THE EFFECTS OF A WEIGHT TRAINING PROGRAM ON AN ACTIVE ELDERLY POPULATION

by

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ABSTRACT

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Twenty active elderly subjects (mean age = 66.4 yr) participated in a 12 week training program. The male subjects (n = 11) saw a 65.1% increase ($p<.00001$) in total maximum weight lifted while the females (n = 9) saw a 72.2% increase ($p<.001$). One-repetition maximums on each of the six weight machines utilized also increased significantly ranging from 68.4% to 125.3% for females and 53.5% to 157.4% for males. Lean body weight for each group did increase, but it was not statistically significant (males $p<.11$, females $p<.18$). The increases in lean body weight were 2.06 and 2.0% for the males and females respectively. The study demostrated the positive effects an exercise training regimen can have on an elderly population.

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Chapter I

It is a well known fact that the population, as a whole, is growing older each decade. For the majority of this population, a sedentary lifestyle is the common occurrence. If this trend continues, the population is destined to a life of ill-health and unhappy years. Researchers have been studying the elderly and their reactions to exercise for many years. The results have almost always shown that the elderly need not become weak and unhealthy as the years go by. It has been shown that the elderly can improve their overall health (physical and emotional well-being) just by undertaking some type of physical exercise. Researchers now need to determine to what degree exercise can benefit the elderly. The degree of benefit needs to be measured in physiological and psychological areas. This study will look at two of these physiological benefits; the possibility of muscular strength increases, and the enhancement of muscle fiber growth.

The current study looked at a population of elderly who were living independently and were socially active as compared to subjects of past studies who were institutionalized and totally sedentary. The current study looked at the effects of a whole body weight training program on muscular strength levels and percent lean body weight. In the past, researchers have performed similar studies, but these researchers only trained one or two of the subject's muscle groups. In addition, the subjects, of these earlier studies, were totally sedentary. It seems obvious that the more sedentary a subject becomes the greater the response to training should be.

The current study utilized very active elderly subjects to prove that even active non-sedentary elderly can obtain significant benefits from exercise programs.

The current study will propose four hypothesis about the effect of training on the elderly. These hypothesis will be stated in the null and are as follows:

The 12 week weight training program will have no effect on the muscular strength levels of the male subjects.

The 12 week weight training program will have no effect on the muscular strength levels of the female subjects.

The 12 week weight training program will have no effect in increasing the percent of lean body weight of the male subjects.

The 12 week weight training program will have no effect in increasing the percent of lean body weight of the female subjects.

Chapter II

The effect of exercise on the elderly has been studied by researchers using many techniques. Exercise, just by description, can range from simple walking to training on weight machines. Each of the studies to be reviewed has its own special purpose and methods. All of these studies will utilize the elderly (50 and up) as subjects, either as the entire population or as part of the population. The methods and findings of each study will be reported with comparisons made to other studies with similar methods and results.

CARDIOPULMONARY RESPONSES

Seals, Hagberg, Hurley, Ehsani, and Holloszy (1984) showed that 11 elderly subjects could significantly increase aerobic power. They found that after six months of low intensity aerobic training (20-30 minutes @ heart rate of <120 BPM) a small but significant increase in VO2 max occurred (25.4 ml/kg/min to 28.2 ml/kg/min). After another six months of high intensity aerobic training (75-85% max heart rate), the subject's VO2 max had increased by a total of 30% (25.4 ml/kg/min to 32.9 ml/kg/min). Seals et al. attributed this increase mainly to an increase in maximal A-

VO2 difference. They saw little change in heart rate, cardiac output, and stroke volume at relative work rates, but blood pressure and systemic vascular resistance were significantly lowered. Seals et al. used CO2 rebreathing to measure cardiac output. The cardiac outputs were measured before training and at the end of each phase of training. The same work rates were used each time (50, 60, and 70% of VO2 max). Seals et al. surmised that elderly people can increase cardiopulmonary factors with prolonged aerobic exercise.

Hagberg and Graves, et al. (1989) studied the effects of isotonic training vs. aerobic training on cardiovascular responses. The subjects were divided into two training groups. The isotonic training group exercised three days/week for 26 weeks. These subjects performed one set of 8-12 repetitions on ten different weight machines. The aerobic group trained for 40 minutes at 50-75% of their VO2 max for the first 13 weeks and 75-85% of VO2 max for the last 13 weeks. Hagberg and Graves, et al. found that the aerobic group increased their VO2 max by 16% during the first 13 weeks and another 9% the second 13 weeks. The aerobic group also saw significant changes in O2 pulse, systolic blood pressure, heart rate, and perceived exertion. The changes reported were increases in O2 pulse, ventilation, and systolic blood pressure. Decreases were seen in heart rate and perceived exertion. Hagberg and

Graves, et al. saw no cardiopulmonary changes in the isotonic group. The isotonic group only saw significant increases in upper and lower body strength levels. The upper body gained 18% while the lower body gained 9% over baseline measurements.

Hagberg and Montain, et al. (1989) performed a study on hypertensive elderly subjects. The study was to determine if exercise could lower blood pressure. The subjects were divided into low intensity and moderate intensity groups. Low intensity consisted of aerobic exercise at 53% of VO2 max. Moderate intensity was at 73% of VO2 max. The two groups exercised three times a week for nine months. Hagberg and Montain, et al. found that low intensity aerobic exercise significantly lowered systolic blood pressure. The study reported a drop of 20mm Hg for systolic blood pressure and a 11-12mm Hg drop for diastolic blood pressure. The moderate intensity group saw the same decrease in diastolic blood pressure, but systolic blood pressure was not significantly lowered (8mm Hg). Hagberg and Montain, et al. did report a 28% increase in VO2 max for the moderate intensity group with no increase in VO2 max for the low intensity group. The study showed that cardiac outputs and total peripheral resistance were lowered after training. These two findings were for the low intensity and moderate intensity groups respectively. Hagberg and Montain, et al. found no change in blood plasma volumes after training.

They found no changes in plasma renin or urinary Na levels after training either.

Sagiv, Fisher, Yaniv, and Rudoy (1989) performed a study using 40 elderly subjects. These subjects were assigned to two groups, aerobic training and isometric training. All subjects exercised three days/week for 30 minutes each session. The aerobic group (running) worked at 70% VO2 max. The isometric group worked at 30% maximum voluntary contraction using a large muscle mass. Sagiv et al. found that the running exercise group had significant changes in body fat%, ejection fraction, end systolic volume, and heart rate. The ejection fraction values increased from 56 to 62%. Heart rate dropped from 73 to 65 BPM. Body fat decreased from 19.6% to 15.1%. End systolic volumes decreased from 45ml to 41ml. The aerobic group had a significant increase in VO2 max (2.08 l/min to 2.36 l/min) only when compared to the isometric group. Left ventricular end systolic volumes were also lower in the aerobic group after training. Sagiv et al. reported that systolic blood pressure and diastolic blood pressure did not change significantly between the two groups after training. Sagiv et al. concluded that aerobic training could improve physical capacity and hemodynamic parameters.

The VO2 max findings of Seals et al. (1984), Hagberg and Graves, et al. (1989), and Hagberg and Montain, et al (1989) show that the elderly can improve pulmonary function.

Sagiv et al. (1989) shows no such improvement even though his subjects exercised in the same intensity range. In earlier studies, de Vries (1970) and Benestad (1965) found no increase in VO2 max after training. These studies utilized a higher training intensity, but the training durations were much shorter. Seals et al. theorizes that the VO2 max findings are different due to the "insufficient" training stimulus of the earlier studies. Sagiv et al. found no decrease in systolic blood pressure or diastolic blood pressure, which is in contrast to Seals et al. and both of Hagberg's studies. This difference in findings can also be attributed to the shorter training in the Sagiv et al. study when compared to the Seals et al. and Hagberg studies.

MUSCLE STRENGTH AND HYPERTROPHY

In a study published in 1961, Perkins and Kaiser found that elderly people could increase their strength levels. These investigators used 20 subjects who ranged in age from 62 to 84 years. The subjects were divided into isotonic and isometric training groups. Each group exercised three times/week using 10 repetitions to max and 10 reps to 50% of max. The muscles trained consisted of plantar flexors, knee extensors, and hip extensors. Perkins and Kaiser reported a 56.88% increase in the isotonic group and a 45.82% increase in the isometric group. This initial elderly study (ages 62 and up) proved that the older population could improve physically.

Liemohn (1975) performed a study utilizing men in the age range of 41 to 83 years. Liemohn had six subjects in the 61 and up age groups. The training stimulus consisted of six weeks of isometric knee extensor, flexor and forearm extensor, flexor exercises. Liemohn found mixed results. The younger subjects showed significant increases in some of the strength test but not all of them. The older subjects had fewer significant strength test values. Liemohn surmised from his data that the trainability of the elderly may be an "individual phenomenon."

Aniansson and Gustafsson (1981) showed that the number of muscle fibers can increase as a result of training. These researchers used 12 subjects ranging in age from 69 to 74 years. The subjects performed body weight resistance movements three times/week for 45 minutes each session for 12 weeks. Muscle biopsies were taken pre and post training from the right vastus lateralis. Right knee extensor strength measurements were taken using a Cybex II dynamometer at 30, 60, 120 and 180 degrees/second. Aniansson and Gustafsson reported a significant increase in the total number of Type II fibers. Type IIA fibers constituted the bulk of this increase. A significant increase in right quadriceps strength was also reported.

However, the Type I fiber area was significantly lowered as a result of the training. Type I fiber area fell from 56.1% to 33.0%. Type IIA fiber area increased from 32.1% to 46.8% while Type IIB fiber area did not change significantly (12.6% to 16.8%). Right quadriceps strength increased in a range of 9-22% through all velocities. Aniansson and Gustafsson stated, "that the old men in the present study were as trainable, with respect to muscle strength, as young men."

Moritani and de Vries (1980) compared old subjects to young subjects. Five young (22 years) subjects and five old (62-72 years) subjects were placed on an isotonic exercise program. The training consisted of dumbbell exercises for the elbow flexors. These exercises were performed twice a day three days/week for eight weeks. The intensity was ten repetitions with 75% of one-rep maximum. The dominant arm was trained with the non-dominant arm serving as a control. Moritani and de Vries showed a significant increase in strength for both young and old groups. The young subjects gained 26 pounds in one-rep maximum while the old subjects gained 13.8 pounds in one-rep maximum. Moritani and de Vries used a measurement of the muscle activation level (EMG) to determine if neural factors or muscle hypertrophy caused the strength increases. In the old subjects, strength was reported to be mostly neural, while the young subjects showed both neural and muscle hypertrophy factors.

Mortiani and de Vries reported that cross-sectional muscle area did not change significantly in the old group, but the muscle activation level did increase significantly. The young group showed significant increases in both muscle activation and hypertrophy. Moritani and de Vries surmised that the old subjects overcame a psychological barrier to muscle stimulation. In other words, the old subjects became accustomed to contracting their muscles during the training phase of the study.

Larsson (1982) performed a similar study to that of Moritani and de Vries (1980) by using young and old subjects. Larsson had his subjects (18 males) train the knee extensor muscles. This training program involved light weights and high repetitions done twice a week for 15 weeks. The ages of the subjects ranged from 22 to 65 years. Strength levels were measured on a Cybex II dynamometer. Larsson found through muscle biopsies that Type I and Type II fiber areas increased significantly. Type I fiber area increased from 28.7% to 34.1% while Type II fiber area increased from 29.5% to 35.4%. The only other significant finding was the strength increase at 60 degrees/second. Larsson reported that most of the fiber hypertrophy occurred in the older subjects. This data conflicts with Moritani and de Vries (1980) in regards to muscle fiber hypertrophy. Larsson theorizes the difference is due to the EMG used by Moritani and de Vries since it only measures total cross-sectional area and not individual fiber size. Larsson believes his subjects did not see increases in strength due to the intensity and type of exercises performed. The light loads and high repetitions are not conducive to strength gains.

Kauffman (1985) performed a study similar to Moritani and de Vries (1980) and Larsson (1982) by comparing young subjects to old. Kauffman utilized female subjects instead of the customary male subjects of previous studies. The subjects in Kauffman's study were 10 young (20-26 years) and 10 old (65-73 years) women. The subjects performed an exercise designed to train the abductor digiti minimi. This training program was of six weeks duration utilizing two sets of 10 repetitions of maximal isometric contractions of the non-dominant abductor digiti minimi. Kauffman reported significant strength increases with a mean gain of 607g for the old group and 819g for the young group. Thus the old group gained 74.10, which is as much as the young group. Kauffman reported that the pre and post training means of each group were not significantly different. This lead Kauffman to believe that age related decline of strength may occur at a later stage in life.

Frontera, Meredith, O'Reilly, Knuttgen, and Evans (1988) executed a study involving 12 older men. The subjects ranged in age from 60 to 72 years. They were trained for 12 weeks using an isotonic exercise routine designed for the knee extensors and flexors. The training stimulus consisted of three sets of eight repetitions with 80% of the one-rep maximum performed three days/week. Subjects were re-evaluated at six weeks and 12 weeks. Muscle biopsies and computerized tomographic scans (CT scans) were utilized to determine muscle/muscle fiber area changes. A Cybex II dynamometer was used to measure peak torque. Frontera et al. reported that flexor and extensor strength increased significantly with flexors gaining 226% and extensors gaining 107.4% over baseline. Peak torque increased significantly for extensors and flexors by 10% and 18.5% at 60 degrees/second and 16.7% and 14.7% at 240 degrees/second, respectively. Total thigh area, total muscle area and quadriceps area were shown to increase significantly by CT scan after training. These increases were 4.8% for total thigh area, 11.4% for total muscle area and 9.3% for quadriceps area. The muscle biopsies were representative of the CT scan findings by showing an increase of Type I fiber area (33.5%) and Type II fiber area (27.6%). Frontera et al. reports that "strength gains in older men were associated with significant muscle hypertrophy." This statement contradicts earlier studies by Aniansson and Gustafsson (1981) who found no muscle fiber increase in Type II and a decrease in Type I fibers. Frontera et al. theorize that their study shows higher strength gains and higher muscle area increases due to the exercise intensities and measurement techniques used. Moritani and de Vries (1980) did not see the same magnitude of changes as Frontera et al., but Moritani and de Vries utilized skinfolds and circumference measurements to calculate muscle areas. Both studies do show that exercise can have positive affects for the elderly.

Hagberg and Graves, et al. (1989) looked at resistance training as a way of increasing VO2 max. Their study was partially covered in the Cardiopulmonary section earlier in this review. Hagberg and Graves et al. theorized that increased muscle mass in the elderly would increase their VO2 max. Hagberg and Graves et al. were using information reported by Fleg and Lakatta (1988) that most of the reduction in VO2 max occurring with age is eliminated if VO2 max is expressed relative to muscle mass. Hagberg and Graves et al. trained a portion of their subjects with isotonic exercises in order to determine if VO2 max could be affected. Hagberg and Graves et al. showed no significant increases in VO2 max by the resistance training group. This group did show significant increases in upper and lower body strength. Strength levels increased by 18% for upper body and 9% for lower body.

Fiatarone et al. (1990) performed the latest study on an elderly population. Fiatarone et al. used 10 subjects who were 90+ years. These subjects were residents of a center for the aged and all were very sedentary. The training stimulus consisted of eight weeks of knee extensor exercises utilizing isotonic movements for three sets of eight repetitions with 80% of their one-rep maximum. Thigh area body composition was measured by CT scans. Fiatarone et al. reported that quadriceps strength increased significantly. The subject's one-rep maximums improved 174% over baseline. The CT scans showed that four of the seven subjects tested had significant muscle area increases. The mean increases for these four subjects were: 11.5% for total muscle area; 14.5% for quadriceps area; and 10.6% for hamstring area.

DISCUSSION

It is apparent that the physical parameters of the elderly can be improved through exercise. The type of, intensity of, and duration of exercise should be determined by the physical, medical, and psychological limitations of each elderly person. It has been shown that benefits can even be obtained by persons in their tenth decade. This is truly amazing. But, it would seem that further research needs to be done in the areas of muscular strength, total lean body weight and muscle fiber hypertrophy. Of all the studies reviewed, only seven utilize the dynamic type of exercise. Progressive resistance type weight movements were used by Perkins and Kaiser (1961), Aniansson and Gustafsson

(1981), Moritani and de Vries (1980), Larsson (1982), Frontera et al. (1989), Hagberg and Graves, et al. (1989), and Fiatarone et al. (1990). Of these seven, only two used a high intensity strength building type of regimen. Frontera et al. (1989) and Fiatarone et al. (1990) are the only two studies to actually train their subjects to become stronger. The current study utilized a similar approach to the subject's training protocol which involved training stimuli in the high intensity range. The reviewed studies never looked at increases in total lean body weight. This was probably due to the fact that all of the reviewed studies only trained very selected muscle groups. The current study utilized a total body exercise program. The three major muscle groups were trained with multiple sets and reps. The third major difference of the current study and the reviewed studies is the use of sedentary subjects. All of the reviewed studies used sedentary subjects. It would be expected for a subject to make greater gains if they begin in such a depressed physical state. The current study utilized subjects who are currently in an on-going elderly aerobics program.

The current study theorizes the subjects can become stronger and grow enough lean muscle to be measured at a macroscopic level by undertaking a total body weight training program.

Chapter III

Subjects

The subjects consisted of 11 males and 9 females recruited from an on-going elderly aerobics program. Each subject was active in the fact that he/she was independent and not relying on others for any assistance. The subjects were also very active in the social environment. Many participated in regular square dance socials. The subjects were screened for orthopedic, blood pressure and other medical contraindications to weight training. All subjects chosen to participate were free from all medical contraindications or any physical impairment that might influence the values obtained from the study. The subjects were untrained with respect to weight training, but they did engage in regular aerobic dance classes prior to beginning the study.

Testing and Data Collection Procedures

One-Repetition Maximums

The subjects were each tested pre-training and post-training on six separate Cybex isotonic weight machines. These machines were the leg press, chest press, lat pulldown, calf raise, lateral raise and abdominal crunch. The pre-training test consisted of a 10-15 repetition maximum. This 10-15 repetition maximum is an amount of weight chosen so that the subject can only perform 10 to 15 repetitions to failure. From this weight and repetition data, a maximum weight can be obtained. The number of repetitions determines the percentage of the maximum actually lifted. For example, 5 repetitions equals 90% of the maximum lifted, 10 repetitions equals 80% of the maximum lifted and 15 repetitions equals 70% of the maximum. The pre-training test was performed during the week prior to the start of the 12 week training period. This initial training period was also used to familiarize the subjects with the weight machines and the procedures of following the training program.

The post-training test was performed on the last friday of the 12 week training period. It consisted of the same 10-15 repetition maximum test as before and utilized the same six machines on which training had occurred. Once again, a weight was chosen which would allow only 10-15 repetitions to failure.

The one-repetition maximums for each of the six weight machines were totalled to give a total maximum weight lifted for each subject. This data was utilized as a comparison of the pre- and post-training strength levels. Strength levels were also compared using the one-repetition maximum of each machine.

Body Composition

Skinfold measurements were taken prior to the pre-training and post-training one-repetition maximum test to determine the percentage of lean body weight. Skinfolds were taken at three sites each for males and females. Males were measured at the pectoral, abdominal and thigh sites. Females were measured at the triceps, supra-iliac and thigh sites. Lange skinfold calipers were utilized with the same person using the same calipers taking the skinfold measurements throughout the study for consistency.

Body composition was determined by using the Jackson and Pollack equations for determination of body density. The Siri formula was then utilized for the purpose of converting body density into percent fat. Lean body weight was then determined by multiplying the percent fat and total body weight to obtain the subject's fat weight. Fat weight was then subtracted from total body weight to acquire actual lean body weight.

Training

The subjects engaged in 12 weeks of 3 days/week of high intensity weight training. Each subject received a personal training regimen based on their pre-training one-repetition maximums. This program was designed to train all the major muscle groups. It consisted of core exercises and accessory exercises. The leg press, chest press and lat pulldown exercises were the core movements while the calf raises, lateral raises and abdominal crunches were the accessory movements. The leg press machine primarily trained the quadriceps, hamstring and hip flexor/extensor muscle groups. The chest press machine exercised the pectoral, deltoids, trapezius and triceps muscle groups. The lat pulldown exercise trained all of the upper back musculature, the latissimi dorsi, the biceps and the forearm muscle groups. The calf raise machine trained the gastrocnemius and soleus muscles. The lateral raise exercised the deltoids and trapezius muscles, and the abdominal crunch machine trained the abdominal muscles.

The intensity of the program ranged from 45% of maximum at the beginning to 75% of maximum for weeks 11 and 12. The average intensity of the 12 weeks was 63.5% of maximum. The sets and repetitions of the training regimen began in a muscular endurance training fashion for weeks 1 to 6 and changed to strength training during week 7 and remained that way for the last five weeks. The sets ranged from only six for the first workout to a maximum of 18/training session for weeks 7-12. The repetitions began in the 12-15 range in order to facilitate muscle endurance. As the training sessions progressed, the repetitions gradually decreased as the training intensities increased. The program was purposely designed to slowly increase the sets and training intensities in order to prevent injuries and over-training. Each training session was performed either before or after the regular aerobics class. The subjects were under no dietary guidlines or restrictions by the researchers. Each subject was allowed to consume calories as they wished.

Statistics

The data was analyzed using the vax computer at The University of Houston-Clear Lake campus. Statistical procedures were carried out utilizing SPSS software available on the vax. A repeated measures ANOVA was used to determine significance of each dependent variable. Alpha was set at .05 prior to the beginning of any data collection. All percent increases/decreases were calculated by use of the following formula: $\frac{\text{final-initial}}{\text{initial}} \times 100 =$ % of increase or decrease.

Chapter IV

RESULTS

The post-training data showed significant increases in the strength levels of all subjects. The female subjects saw an average increase of 72.2% ($p<.001$) in total maximum weight lifted. The male subjects showed an average increase of 65.1% ($p<.00001$) in total maximum weight. The average one-repetition maximum increase on each weight machine was also shown to be statistically significant. The increases in one-repetition maximum for the six weight machines are listed in table 1. The male lateral raise statistics were performed with a n = 9. Two of the subjects developed minor shoulder irritations during week two, so lateral raises were deleted from their programs.

TABLE 1: AVERAGE INDIVIDUAL WEIGHT MACHINE INCREASES

Machine	Male %	F-ratio/P<	Female %	F-ratio/P<
Leg Press	60.4	76.2/.00001	80.3	19.2/.01
Chest Press	55.7	136.4/.00001	75.3	71.3/.00001
Lat Pulldown	56.2	80.4/.00001	68.4	77.1/.00001
Calf Raises	104.33	35.4/.0001	125.3	28.8/.001
Lateral Rs.	157.4	33.7/.001	71.0	6.5/.05
Abdominal	53.5	25.8/.001	84.9	25.7/.001

The subject's body composition, after training, was shown to be reasonably close to pre-training measurements. Lean body weight increases were not statistically significant. The subjects did increase lean weight but by only 2.1% ($p<.11$) for males and 2.0% ($p<.18$) for females. Subject total body weight, for both males and females, did not vary more than one percent: males = +.45% ; females = +.74%. The average percent body fat of the female subjects decreased by only .86% while the men decreased their body fat by 5.4%.

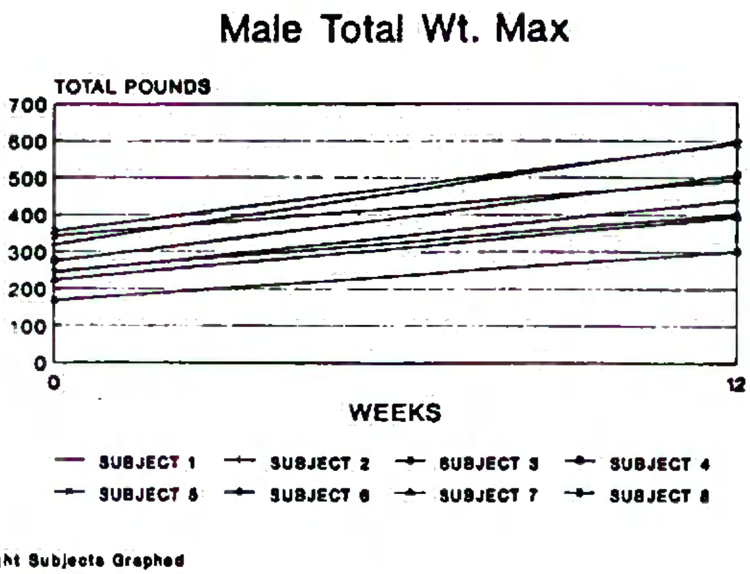
The following table shows the study data in summary form.

TABLE 2: SUMMARY OF STUDY DATA

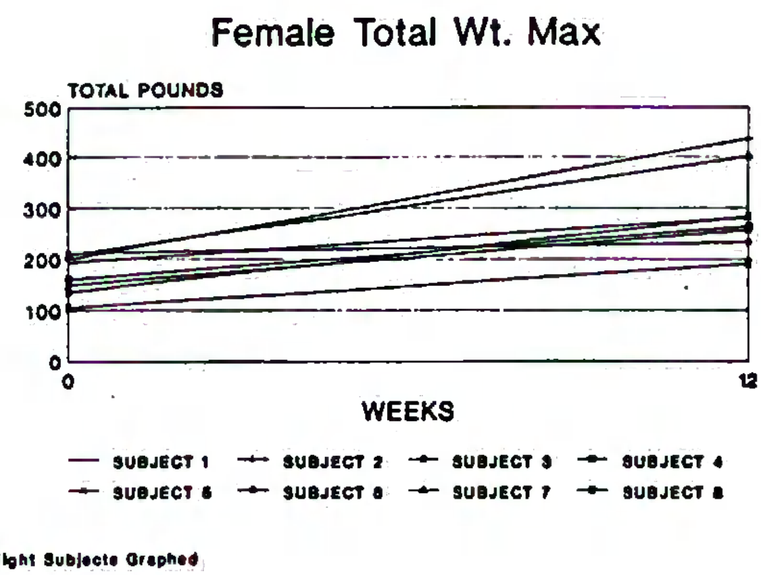
	MALES %	F-ratio/P<	FEMALES %	F-ratio/P <
Age	69.4	(range=64-81)	63.0	(range=51-71)
TBW	.45		.74	
LBW	2.1	3.08/.11	2.0	2.15/.18
% Fat	-5.4	2.9/.117	-.86	0.69/.428
TOTAL WT.	65.1	100.8/.00001	72.2	32.2/.001
Leg press	60.4	76.2/.00001	80.3	19.1/.01
Chest pr.	55.7	136.4/.00001	75.3	71.3/.00001
Lat pull.	56.2	80.4/.00001	68.4	77.1/.00001
Calf rai.	104.3	35.4/.0001	125.3	28.8/.001
Lat ra.	157.4	33.7/.001	71.0	6.5/.05
Abdominal	53.5	25.8/.001	84.9	25.7/.001

Graphs A and B show the pre and post-training total maximum weight amounts of the male and female groups. Graphs C and D show the pre and post lean body weight measurements.

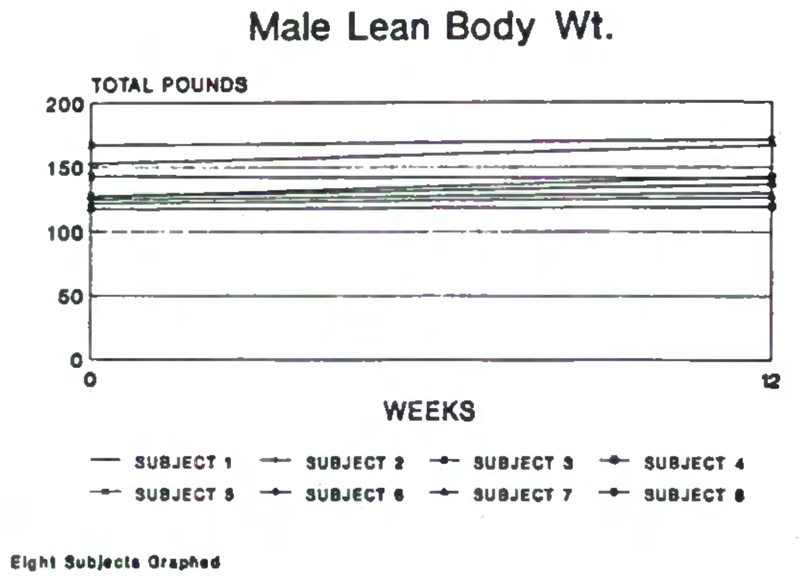
GRAPH A: MALE TOTAL MAX



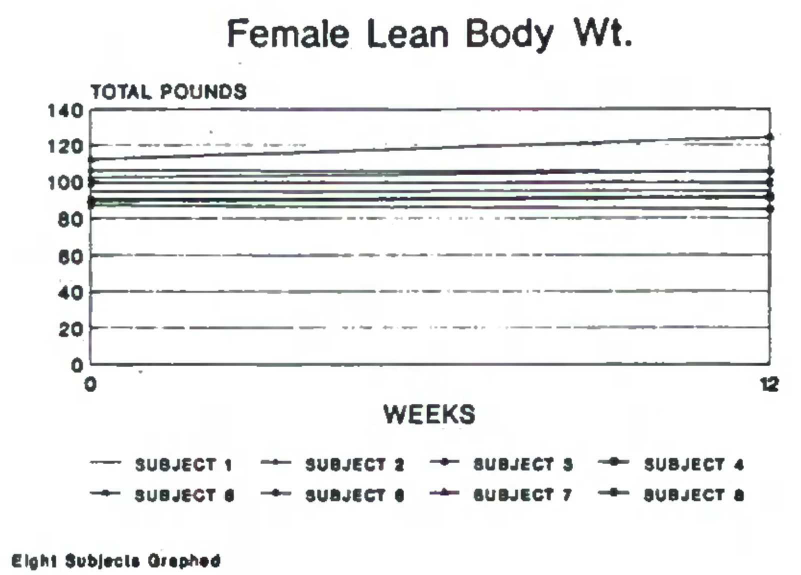
GRAPH B: FEMALE TOTAL MAX



GRAPH C: MALE LEAN BODY WEIGHT



GRAPH D: FEMALE LEAN BODY WEIGHT



The following tables list the pre-training and post-training measurements of each subject.

TABLE 3: MALE TOTAL WEIGHT MAXIMUMS

subject	pre-tr	post-tr	diff	% inc/dec
01	243	439	196	80.7
02	320	598	278	86.9
03	168	302	134	79.8
04	274	507	233	85.0
05	342	494	152	44.4
06	247	403	156	63.2
07	224	395	171	76.3
08	355	593	238	67.0
09	328	553	225	68.6
10	309	386	77	24.9
11	314	437	123	39.2

TABLE 4: FEMALE TOTAL WEIGHT MAXIMUMS

subject	pre-tr	post-tr	diff	% inc/dec
01	193	283	90	46.6
02	200	436	236	118.0
03	149	257	108	72.5
04	160	264	104	65.0
05	136	285	149	109.6
06	212	233	21	9.9
07	208	401	193	92.8
08	105	191	86	81.9
09	181	278	97	53.6

TABLE 5: FEMALE LEAN BODY WEIGHT MEASUREMENTS

subject	pre-tr	post-tr	diff	% inc/dec
01	94.26	94.73	.47	.5
02	102.36	105.47	3.11	3.0
03	87.01	84.8	-2.21	-2.5
04	88.98	90.97	1.99	2.2
05	90.22	91.78	1.56	1.7
06	105.89	105.23	-.66	-.6
07	112.03	124.48	12.45	11.1
08	99.16	98.90	-.26	-.3
09	93.07	95.2	2.13	2.3

TABLE 6: MALE LEAN BODY WEIGHT MEASUREMENTS

subject	pre-tr	post-tr	diff	% inc/dec
01	124.69	129.61	4.92	3.9
02	152.94	166.93	13.99	9.1
03	126.91	124.77	-2.14	-1.7
04	117.22	119.31	2.09	1.8
05	167.24	171.22	3.98	2.4
06	121.97	126.25	4.28	3.5
07	126.69	136.81	10.12	8.0
08	142.65	140.90	-1.75	-1.2
09	141.18	138.54	-2.64	-1.9
10	124.07	122.46	-1.61	-1.3
11	157.52	157.57	.05	.03

TABLE 7: ONE-REPETITION MAXIMUMS on CORE EXERCISES

	leg press		chest press		lat pulld.	
subject	pre	post	pre	post	pre	post
Females						
01	59	71	26	38	33	53
02	50	125	31	42	50	74
03	38	66	21	36	29	57
04	44	71	21	37	31	47
05	44	81	20	44	21	46
06	53	75	25	44	44	57
07	50	130	43	49	26	56
08	26	50	14	36	20	29
09	46	64	21	38	38	57
males						
01	63	108	43	61	39	77
02	86	150	56	88	57	100
03	50	88	25	43	25	50
04	88	143	43	77	57	70
05	86	129	56	85	63	88
06	63	121	36	64	43	72
07	63	107	39	63	33	56
08	83	150	67	103	83	114
09	72	106	56	83	72	111
10	81	97	45	65	64	75
11	93	112	57	71	64	88

Chapter V

Discussion

Strength

The number of actual studies involving elderly subjects and dynamic weight training is relatively few in number. One proposed reason by Fiatarone et al. (1990) is the reluctance of researchers to apply a high-intensity regimen to elderly subjects. This is certainly a valid reason since a researcher should always be careful not to injure or over-stress his/her subjects. The current study was designed specifically to keep injury and over-training to a minimum. The strength results may have been larger if the 12 week average intensity had been higher, but the chance of injury would certainly have been greater.

The results of the post-training test show that an active elderly population can obtain very significant strength gains. The current study's strength findings are in agreement with the results of earlier studies by Fiatarone et al. (1990), Frontera, Meredith, O'Reilly, Knuttgen, and Evans (1988) and Moritani and de Vries (1980). These earlier studies found that an elderly population can siginficantly increase strength levels in the muscle areas trained. The current study and two earlier studies [Fiatarone et al. (1990) and Frontera et al. (1988)] involved high-intensity dynamic weight training exercises and dynamic post-training testing & movements. Moritani and de Vries (1980), on the other hand, utilized high-intensity dynamic training with an isometric post-training test. This is the probable reason Moritani and de Vries saw only a 23 to 30% increase in muscular strength as compared to the much larger percentages shown in the current study and earlier studies. The specificity of training principle precludes that dynamic training movements do not increase isometric strength whereas isometric training will not increase dynamic strength.

The current study also shows greater gains than other studies of elderly subjects. The research of Aniansson and Gustafsson (1981), Larsson (1982) and Hagberg and Graves, et al. (1989) all showed little or no increase in strength. These studies utilized training intensities in the low to moderate range which is not necessarily suited to strength inducement.

The current study is the only known study to utilize a total body dynamic training regimen for an elderly population. Of the earlier studies mentioned which did utilize dynamic training, none of them trained all the major muscle groups simultaneously. Aniansson and Gustafsson (1981), Larsson (1982), Frontera, Meredith, O'Reilly, Knuttgen, and Evans (1988), Moritani and de Vries (1980) and Fiatarone et al. (1990) all studied the effects of training on one or two muscle groups only. The findings of the current study would indicate that strength increases of equal or greater magnitude of earlier studies can be obtained even when the whole body is trained. These findings are significant since the exercising public does not and should not train just one or two muscle areas. People, especially the elderly, should engage in total body training programs very similar to the regimen utilized in the current study.

It has been reported by Larsson, Grimby and Karlsson (1979) that over the normal adult life-span a 30 to 40% loss of strength can occur. The current study's results and the findings of many of the earlier studies would seem to prove the elderly can actually re-gain strength levels possessed at earlier ages. With an average increase of 72.2% for females and 67.8% for males, the current study shows that an active elderly population can become as strong as they were years before.

Muscle Hypertrophy

The results of the post-training skinfold measurements in the current study showed little change in lean body weight. Earlier studies utilizing muscle biopsies or computerized tomographic scans (CT scans) have shown significant gains in Type I and/or Type II muscle fibers. The findings of Aniansson and Gustafsson (1981), Larsson (1982), Frontera, Meredith, O'Reilly, Knuttgen and Evans (1988) and Fiatarone et al. (1990) show that muscle hypertrophy at the microscopic level is possible for an elderly population. The current study showed that lean body weight at the macroscopic level was fairly stable between pre and post-training measurements. It is possible the lean body weight increases of 2.1% ($p<.11$) for males and 2.0% ($p<.18$) for females may have had a higher degree of significance if hydrostatic weighing had been utilized. This is only speculation by the researchers since reliability in any hydrostatic test is dependent on the subject's ability to demonstrate the procedure required for repeated trials.

The minimal lean tissue increase could also have been attributed to the fact that each subject was under no dietary guidelines. The growth of lean muscle requires a daily caloric surplus. Since the subjects were eating at will, it is probable the needed amount of calories was not being ingested. The possibility of not growing enough muscle tissue to be seen at a macroscopic level may have been diminished by the reduced calorie intake. It would be advisable to repeat the current study with biopsies being taken at the major muscle areas (quadriceps, gastrocnemius, pectorals, and latissimi dorsi) in order to determine the amount of muscle growth at the microscopic level.

The current study may also have shown a higher degree of macroscopic lean body weight increases if a longer training stimulus would have been utilized. Also, the current study's lack of increase in lean body weight may be due to the subjects being more active. Since the subjects had less muscle atrophy when compared to completely sedentary subjects, the potential for muscle growth may have been diminished. Earlier studies by Moritani and de Vries (1980) showed that the elderly subjects first increased strength by neural factors. After the first six weeks of training, the strength increases were seen to be attributed to the increased size of the muscle fibers. If Moritani and de Vries' findings are correct, then the bulk of the actual tissue growth, in the current study, may have just begun to develop. Future research in this area should utilize training programs of longer duration.

Conclusion

The current study and earlier studies have demonstrated that an elderly population can improve physical and physiological characteristics with exercise. Liemohn (1975) was correct when he stated that elderly trainability is an "individual phenomenon." Each of the subjects in the current study, as with all the previous studies, showed their own "individual" performance increases. The wide range of percentage increases is a measure of the difference between each subject. It is very important to note that in virtually every study performed on an elderly population, many of the subjects improved their physical and physiological measurements. Even if progress and enhancement of physical properties is slower for some than others, exercise for an elderly population will diminish the bodily age factors which occur as the years go by.

The physical and physiological research of the elderly is currently on the rise. A promising future lies in wait for researchers wanting to determine the extent of benefit which can be obtained by an exercising elderly population. This future research should include more muscular strength and muscle hypertrophy research. The muscle hypertrophy research should be at the microscopic and macroscopic levels. A study which utilizes a longer training stimulus with muscle biopsies being taken at various intervals would be very helpful in determining exactly how, why, and when muscle tissue growth occurs in an elderly population. With only a few studies to look back on, the future researcher needs to be both creative and careful when elderly subjects are used.

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