar level and then rose up to the starting position. Subjects were expected to breathe out while pushing up.
- Dips (in a seated position or with legs extended): The Strength Assistant was set-up parallel to the body. Each hand was placed on one side of the Strength Assistant. While in a seated position, the body was lowered until the height regulator was touched by the person's bottom or to ground-level, then raised

up to the starting position. Subjects were expected to breathe out while pushing up and keep their head at a fifteen degree angle to the horizon.

Conduct the Study

The experiment was conducted as outlined in the lab report shown in Appendix A. Subjects were assessed in regards to fitness and strength levels. Experimental trials were performed on Tuesdays, Wednesdays, and Fridays during the three-week period. There was a make-up trial scheduled on the Thursday of the final week for any subject that was absent for any of the previous experimental trials. Representatives from the My Loving Works, Inc. were present at every experimental trial to ensure proper use of the strength assistant device. Subjects performed repetitions and sets for each of the four movements until they were fatigued. Sets consisted of no more than ten repetitions. Subjects recorded how many repetitions and sets they performed at each experimental trial.

At the end of the three week study period, the subjects were again assessed in regard to personal fitness and strength levels. The data collected before and after the experiment was compiled and analyzed. The data is summarized in Appendix B for both the experimental and control groups.

As shown in Figure 1, the average number of movements performed by each subject in the experimental group increased throughout the three week period. As expected, on average, males performed a higher number of movement repetitions than females throughout the experiment. The linear slope increased significantly for both groups.

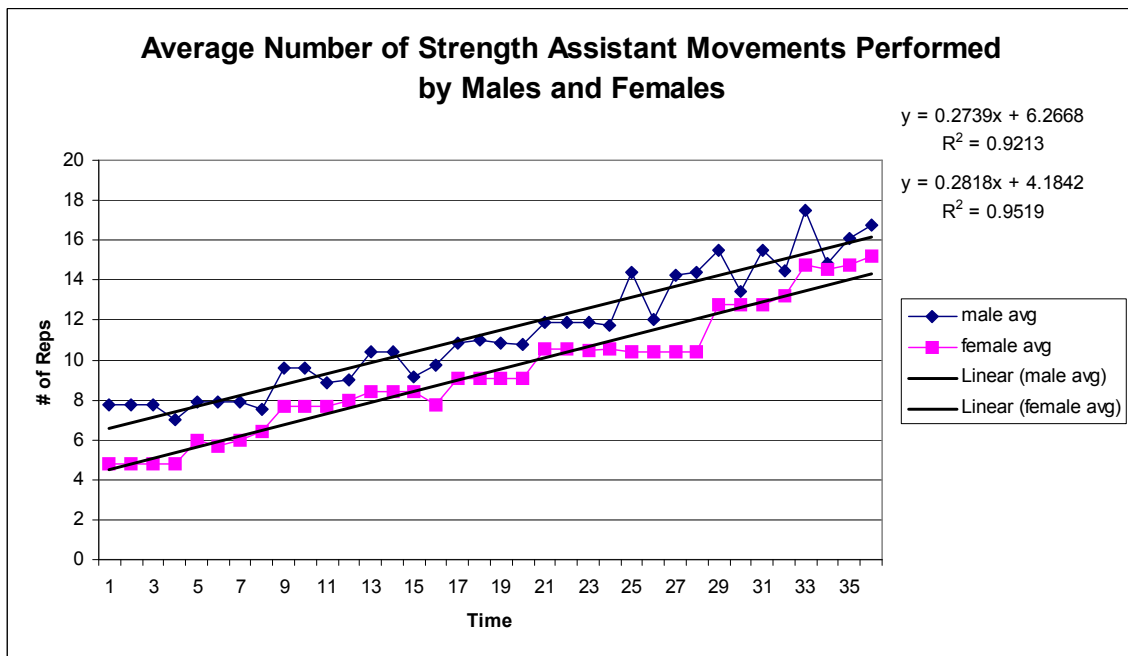


Figure 1: Average Number of Strength Assistant Movements for Males and Females

Analyze the Data

To illustrate the difference in strength and fitness between week 1 and week 3, the calculated difference is displayed in the boxplots shown in Figures 2 through 9 below. Note that a difference of zero implies that there was no difference in strength between week 1 and week 3. For each boxplot shown in Figures 2 through 9, the y-axis shows the difference between the pre- and post-test assessment for each individual variable. Variables are stratified by control group and experimental group as well as by gender along the x-axis. Note that a difference of zero implies that there was no change from week 1 to week 3.

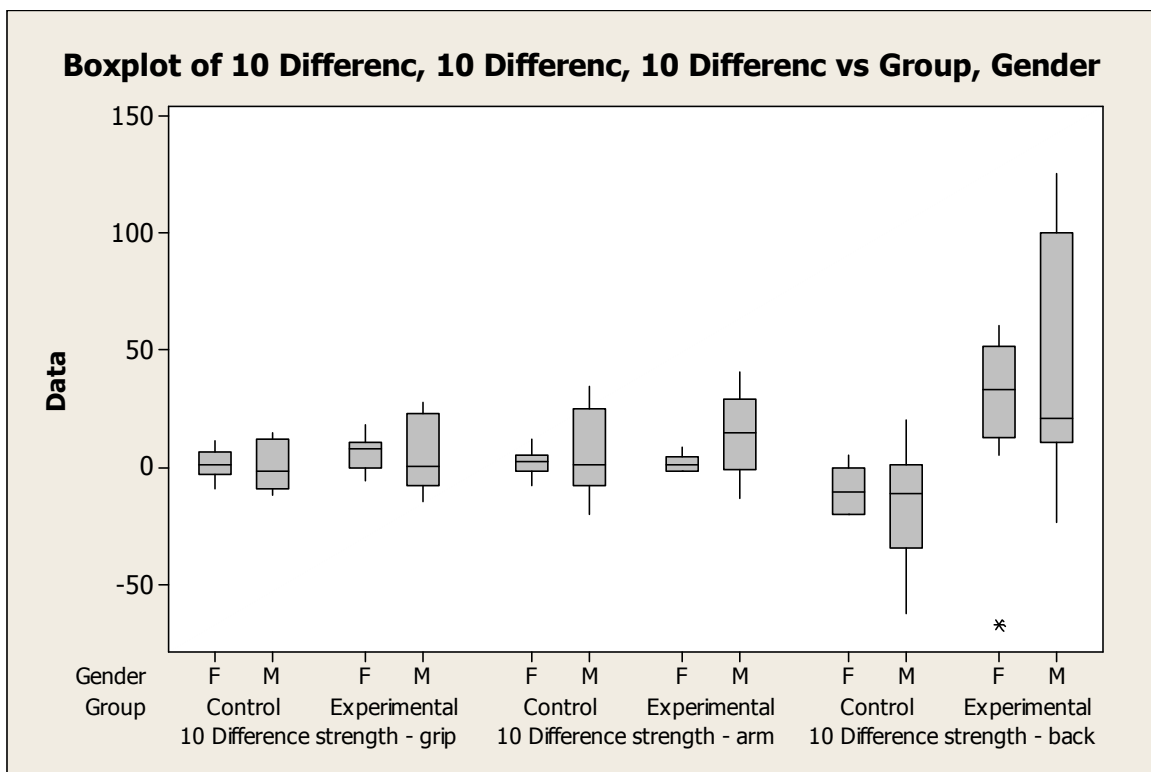


Figure 2: Boxplot of difference in grip, arm and back strength before and after the study time period for both the experimental group and the control group stratified by male/female

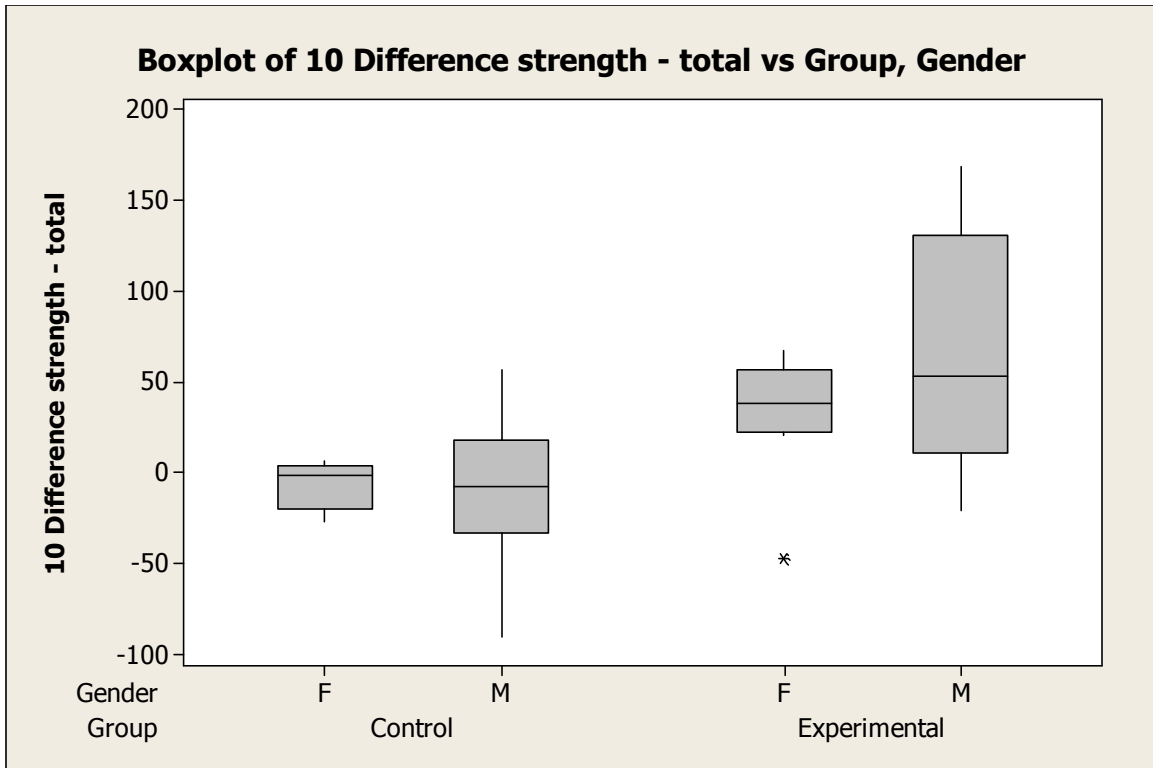


Figure 3: Boxplot of difference in total strength before and after the study time period for both the experimental group and the control group stratified by male/female

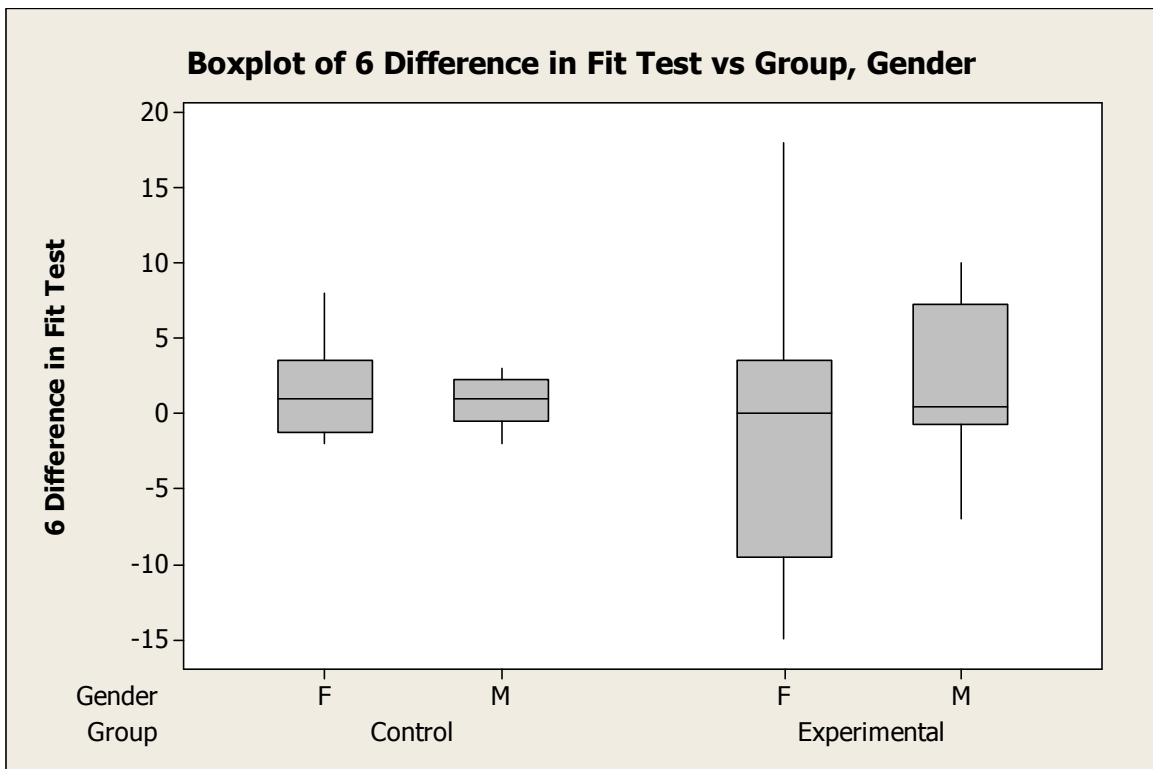


Figure 4: Boxplot of difference in aerobic capacity (fit test) score for experimental group and control group

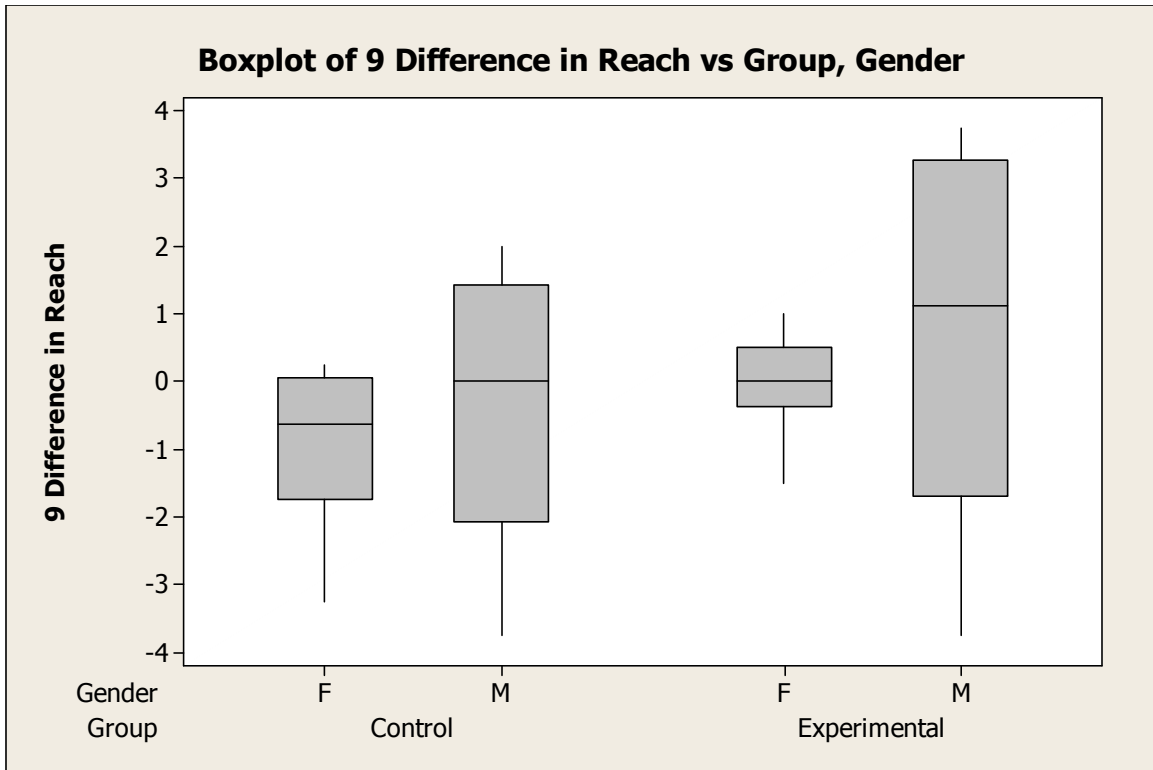


Figure 5: Boxplot of difference in reach for experimental group and control group

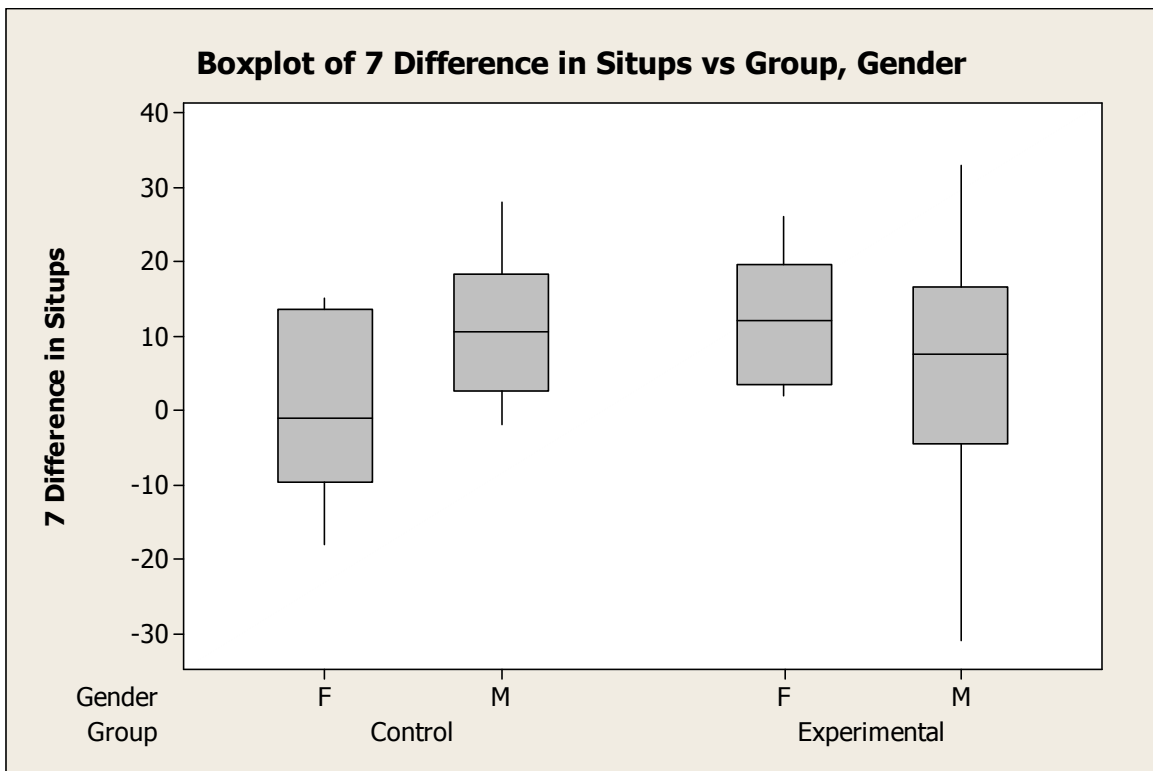


Figure 6: Boxplot of difference in number of sit-ups performed for experimental group and control group

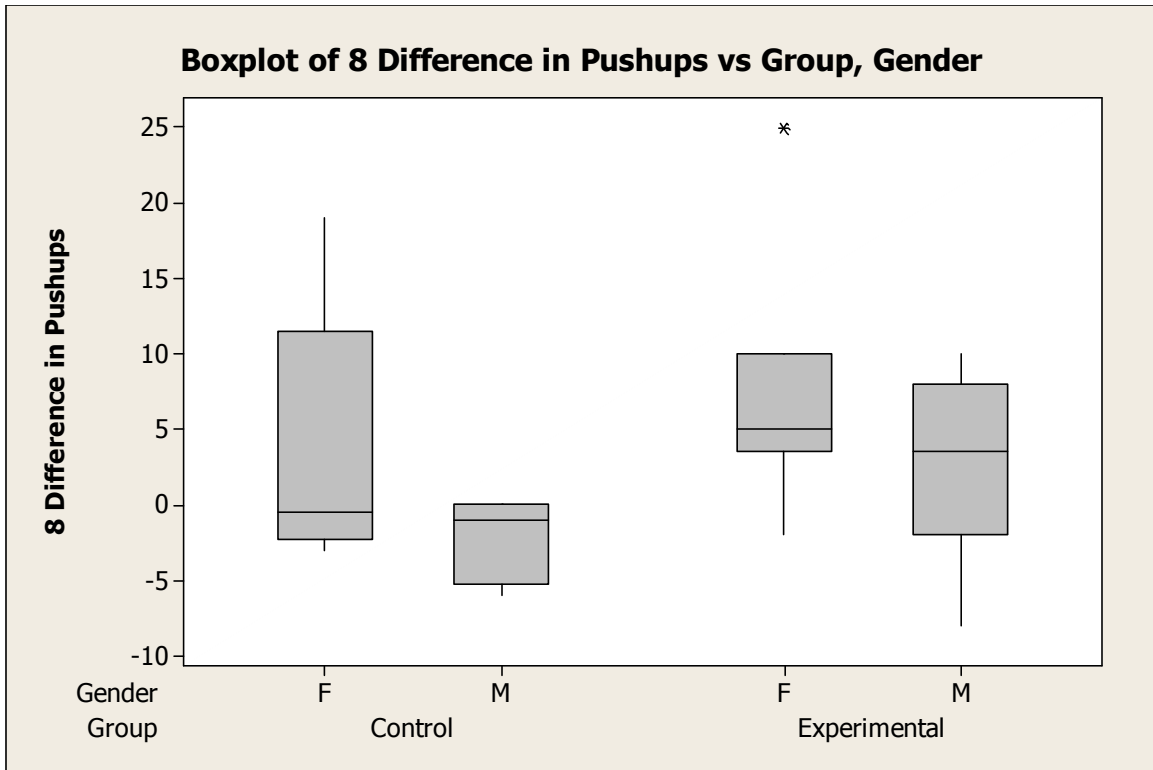


Figure 7: Boxplot of difference in number of push-ups performed for experimental group and control group

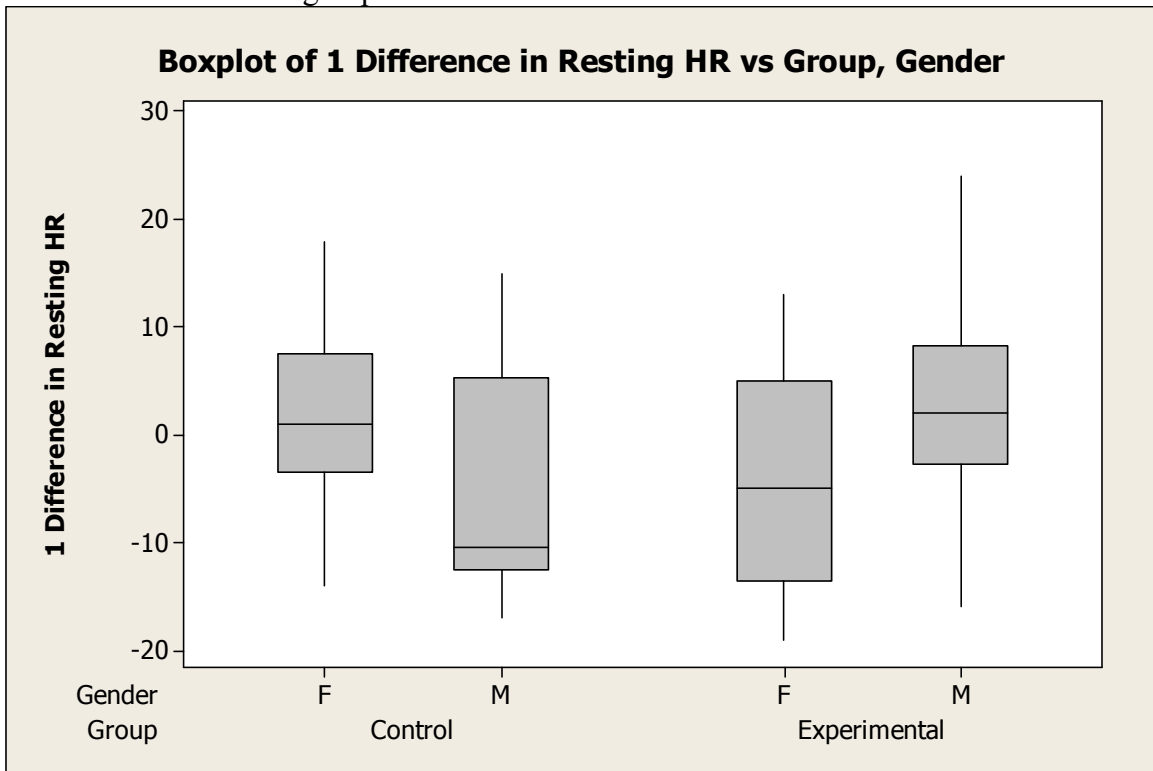


Figure 8: Boxplot of difference in heart rate for the experimental group and the control group

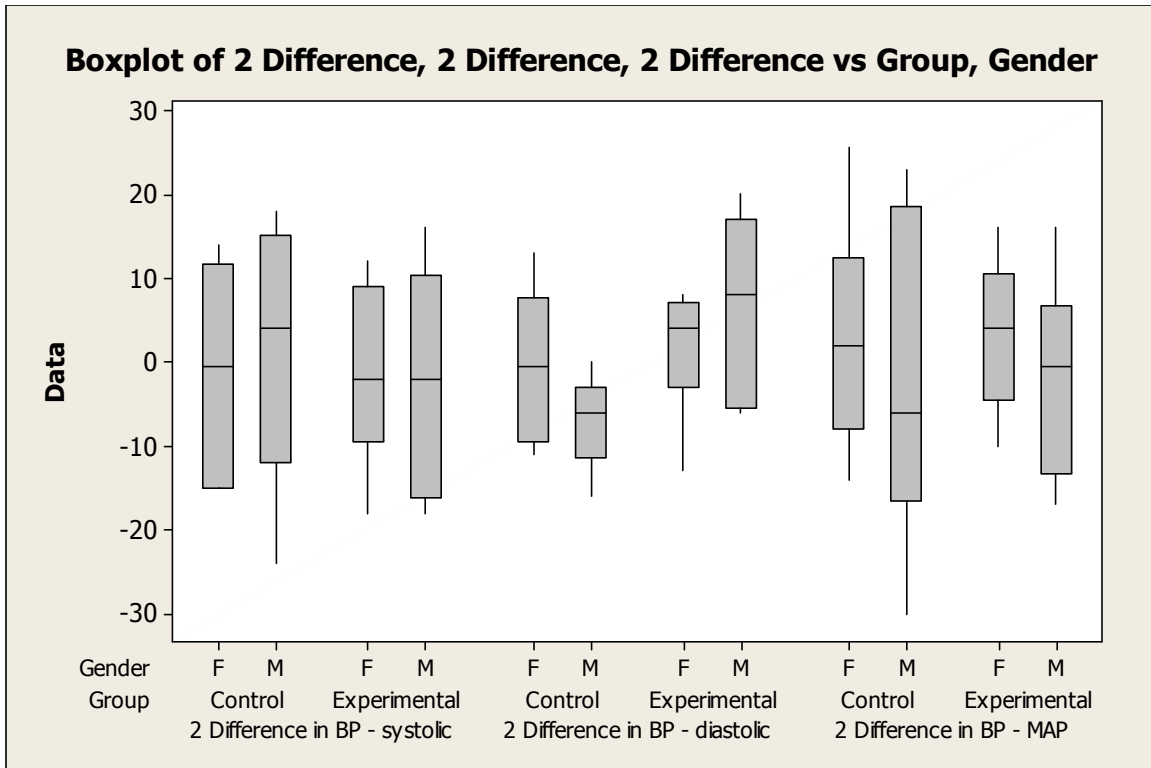


Figure 9: Boxplot of difference in blood pressure (systolic, diastolic, and mean arterial pressure) for the experimental group and the control group

In order to test the significance of the difference before and after using the strength assistant, a paired t-test was used. Tables 1a and 1b, show the p-values as calculated using a paired t one-sided hypothesis test with 95% chosen as the level of confidence desired. Significant factors are highlighted with bold font.

Table of p-values from paired t-test	Control	Experimental
N	12	17
1 Resting HR	0.289	0.384
2 Blood Pressure - MAP	0.476	0.354
6 Aerobic Capacity - Fit Test Score	0.080	0.488
7 Situps	0.072	0.011
8 Pushups	0.356	0.004
9 Reach	0.112	0.230
10 strength - grip	0.392	0.043
10 strength - arm	0.179	0.018
10 strength - back	0.023	0.004
10 strength - total	0.201	0.001

Table 1a: Table of p-values for all paired t-tests for both the experimental group and the control group

	Control		Experimental	
	Female	Male	Female	Male
N	6	6	9	8
1 Resting HR	0.352	0.154	0.136	0.238
2 Blood Pressure - MAP	0.307	0.390	0.145	0.338
6 Aerobic Capacity - Fit Test Score	0.168	0.154	0.337	0.197
7 Situps	0.487	0.021	0.001	0.243
8 Pushups	0.171	0.049	0.007	0.126
9 Reach	0.063	0.356	0.500	0.231
10 strength - grip	0.344	0.482	0.019	0.226
10 strength - arm	0.244	0.247	0.109	0.027
10 strength - back	0.027	0.102	0.048	0.022
10 strength - total	0.132	0.311	0.010	0.014

Table 1b: Table of p-values for all paired t-tests for both the experimental group and the control group

Conclusions, Recommendations, and Applications

When males and females are analyzed together, the experimental group significantly increased the number of sit-ups, number of push-ups, grip strength, arm strength, back strength and total strength. The control group also showed a significant increase in back strength.

The analysis becomes a bit more complex when the data is stratified by males and females. Females in the experimental group were shown to significantly increase the number of sit-ups and pushups that could be performed as well as grip strength. Both males and females in the experimental group increased back strength and total strength scores. In the control group, males increased the number of sit-ups and push-ups that could be performed and the females showed an increased back strength score. These results lead the researchers to conclude that more data should be taken to make more accurate conclusions regarding the Strength Assistant.

Recommendations for the next experiment of the Strength Assistant are many and varied. First, to reduce variability, participants should be required to wear athletic attire during the fitness assessments so that their performance is not hindered by uncomfortable or restrictive clothing. Since the experimental group performed the movements in the classroom, typical street clothing was worn. Second, the selection of experimental and control group participants should be carefully screened so that participants are not currently engaging in strength training exercises of any kind and who have not participated in strength training for a determined period of time prior to testing (i.e. 1-3 months). Third, all pre and post strength and fitness assessments should be conducted by a dedicated group of research assistants to ensure test accuracy.

Some special circumstances that were encountered during this experiment may have affected the results. First, students complained that the temperature of the classroom was quite cold and may have impacted the results. Second, body fat was measured by the Omron Body Fat Analyzer. The data showed a significant change in body fat; however,

the error rate of the equipment was higher than the observed difference. To avoid drawing conclusions on false data, the body fat data was thrown out. In future testing, consideration should be made as to the reliability of the body fat analyzer under various testing conditions (i.e. subject hydration, activity level before testing, etc.) as these conditions may vary pre- and post-test.

The results of this lab could be used in the work environment where manual labor is used. The methods used in this lab assess the physical fitness and/or strength of an employee and attempt to increase the overall strength of a person. Ergonomics is concerned with the design of work and methods for accommodating workers. The integration of physical fitness into the Ergonomics classroom allows the student to discover methods of improving physical fitness levels and subsequently improve the productivity of workers in a manual labor environment. The focus of the lab should focus on worker safety and improved overall health to avoid injury in the workplace.

In summary, the Strength Assistant apparatus appeared to improve the strength of the subjects in the experimental group in a short time period. Recall that this testing was done over a three week time period with the strength assistant used less than five minutes per day for three days per week. It should be noted that the Strength Assistant did not improve other fitness measurements (i.e. aerobic capacity) but did have an impact on basic strength (Jackson evaluation) and muscular endurance (sit-ups and push-ups).

Appendix A

Physical Fitness Lab Sheet

#1 Resting Heart Rate (RHR): _____ bpm

#2 Resting Blood Pressure: _____ / _____
Systolic _____ Diastolic _____ MAP _____

Equipment: IVAC Vital-Check Model 4000 Blood Pressure Monitor

Procedure:

Set pressure control to 125 mm Hg and Mode control to Manual.

Have another person place cuff on your upper arm with "artery" label over inside of elbow.

Sit quietly with arm supported.

Press start button and wait for results to be displayed.

Record the systolic, diastolic, and mean arterial pressure.

Compare results to normal population data.

#3 Weight: _____ lbs.

#4 Height: _____ inches

#5 Body fat test using Bioelectric Impedance: _____ %

#6 Aerobic Capacity (cardiovascular test):

Choose one of the LifeFitness Machines in the Rec Center: (circle one used)

Life Cycle Aerobic Trainer 9500HR

Calculate 85% age predicted max HR:

$220 - \text{age} = \underline{\hspace{2cm}} - \text{RHR} = \times 0.85 = \underline{\hspace{2cm}} + \text{RHR} = \underline{\hspace{2cm}}$

Record Ending Heart Rate: _____ bpm

Record Fit Test Score: _____ VO_2 max mL/(kg-min) estimate

#7 Half Sit-up Test (muscular endurance): Number of curls _____

#8 Push-up Test (muscular endurance): Number of push-ups _____

#9 Modified Sit-and-Reach Test (flexibility):

Trial #1 _____ inches #2 _____ #3 _____ *Record inches from Scale B

Best of three trials _____

#10 Overall strength using Jackson Evaluation System (previous lab)

Average Grip: _____

Average Arm: _____

Average Back: _____

Total Strength Score: _____

#11 Strength Assistant Movements: Number of Repetitions

An extended pause will halt counting and subject should move on to next movement

Test will last no longer than five minutes

Keep this sheet and record data during Tuesday labs

Movement #1: _____

Movement #2: _____

Movement #3: _____

Movement #4: _____

Appendix B

The following pages contain the raw data used for analysis. The numbers are correlated to the Lab Report in Appendix A. The first table contains Subject Information with headings defined as follows:

Subj = subject identifier number. Student names were converted into a number for anonymity.

M/F = gender M=male, F=female

Age = age of subject ranging from 18-23

3 = weight in pounds

4 = height in inches

Week 1 Data, Week 3 Data and Difference Data contain row records correlated to the Subject Information. All have identical column headings defined as follows:

1 = Resting HR

2 = Blood Pressure - systolic

2 = Blood Pressure - diastolic

2 = Blood Pressure - MAP

5 = Body fat

6 = Aerobic Capacity - Fit Test Score

7 = Situps

8 = Pushups

9 = Reach

10 = strength - grip

10 = strength - arm

10 = strength - back

10 = strength – total

Subject Information

<i>Subj</i>	<i>M/F</i>	<i>E/C</i>	<i>Age</i>	<i>3</i>	<i>4</i>
<u>1</u>	M	E	20	190	76.6
<u>2</u>	F	E	22	145	64
<u>3</u>	M	E	21	165	72
<u>4</u>	F	E	21	164	62
<u>5</u>	M	E	22	185	74.1
<u>7</u>	F	E	20	152	66
<u>8</u>	M	E	21	229	70.3
<u>9</u>	F	E	22	115	66
<u>11</u>	F	E	21	240	71
<u>12</u>	F	E	23	140	68
<u>13</u>	M	E	22	170	65
<u>14</u>	M	E	23	157	73
<u>15</u>	M	E	22	160	69
<u>16</u>	M	E	22	196	74
<u>17</u>	F	E	22	126	62
<u>18</u>	F	E	22	145	68
<u>19</u>	F	E	21	175	67
<u>21</u>	F	C	19	124	64.5
<u>22</u>	M	C	22	173.8	71
<u>23</u>	M	C	18	165	71
<u>24</u>	M	C	20	205	77
<u>25</u>	F	C	22	125	64
<u>26</u>	F	C	20	160	68
<u>28*</u>	M	C	22	175	71
<u>30</u>	F	C	21	234	72
<u>33</u>	M	C	23	175	70
<u>34</u>	M	C	23	175	65
<u>38*</u>	F	C	22	135	62
<u>6</u>	F	C	21	109	62.5

Week 1 Data

1	2	2	2	5	6	7	8	9	10	10	10	10
66	114	66	79	5.5	44	49	27	15.7	79.25	96.5	289.5	465.25
74	112	58	74	24	41	14	5	12.75	43.25	36.5	55.5	135.25
69	111	48	83	5.8	27	66	25	19.5	86	84	267	437
83	130	74	87	28.3	26	33	30	18.75	51	58.5	95	204.5
58	120	68	85	5.5	40	54	38	16	88	65.5	250	403.5
51	106	58	66	23.5	53	58	10	17.75	24.25	34	97	155.25
67	144	86	103	21.8	38	45	35	13	106.5	87	253	446.5
74	100	58	80	11.7	63	32	16	13.25	36.25	32	77	145.25
85	122	80	88	35.9	21	72	12	18.75	51.25	42.5	144.5	238.25
76	108	68	79	14.6	39	30	22	21	56	63	153.5	272.5
70	116	60	79	16.8	47	41	28	16.5	45.5	65.5	70	181
59	144	64	99	10	50	57	34	13.75	104.7	66.5	198	369.25
64	122	54	70	14.6	35	28	35	13.75	62.5	46.5	101.5	210.5
93	110	70	90	19.1	32	24	11	11	82.5	50.5	220.5	353.5
81	100	62	74	24.5	38	37	10	13.5	42.5	30	69	141.5
77	120	72	83	20.4	49	61	30	23	43.5	34	75.5	153
76	110	70	82	28.6	37	53	26	19	35.75	40.5	88	164.25
67	148	68	77	17.4	52	40	25	17	18	24.5	103	145.5
67	144	82	106	10.4	37	67	35	18.5	91.25	38	192	321.25
77	138	80	96	14.5	24	29	41	15.25	82.25	79	227.5	388.75
74	162	88	100	11.3	41	30	20	10.5	91.25	88	196.5	375.75
85	111	69	80	20	44	42	23	13.25	33.5	32.5	65	131
76	140	88	105	25.4	32	39	25	12.75	60	47.5	177.5	285
85	136	80	104	15.3	40	33	28	5.75	79	72.5	182	333.5
83	115	80	97.5	34.4	25	78	3	11.75	76.5	53	191.5	321
65	154	80	91	12.3	35	36	50	11	68.75	77.5	180.5	326.75
76	152	96	100	18.5	32	46	49	11.25	71.25	67.5	142	280.75
74	100	62	78	25.9	37	37	21	13.5	57.5	39	179.5	276
73	112	69	89	13.4	63	43	19	18	41	25.5	59.5	126

Week 3 Data

<i>1</i>	<i>2</i>	<i>2</i>	<i>2</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>	<i>10</i>	<i>10</i>	<i>10</i>	<i>10</i>
90	130	80	87	5.5	45	67	32	19	107	111	393.5	611.5
55	110	66	89	25	44	18	10	11.25	43.25	36	113	192.25
71	122	66	86	8.6	37	35	34	17.5	80.25	92.5	243.5	416.25
74	123	68	77	29	19	59	32	19.25	60.5	56.5	128.5	245.5
60	128	62	81	8.7	33	51	35	15.25	116	106	265.5	487.5
64	88	58	71	24	45	72	15	17.75	27.25	35	117	179.25
76	126	80	95	23	38	40	40	16.75	115.5	120	379	614.5
83	98	62	83	12.9	48	49	14	13.5	48.5	35	82	165.5
67	110	67	80	36.2	24	74	17	18.5	59	51	184	294
71	116	70	78	16.1	39	52	47	22	74.25	64.5	86	224.75
71	102	68	82	19.5	46	53	30	12.75	41.25	52.5	159	252.75
43	127	72	82	12.1	59	61	26	15.75	89.75	62	225	376.75
70	126	74	86	17.7	35	61	45	17	54.25	64.5	110.5	229.25
89	102	66	75	17.8	34	35	12	11.25	87.25	66	235	388.25
77	108	70	78	22.8	56	46	20	13	37	28	114.5	179.5
71	130	78	99	22	38	64	40	23	43.5	40	136	219.5
77	122	76	88	30.1	41	65	35	19.5	43.5	39.5	110.5	193.5
71	133	72	102.5	18.1	51	53	34	15.75	29	36.5	83	148.5
57	148	78	76	8	35	74	30	17	87	72.5	166.5	326
66	142	64	91	13.3	24	57	35	16	73.75	59	165	297.75
57	138	80	88	14.3	43	34	20	6.75	102.2	84.5	178.5	365.25
87	116	58	74	22.1	45	35	21	12.75	35.75	24.5	53	113.25
76	125	79	91	24.3	30	40	26	12	58.75	50	182.5	291.25
87	154	76	97	15.8	42	31	28	5	67	75	177	319
83	126	75	100.5	33.8	26	60	0	12	67.25	55	171.5	293.75
54	146	70	108	10.8	38	50	50	13	83.25	99	200.5	382.75
91	166	96	123	17.7	32	61	47	12.5	71.75	67	137	275.75
60	114	68	86	27.4	45	34	40	10.25	62.5	41.5	171	275
91	106	82	90	13.6	65	58	17	18	40.25	26	57	123.25

Difference Data

1	2	2	2	5	6	7	8	9	10	10	10	10
24	16	14	8	0	1	18	5	3.3	27.75	14.5	104	146.25
-19	-2	8	15	1	3	4	5	-1.5	0	-0.5	57.5	57
2	11	18	3	2.8	10	-31	9	-2	-5.75	8.5	-23.5	-20.75
-9	-7	-6	-10	0.7	-7	26	2	0.5	9.5	-2	33.5	41
2	8	-6	-4	3.2	-7	-3	-3	-0.75	28	40.5	15.5	84
13	-18	0	5	0.5	-8	14	5	0	3	1	20	24
9	-18	-6	-8	1.2	0	-5	5	3.75	9	33	126	168
9	-2	4	3	1.2	-15	17	-2	0.25	12.25	3	5	20.25
-18	-12	-13	-8	0.3	3	2	5	-0.25	7.75	8.5	39.5	55.75
-5	8	2	-1	1.5	0	22	25	1	18.25	1.5	-67.5	-47.75
1	-14	8	3	2.7	-1	12	2	-3.75	-4.25	-13	89	71.75
-16	-17	8	-17	2.1	9	4	-8	2	-15	-4.5	27	7.5
6	4	20	16	3.1	0	33	10	3.25	-8.25	18	9	18.75
-4	-8	-4	-15	-1.3	2	11	1	0.25	4.75	15.5	14.5	34.75
-4	8	8	4	-1.7	18	9	10	-0.5	-5.5	-2	45.5	38
-6	10	6	16	1.6	-11	3	10	0	0	6	60.5	66.5
1	12	6	6	1.5	4	12	9	0.5	7.75	-1	22.5	29.25
4	-15	4	25	0.7	-1	13	9	-1.25	11	12	-20	3
-10	4	-4	-30	-2.4	-2	7	-5	-1.5	-4.25	34.5	-25.5	4.75
-11	4	-16	-5	-1.2	0	28	-6	0.75	-8.5	-20	-62.5	-91
-17	-24	-8	-12	3	2	4	0	-3.75	11	-3.5	-18	-10.5
2	5	-11	-6	2.1	1	-7	-2	-0.5	2.25	-8	-12	-17.75
0	-15	-9	-14	-1.1	-2	1	1	-0.75	-1.25	2.5	5	6.25
2	18	-4	-7	0.5	2	-2	0	-0.75	-12	2.5	-5	-14.5
0	11	-5	3	-0.6	1	-18	-3	0.25	-9.25	2	-20	-27.25
-11	-8	-10	17	-1.5	3	14	0	2	14.5	21.5	20	56
15	14	0	23	-0.8	0	15	-2	1.25	0.5	-0.5	-5	-5
-14	14	6	8	1.5	8	-3	19	-3.25	5	2.5	-8.5	-1
18	-6	13	1	0.2	2	15	-2	0	-0.75	0.5	-2.5	-2.75

Appendix C

Movement Repetitions Data for Experimental Group

W ee k	Mov e	<u>2</u>	<u>4</u>	<u>7</u>	<u>9</u>	<u>11</u>	<u>12</u>	<u>17</u>	<u>18</u>	<u>19</u>	<u>1</u>	<u>3</u>	<u>5</u>	<u>8</u>	<u>13</u>	<u>14</u>	<u>15</u>	<u>16</u>
		F	F	F	F	F	F	F	F	F	M	M	M	M	M	M	M	M
1	1	3	5	3	5	5	5	5	5	7	8	8	5	5	5	15	8	5
1	2	3	5	3	5	5	5	5	5	7	8	8	5	5	5	15	8	5
1	3	3	5	3	5	5	5	5	5	7	8	8	5	5	5	15	8	5
1	4	3	5	3	5	5	5	5	5	7	7	8	5	5	5	15	4	5
1	1	3	6	3	6	5	10	5	8	8	8	8	6	5	5	15	10	6
1	2	0	6	3	6	5	10	5	8	8	8	8	6	5	5	15	10	6
1	3	3	6	3	6	5	10	5	8	8	8	8	6	5	5	15	10	6
1	4	3	6	3	10	5	10	5	8	8	7	8	6	5	5	15	8	6
1	1	4	7	3	7	8	15	5	10	10	10	10	8	6	5	20	10	8
1	2	4	7	3	7	8	15	5	10	10	10	10	8	6	5	20	10	8
1	3	4	7	3	7	8	15	5	10	10	10	10	8	6	5	15	10	7
1	4	4	7	3	10	8	15	5	10	10	8	10	8	6	5	15	10	10
2	1	4	10	3	10	9	15	5	10	10	10	10	8	7	10	20	10	8
2	2	4	10	3	10	9	15	5	10	10	10	10	8	7	10	20	10	8
2	3	4	10	3	10	9	15	5	10	10	10	10	8	7	5	15	10	8
2	4	4	4	3	10	9	15	5	10	10	10	10	8	7	10	15	10	8
2	1	4	10	4	10	9	15	5	10	15	10	10	9	7	8	20	15	8
2	2	4	10	4	10	9	15	5	10	15	10	10	9	7	8	20	15	9
2	3	4	10	4	10	9	15	5	10	15	10	10	9	7	8	20	15	8
2	4	4	10	4	10	9	15	5	10	15	8	10	9	7	8	20	15	9
2	1	5	10	5	10	10	20	8	12	15	10	15	9	8	8	20	15	10
2	2	5	10	5	10	10	20	8	12	15	10	15	9	8	8	20	15	10
2	3	5	10	4	10	10	20	8	12	15	10	15	9	8	8	20	15	10
2	4	5	10	5	10	10	20	8	12	15	10	15	9	8	8	20	15	9
3	1	5	10	5	16	10	20	8	14	15	13	15	10	9	13	30	15	10
3	2	5	10	5	16	10	20	8	14	15	13	15	9	9	13	30	15	10
3	3	5	10	5	16	10	20	8	14	15	13	15	9	9	13	30	15	10
3	4	5	10	5	16	10	20	8	14	15	13	15	10	9	13	30	15	10
3	1	5	15	5	16	13	20	8	18	15	13	18	10	9	16	30	18	10
3	2	5	15	5	16	13	20	8	18	15	13	18	10	9	16	30	18	10
3	3	5	15	5	16	13	20	8	18	15	13	18	10	9	16	30	18	10
3	4	5	15	5	20	13	20	8	18	15	13	10	10	9	16	30	18	10
3	1	5	15	7	16	15	25	10	20	20	16	20	14	10	20	30	20	10
3	2	5	15	5	16	15	25	10	20	20	16	18	10	10	20	30	20	10
3	3	5	15	7	16	15	25	10	20	20	14	20	10	10	15	30	20	10
3	4	5	15	7	20	15	25	10	20	20	14	20	10	10	20	30	20	10

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