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Changes in testosterone levels and muscular hypertrophy in women due to a strength-training program

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CHANGES IN TESTOSTERONE LEVELS AND MUSCULAR HYPERTROPHY IN WOMEN DUE TO A STRENGTH-TRAINING PROGRAM

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Changes in Plasma Testosterone and Muscular Hypertrophy in Women Due to a Strength-training Program

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The effects of a strength-training program on the hormone testosterone in females have not been investigated. Olympic-calibre female swimmers have demonstrated a significant rise in testosterone immediately following maximal exercise. Research also has found significant hypertrophy in females following a 10-week strength-training program. The current growth of women's athletics creates a need for more research on the physiology of women in athletics. This study investigated the effects of immediate exercise and an eight-week strength-training program on protein-bound testosterone levels in women.

A sample of 24 collegiate women were randomly selected from the women enrolled in Health and Physical Education class to participate in an eight-week study assessing changes in muscular hypertrophy, strength, and plasma testosterone levels as a result of a strength-training program. Subjects were randomly assigned to a control or experimental group. The experimental group subjects underwent strength training on the University Gym three days per week for the duration of the study. The control subjects maintained their individual physical activities minus any weight training. All subjects had testosterone levels measured for protein-bound testosterone by the Competitive Protein Binding technique. Blood samples were taken from the experimental group in the form of a resting level pre-test, post-exercise initial test, resting level post-training, and a post-exercise final test. The control group had pre-test and post-test levels measured. Hypertrophy was measured anthropometrically by girth and skinfold thicknesses. The strength assessments (1-RM) using a bench press, two arm underhand curls, military press, latissimus pull, leg press, leg extensors, and leg flexor lifts were observed during the pre-tests and post-tests in the two groups. Twenty subjects completed the study with attrition occurring only in the experimental group. The averages for the experimental group were compared with those for the control group (t-test, independent groups); within each group, measurements made at the conclusion of the experiment were compared with those made at its start (t-test, paired observations). The relation between testosterone level and each of the other variables was examined (Pearson product-moment).

There were no significant differences in testosterone after maximal exercise or over length of the study. Significant gains in strength and hypertrophy of the arm were noted in the experimental group, with a slight yet insignificant decrease in percent body fat. Testosterone correlations were random; they had little relation to the body composition changes that occurred.

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CHAPTER 1

INTRODUCTION AND STATEMENT OF PROBLEM

The current growth of women's athletics indicates a need for more research on the physiology of women in sports. With a major emphasis on strength training for sports, women athletes are including specific pre-season weight training programs in their training. Significant strength gains have resulted from such training programs (Brown and Wilmore, 1974; Wilmore, 1974, 1978; Oyster, 1979). These strength gains can be accompanied by changes in body composition and, sometimes, hypertrophy. The enlargement of muscle due to the increase in diameter of the individual muscle fibers is still believed to be less pronounced in women. Brown and Wilmore (1974), however, have reported significant hypertrophy in women athletes due to a strength-training program.

The dominant male sex hormone, testosterone, is of potent protein anabolic action; it is responsible for the maintenance of muscle and bone tissue and muscle hypertrophy in men (Fahey, et al., 1974). Although testosterone is secreted in much lower levels in women, elevation of this androgen is known to have visible anabolic-androgenic effects such as secondary sex characteristics and masculinization (Lunde and Hamburg, 1972).

Olympic-caliber female swimmers have demonstrated a significant rise in testosterone immediately following maximal effort exercise (Sutton, et al., 1973). These elite athletes were found to have a rise in serum testosterone from 82 $\pm$ 5 to 98 $\pm$ 5 (ng/100 ml). The changes in testosterone levels are presumably associated with the metabolic changes which occur during exercise. Normal plasma testosterone concentrations in females for a 24-hour period are 39.8 $\pm$ 11.8 (ng/100 ml) (Tyler, et al., 1975). Because testosterone has a half-life of 3.4 hours and elevated testosterone levels may persist for 30 minutes following maximal exercise (Lamb, 1974), an apparent rise in testosterone after exercise might be accounted for in other ways; for example, peripheral interconversion (the conversion of estrogen to androgens and visa versa, Killinger, 1977), or decrease in the degradation of circulating testosterone due to a decreased blood flow to the liver, which occurs during strenuous exercise. The plasma testosterone from a random sample of collegiate-aged females, however, remained unchanged following maximal exercise (Weiss, et al., 1980). Krahenkuhl, et al. (1978) found no significant relationship between the strength gains and testosterone pre-training levels in collegiate women. Such a relationship would indicate that testosterone levels affect long-term adaptation to training. At present, this has not been confirmed.

Instead of enlisting male subjects, which has been the norm with previous research, this study was conducted with women subjects. The extent to which testosterone is related to individual differences in strength and, therefore, the enhancement of performance capacities in

women is unknown; however, high testosterone measures subsequent to a strength-training program would suggest that testosterone could be a causal factor of hypertrophy and strength gains in women.

Purpose of the Study

This study investigated the effects both of immediate exercise and an eight-week strength-training program on protein-bound testosterone levels in 20 female subjects. Changes in body composition and muscular hypertrophy were monitored in order to associate the variables with plasma testosterone measures.

Hypotheses

The study was conducted to test the following hypotheses:

1. A weight training session of maximal effort will not immediately change testosterone levels. The alternative hypothesis is that weight training sessions of maximal effort will immediately change testosterone levels. $(T_1 - T_2)$ $(T_3 - T_4)$
2. Testosterone levels will not be significantly different as a result of the weight training program. The alternative hypothesis is that testosterone levels will be significantly different as a result of the weight training Program. $(T_1 - T_3)$
3. The weight training program will not effect the subject's strength. The alternative hypothesis is that strength will increase as an effect of a weight training program.

4. Hypertrophy will not result as an effect of the eight week weight training program. The alternative hypothesis is that hypertrophy will increase eight weeks later as an effect of the weight training program.

Limitations and Delimitations

Testosterone, when in the free state, accounts for the steriods' anabolic-androgenic action (and may have specific correlations with variables in this study). This form of the hormone (not bound to a protein molecule) normally occurs in very small amounts in women, and therefore, expensive to assay.

Also, due to the financial expense of testosterone assays, the sample size was moderately small. There were 24 participants in the study. Four subjects from the experimental group subsequently withdrew from the study.

The study was conducted over an eight week period. This time factor may account for less than significant hypertrophy. In comparison, in Brown and Wilmore's six month study (1974), hypertrophy did occur.

CHAPTER 2

PROCEDURE

Selection

Twenty-four women enrolled in University of Montana Health and Physical Education classes were randomly selected (using a Table of random numbers) to participate in the study assessing changes in muscular hypertrophy, strength, and plasma testosterone levels as a result of an eight week strength-training program.

In an attempt to keep study results unbiased, certain restrictions were made on individuals considered in the subject selection. Individuals who lifted weights regularly were eliminated as this activity might affect data on strength and hypertrophy. Also, any women who had recently taken oral contraceptives (Kjeld, et al., 1976; Killinger, 1977) and those who consistently ran for exercise (Kuoppasalmi, 1976; Mayes, 1980) were deleted. Both activities result in higher estrogen levels and make accurate testosterone assays impossible. These restrictions were observed throughout the study.

Subjects were randomly assigned either to a control or an experimental group. The experimental group subjects underwent strength training on the Universal Gym three days per week for eight weeks. The control group remained untrained but was not sedentary.

Training Design

Strength training was performed three days per week on alternate days using the Universal Gym. The (one week) learning phase of the weight-training program was based on the training program design used by Brown and Wilmore (1974), in which significant hypertrophy was recorded in women. After the experimental group became familiar with the weight equipment, and for the remainder of the study, emphasis was placed on high-intensity, high-volume training; that is increasing the amount of weight lifted per set when the maximum rep number (8 reps) can be performed for all three sets; (this decreases the number of reps/set to 6 reps.) when weight is increased. Weight loads were increased progressively as strength improved. All lifting sessions were preceded by a five-minute warm-up of general stretching exercises to reduce the risk of muscle injury and soreness. (Exercises of legs, back and shoulders were demonstrated and recommended to the experimental group, but individual preference was allowed.)

Lifts

For the upper body, the following lifts were performed: bench press, military press, latissimus pull, and two arm underhand curls. For the lower body, the leg press, toe raises, knee extensor and knee flexor lifts were used (see Appendix B).

Repetitions and Sets

A single warm-up set of 10 repetitions (reps) at 50 percent of 1-repetition maximum (RM) was followed by three sets of six to eight reps on each exercise. All of the reps in the sets were performed at

80 percent of 1-RM. When eight reps could be performed in each of three sets, the weight load was increased without re-assessing the new value of 1-RM.

Testosterone Sampling

Testosterone levels were measured for bound testosterone by the Competitive Protein Binding technique (CPB). Blood samples were taken by the University Health Service (see Table 1).

Table 1

Blood Sampling for Testosterone Assay

Sample extractions	Number of Samples	
	Control group	Experimental Group
Resting level (T_1)*	12	11
(pre-test)	JANUARY 16, 1981	
Post-exercise (T_2)		11
Resting level (T_3)	12	8
(post-test)	MARCH 16, 1981	
Post-exercise (T_4)		8

*T = testosterone

* All pre-test and post-test variables were tested on the above days.

samples were frozen and sent to the Endocrine Science Laboratories of Tarzana, California for Testosterone Radioimmunoassay for later analysis using the assay procedure described by Furuyama (Endocrine Science Laboratories, 1972).

All plasma samples were drawn early in the morning (between 8:00 - 9:30 A.M.) according to standard practice. Diurinal variations are not a problem with female plasma samples when measuring testosterone (Mayes, 1982). Also, the pre-tests and post-tests were taken eight weeks apart to coincide with the average menstrual cycle (28 days). Twenty-four hours prior to the plasma sampling, subjects were requested to not participate in the taking of alcoholic beverages or marijuana, as it is known to repress testosterone, making assay readings inaccurate (Mayes, 1980).

Hypertrophy, Skinfold, and Body Density Measures

Girth measurements for hypertrophy were made using an anthropometric cloth tape at the area of greatest width at the following sites: shoulders, chest, buttocks, abdomen, thigh, calf, biceps, and forearms. Also used to assess hypertrophy of the arm was the mid-upper-arm muscle circumference formula (Blackburn, et al., 1977).

MAC - (x TSF) = MAMC

where MAC = mid-upper-arm circumference (bicep girth) (cm)

TSF = tricep skinfold (cm)

MAMC = mid-upper-arm muscle circumference (cm)

All measures were taken by the same individual. Skinfold measurements to assess percent of body fat in both the control group and the experimental group were made with Lange skinfold calipers at the following

sites in accordance with Mathews (1976) and Sharkey (1980): triceps, chest, iliac, abdomen, scapula, and thigh. The average of three trials was used (Sharkey, 1980); readings were taken during pre-test and post-test periods. All test measures were taken by the same individual.

Body density and precent body fat were calculated using the under-water weighing technique described by Sharkey (1980) and outlined by Mathews, et al. (1976) for the experimental group only (see formula below). After stabilizing the readings, three more readings were averaged. All measures were taken by the same individual.

Formulas:

$$\text{Body Density} = \frac{\text{Weight in Air}}{\text{Weight in Air} - (\text{Wt. Water} - \text{Apparatus Wt}) - \text{Residual Vol} + 100}{\text{Density of Water}}$$

$$\text{Percent Fat} = \frac{495}{\text{Body Density}} - 450$$

All data was recorded by the person measuring the subject. Hypertrophy, skinfold, and body density measures were made in the Human Performance Laboratory at the University of Montana.

Strength Assessments

The strength assessments made by 1-RM on the bench press, military press, latissimus pull, two arm underhand curls, leg press, toe raises, knee extensor, and knee flexor lifts were strength specific using the best effort of three attempts. Strength measures were taken during the pre-tests and post-tests, and recorded by the experimenter.

Statistical Techniques

Paired t-test and t-tests for independent groups were employed to assess pre-treatment and post-treatment effects on testosterone, strength, and hypertrophy [t.05 (11df) ± 2.201; t.05 (7df) ± 2.365]. Pearson product-moment correlations were used to determine relationships between the testosterone readings from the pre-tests (T_1) and the post-tests (T_3), and the other variables. Relationships among testosterone, strength, and hypertrophy were examined. All statistical computations were performed using SPSS.

CHAPTER 3

RESULTS

Plasma Testosterone Test Results

The serum testosterone means for the experimental group were within a normal range (39.8 $\pm$ 11.8 ng/100 ml) for all four readings (normal range = 38.875 - 48.750 ng/100 ml). There was no significant difference in testosterone due to immediate exercise (T_1 - T_2 or T_3 - T_4). This supports null hypothesis 1. Testosterone declined from the first (T_1) to the third sample (T_3) eight weeks later, but not significantly. This supports null hypothesis 2.

The control group was slightly above the normal range for the initial testosterone measure (T_1) (51.667 ng/100 ml). The post-test reading (T_3) (44.250 ng/100 ml) was within the normal range.

Hypertrophy and Strength Data

The training program produced muscular hypertrophy of the arms in the biceps and forearm areas (anthropometrically measured) in the experimental group. Significant pre-test to post-test changes in all the strength measures for the experimental group were noted. When the t-test for independent groups was computed between the control and experimental groups, three experimental post-test strength measures (two arm underhand curls, knee extensors, and the leg press) were significantly different from the control, supporting alternative hypotheses 3 and 4 (see Table 2).

TABLE 2

Summary Table: Mean, Standard Deviation, t-test Values Pre-test and Post-Test

	Control (N = 12)			Experimental (N = 8)		
Strength: (kg)	$\bar{X}$	SD	t-test	$\bar{X}$	SD	t-test
bench press +	34.397 34.964	6.403 7.346	(-1.00)	34.870 38.414	5.170 5.858	-4.69*
knee flexor	25.326 23.625	15.603 15.970	(1.99)	25.515 28.917	13.755 11.931	-2.71*
knee extensor	44.981 42.619	6.861 7.298	(1.72)	48.194 58.825	5.387 5.522	-2.81*
latissimus pull	34.775 36.004	5.326 7.108	(1.82)	33.878 39.122	3.902 5.143	-4.08*
leg press	129.916 123.509	32.010 29.636	(1.49)	127.715 163.577	16.139 21.047	-5.75*
military press	31.279 32.224	3.260 3.366	(-1.82)	32.744 35.682	3.807 4.809	-5.60*
2 arm curl	16.821 16.348	2.259 2.624	(1.33)	17.718 20.837	2.426 3.782	-3.27*

+ 1st measure of each double-listed variable is a pretest measurement; the second is a post-test measurement

* $t_{.05}$ (11 df) $\pm$ 2.201
  $t_{.05}$ (7 df) $\pm$ 2.365

TABLE 2 (continued)

	Control (N = 12)			Experimental (N = 8)		
Hypertrophy: (cm)	$\bar{X}$	SD	t-test	$\bar{X}$	SD	t-test
biceps	26.258	2.532	(-0.90)	25.559	1.689	-2.76*
	26.458	2.155		26.352	2.173	
forearm	23.680	1.229	-3.32*	23.376	1.099	-2.55*
	24.156	1.184		23.733	1.221	
Skinfold: (mm)						
iliac	27.333	8.004	3.96*	22.025	4.924	1.84
	23.025	7.114		20.063	5.550	
scapula	20.125	5.769	3.54*	16.550	4.473	(1.25)
	17.108	4.538		15.938	3.435	
triceps	24.775	5.583	2.82*	24.112	4.332	(-0.55)
	22.908	5.179		24.612	4.897	
Skinfold % fat(+)			3.77*			(0.15)

(pg. 8-9) Reference Mathews, 1976; Sharkey, 1980. (+)

Skinfold and Percent Body Fat Data

Both groups had some skinfold decreases, and therefore percent body fat decreased over the period of the study. Decreases in the experimental group, however, were not significantly greater than the control group decreases.

Body Density Calculations of the Experimental Group

Underwater weighing techniques were used to calculate body density and percent body fat for the experimental group only. The mean body density for the group was 1.055 (for both pre-test and post-test) with a standard deviation of 0.011 to 0.009 respectively. Body density did not change significantly due to the training program. Percent body fat did not decrease (19.215, S.D. = 4.871; 19.176 post-test, S.D. = 4.137).

Testosterone Correlations with Other Variables

In the control group two significant negative correlations were noted: between T_1 and the chest skinfold measure ($r = -.5603$) and between T_1 and the two arm underhand curls ($r = -.6083$) strength 1-RM.

The experimental group had significant correlations which were all negative. Two of these negative correlations were from initial testosterone readings and strength measures: T_1 to bench press ($r = -.6689$), and T_1 to military press ($r = -.7565$). Other negative correlations were: T_3 to shoulder hypertrophy ($r = -.6694$); T_3 to calf hypertrophy ($r = -.6692$); and T_3 to percent body fat ($r = -.6668$).

Data values are tabled and located in the appendix E.

Correlations of Changes in Testosterone with Changes in the Other Variables

In the control group, three significant correlations were computed when the difference in other variables were correlated to the differences in testosterone readings (T_1-T_3). The only negative correlation noted was between T_1-T_3 and dry weight differences (t = -.5532). The other correlations for the control group were testosterone differences and leg flexor (hamstring) differences (r = .7953); and testosterone differences and abdomen skinfold differences (r = .5672).

The experimental group had four significant negative correlations noted. Because the experimental group had four testosterone readings in the study, correlations were computed between rest level testosterone differences (T_1-T_3), and post exercise testosterone differences (T_2-T_4). Correlations between both testosterone differences (T_1-T_3 and T_2-T_4) and bench press strength differences at 1-RM were noted (r = -.7711 and r = -.7209 respectively). Other correlations were thigh hypertrophy differences to testosterone differences (r = -.6627); and skinfold percent fat differences to testosterone differences (r = -.6852).

CHAPTER 4

DISCUSSION

Testosterone

The null hypothesis 1, that no increase in testosterone will occur immediately following maximal exercise, was supported. This agrees with previous research by Weiss, et al. (1980) and Krahenkuhl, et al. (1978); which demonstrated that plasma testosterone does not increase in a random sample of collegiate women following maximal exercise.

T_1 to T_3 changes were not evident as was expected supporting null hypothesis 2. The control group's testosterone level, which dropped, was the only significant testosterone change noted in the group. (The drop in testosterone within the experimental group, although not significant, was expected as plasma testosterone decreases slightly during menses and the recovery phase (Yen, 1977; see Fig. 1, p. 17). This drop may be attributed to other hormonal fluctuations during menstruation; such as peripheral interconversion (Killinger, 1977). Fifty percent of the women in the experimental group and 60% in the control group were in their recovery phase (six days following menses) during their pre-tests. In the post-tests, 50% of the women in the experimental group and control group were in their menstruation phase even though the plasma testosterone samples were taken eight weeks apart. This showed individual variance in cycle length in the experimental group for those women who menstruated.

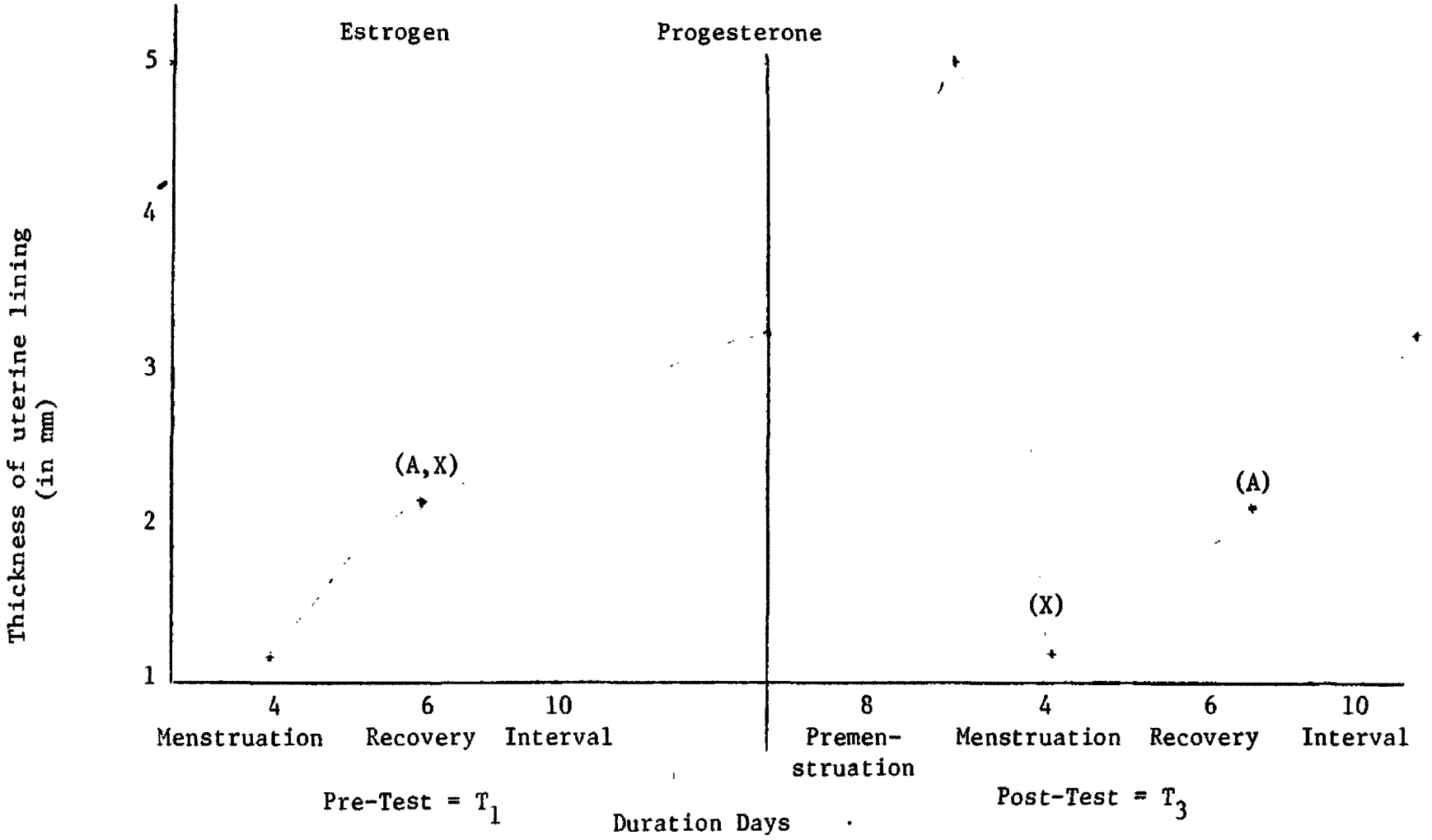

Figure 1. Menstrual cycle. The period of the regularly recurring physiological changes in the endometrium that culminate in its shedding (menstruation). Also, performance is at a peak up to 15 days after post menstruation (during Interval Phase).

PRETEST: 50% of the experimental group (X) and 60% of the control group (A) were in the recovery phase. POST-TEST: 50% of the Experimental Group.

Source:

Dorland's Illustrated Medical Dictionary (25th ed. Philadelphia, Pennsylvania: W. B. Saunders Company, 1976).

The experimental group showed significant strength gains and a significant increase in hypertrophy supporting alternative hypotheses 3 and 4 respectively, as expected. The resulting data help to support previous research by Brown et al (1974); in which both strength and hypertrophy increases were noted in women athletes. The experimental group noted significant strength increases in all of the eight lifts practiced, but primarily in the three leg exercises. The experimental group also showed a significant increase in the arm measurements - biceps and forearm (anthropometrically) for muscular hypertrophy. Body density calculated by underwater weighing techniques for the experimental group showed no significant increase. Percent body fat, calculated from skinfold measurements did not significantly decrease in the experimental, but did in the control group.

The exercise of weight lifting may not be a sufficient stressor, as swimming was in Sutton's study (1973) causing metabolic changes in Olympic caliber swimmers. Seven of the 20 subjects, five from the control group and two from the experimental group had plasma testosterone levels above the normal female range (maximum normal range 51.6 ng/100 ml) during the initial plasma sampling (see Appendix C). During the post-test testosterone sampling, four of the five control group subjects again had higher than normal testosterone levels. These samples were taken at a resting level, and therefore, were not due to maximal exercise performance. Three of the experimental group subjects including the two noted above from the initial sample, showed an increase in testosterone levels after both testosterone samples taken following the weight lifting exercise (T_2 and T_4).

Another factor which may have a bearing on the data would be that of training intensity. Subjects will all have different physiological make-up, testosterone levels, and/or somatotypes (Mathews et al. 1976). The need for maximum training effort was emphasized throughout the study. Even so, training effort for one individual may not have been as hard as another subject's effort. It is, therefore, possible that a woman with a lower testosterone level may work harder in weight training and compensate for a lower level of testosterone. A self rated perception scale used during the post-test may have proved useful.

Correlations of testosterone with all other varibles appear to be random within both groups and do not appear to relate to pre-test or post-test measures. Had testosterone assays been analyzed with both free and bound testosterone measures recorded, possible significant correlations may have been noted between testosterone and the other variables. Changes (i.e. differences in pre-test to post-test measures) in variables correlate to testosterone, appear to be random. One exception to this randomness may be the correlations between the experimental group's variables: testosterone and bench press. All of the correlations between experimental group's testosterone and bench press were computed to have a significant inversely related correlation. Correlations between changes in strength and changes in testosterone appeared random and may be due to other variables. Fahey et al. (1976) have suggested that differences in strength within each sex do not appear to be related to differences in serum testosterone. That plasma testosterone increases protein synthesis in men is well documented (Fahey et al. 1976, Lamb 1975); however, the low levels in females may not be enough to influence differences in strength.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to investigate the effects of both immediate exercise and an eight-week strength-training program on protein-bound testosterone levels in women, while monitoring changes in body composition and muscular hypertrophy. Twenty-four volunteers were randomly assigned either to a control or an experimental group. Four subjects of the experimental group subsequently withdrew from the study. The experimental group underwent an eight-week strength-training program according to the procedures of Berger (1962 a,b).

Subjects of both groups were tested initially and upon completion of the experimental group's training program for strength, hypertrophy, and skinfold. Testosterone plasma samples were assayed before and after exercise at the onset and finish of the training program. The experimental group subjects responded to the training by showing significant increases in strength and arm hypertrophy and, although not significant, a slight decrease in percent body fat.

Conclusion

The results of the study led to five conclusions:

1. There is no change in testosterone levels following a session of strength training.

2. There is no consistant significant relationship between serum testosterone level and pre-test or post-test strength.

3. Strength increased significantly following an eight-week strength-training program in the muscle groups tests.

4. In females, hypertrophy occurred in the arms following an eight-week strength-training program.

5. A higher level of testosterone naturally occurring in some females does not infer greater strength. High levels of testosterone were not necessarily associated with hypertrophy in women who trained for strength.

Recommendations for Future Studies on Serum Testosterone Levels in Females

1. An aggression-assertiveness evaluation or a masculinity-femininity assessment should be considered in future studies monitoring changes in testosterone. Several subjects were noted to have above normal serum testosterone levels. No secondary sex characteristics, as described by Lunde and Hamburg (1972) were noted. These elevated testosterone levels may, however, show their effect in some form of a masculine assessment. As an example, testosterone and aggression have been correlated in several psychological studies concerning male subjects.

2. A similar study using highly trained female swimmers (as did Sutton et al., 1973) should be conducted. A second study would show empirical evidence either in support of or against Sutton's findings. Also, this would give empirical data concerning long term training effects on serum testosterone levels in elite female athletes. Sutton reported the only reference to an increase in testosterone levels in females

(swimmers) immediately after maximal exercise. For the same reasons a comparison between elite female athletes, average athletes, and non-athletes is recommended.

3. A comparison of male and female athletes would provide valuable information concerning the relationships of testosterone to performance. This study could correlate composite body strength measure with testosterone. This would provide more information on the relationship, if any, between pre- and post-training testosterone and measures of strength and hypertrophy.

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APPENDIX A

APPENDIX A

Warm-up Stretching Exercises (With Variation)

1. Sitting Toe Touch: Performed by sitting on the floor and pulling the body forward and downward. Stretching in this area of the lower back is made more effective with the knees bent since the muscles of the back of the thigh do not limit the movement. This stretch can be done with legs straight, and/or with feet spread which then emphasizes the stretch on more of the upper back; crossing over will stretch the shoulders. (Stretches the back, buttocks, upper and lower legs.)

2. Chest Stretch: Lie face down, with legs straight, feet together, and arms together in front of the head. Raise the chest, head, and arms from the floor by arching the upper part of the chest. By pulling back with the legs while the arms grasp the ankles, the shoulders, legs, and ankles are also stretched. (Stretches chest and shoulders.)

3. Shoulder stand: Lie on the back and slowly raise straight legs in the air over the shoulders. Do not turn the head. Support the hips with the hands. Many variations can be performed: a) point toes and alternately touch toes to floor over head (stretches back of legs and back); b) spread legs to opposite sides as wide as possible (stretches inner thighs); c) flex ankles; d) when lowering legs, arch lower back - as in a back bend while still supporting hips. (Stretches legs, hip joint, upper back, and neck.)

APPENDIX B

APPENDIX B

Strength Training Program

Strength Training

The following exercises were performed on the University Gym

3 times per week, for 8 weeks by the experimental group:

PRESS STATION

Primary Muscle Groups: Pectorals (chest), Deltoids (shoulders), Triceps (elbow extensor)
General Instructions: bench and standing positions vary with exercise. Compensate for right or left hand dominance by moving weak hand out ½" to 3/4" on handles.
Action: Inhale high in the chest, hold breath and drive weights up with arms. Exhale sharply as weight approaches top, inhale down and repeat. Mentally concentrate on muscle groups involved.

Exercises

1. BENCH PRESS--Muscles: Pectorals, Deltoids, Triceps. Instructions: lie on bench, head next to machine, bend of handles above chest feet on floor. Girls--elevate bench, medium to wide grip, breathing same. Place feet flat on bench with knees bent or cross legs and pull knees to stomach (to keep back flat on bench and prevent lower back strain.) Action: Press weight up and exhale sharply, return weight with control.

SHOULDER PRESS STATION

Primary Muscle Groups: Deltoids (shoulders), Triceps (arm), Minor Muscles: Trapezius (back)

Exercises

2. FORWARD SHOULDER PRESS -- muscles: Deltoids, Triceps. Instructions: Sit facing machine, shoulders almost touch handles. Place feet inside rung of stool, so as not to push with legs. Action: Breathe high in chest, exhale top, inhale coming down (blow weight up). Watch weight throughout press--to keep back flat.

HIGH BACK STATION
Primary muscle groups: Latissimus dorsi (back), Trapezius (upper back), Teres major & minor (shoulder), Rhomboids (back), Deltoids (shoulder), Biceps and Brachialis (front & upper arm), Triceps (back of upper arm), Pectorals (chest).

Exercises

3. BACK PULL DOWN--muscles: above
Instructions: kneeling position, facing machine, directly under bar. Back straight, hips in. Wide grip on bar.
Action: pull bar down to back of neck--exhale. Inhale up high in chest as arm straightened and weight returns to starting position.

FRONT PULL DOWN--muscles: back and upper arm. Instructions: kneeling position, facing machine, directly under bar. Back straight, hips in. Wide grip on bar. Action: Tilt head back, elevate chest, pull bar to sternum. Exhale down, inhale up (blow weight up).

LOW PULLEY STATION--Optional: Use Stirrup handles or Multi-curl bar, Ankle strap, and Head harness.

Exercises

4. DOUBLE ARM CURL--(bar or handles) muscles: Biceps, Brachialis, Instructions: lying down, knees bent, back flat. Narrow grip palms facing forward.
Action: curl palms toward shoulders--bending elbows bring bar in an arc to chest--inhale up. Exhale down (blow weight down).

5. LEG PRESS STATION
Primary Muscle Groups: Quadriceps (thigh, knee extensor) including rectus femoris, vastus lateralis, vastus intermedius, vastus medialis; Psoas group (hip flexors) including psoas major and minor, and iliacus. New upper leg press station includes muscle groups listed above and the Gluteal muscle group.
General Instructions: Sit up straight, lower back against back of seat, grasp handles on side of chair (to keep from sliding).
Action: inhale high in chest, hold breath - push weight up, exhale as weight approaches top.

UPPER LEG PRESS--(upper position pedals) Instructions: position as given above, blow weight up, press maximum weight. Action: extend legs fully through knee joint from hips, return to starting position and control of weight.

THIGH AND KNEE MACHINE

Exercises

6. DOUBLE LEG EXTENSION--muscles: Quadriceps Femoris (rectus femoris, vastus lateralis, vastus intermedius, vastus medialis) of the front on upper leg. Vastus Internus Sartorius (thigh) Patella tendon. Instructions: sit upright on table, place top of foot under bottom of rollers, reach and hold onto table with hands. Action: lift both legs together. Lower weight under control to starting position and repeat.

7. DOUBLE LEG CURL--muscles: Hamstrings (biceps femoris, semimembranosus of the back of upper leg, Gluteus Maximus. Instructions: lying on stomach on table place heels under rollers, with knees in line with hinge or pin. Keep hips flat, chest down, head down, hold onto legs of table with hands. **If hips rise, you are handling too much weight. Action: pull heels as far as possible toward hips, control the weight to starting point and repeat. note: the other 35% of the knee strength is accomplished through this exercise.

APPENDIX C

Code Number:	1	2	3	4	5	6	7	8	9	10	11	12	13
Group: Control or Experimental	C		E		E	C	C	C	E	E		C	
Pre weight dry	56.136		61.364		58.295	71.932	50.568	56.591	66.250	51.488		72.386	
Post weight dry	56.18		58.182		53.409	69.886	52.273	56.364	68.182	49.545		68.636	
Pre tricep skinfold	20		30		20	30	14	29	30	24		27	
Post tricep skinfold	17.6		27		19.3	28.2	16.3	23.3	34	21.3		22.6	
Pre chest skinfold	10		6		4	10	4	7	7	8.3		9	
Post chest skinfold	4.5		7.6		4.3	9.6	5.6	12	6	6.6		8.3	
Pre iliac skinfold	20		25.5		20.3	32	11	34	32	18.5		28	
Post iliac skinfold	16.3		17.6		18	31.6	12.3	27.3	32.6	15.3		27.6	
Pre abdomen skinfold	20.3		15		14.3	27	8.6	33	34	20		20	
Post abdomen skinfold	20.5		16.3		14.6	21	10	24	35	15.6		27	
Pre scapula skinfold	15		23		11.5	21	11.5	31	24	13.6		25	

Code Number:	14	15	16	17	18	19	20	21	22	23	24
Group: Control or Experimental	E	C	C	E	C	E	C	C	C	E	C
Pre weight dry	55.682	46.364	56.591	56.023	68.750	54.205	54.659	56.477	67.386	56.705	72.273
Post weight dry	58.295	47.614	53.750	55.682	65.682	55.000	54.001	58.002	69.091	60.006	73.182
Pre tricep skinfold	17.6	20	19.3	23	32	23.3	23	30	24	25	29
Post tricep skinfold	20	16.3	18.8	23.3	28.6	24	20.3	30	23.3	28	29.6
Pre chest skinfold	6.3	8.3	10.3	7	9	8	10	8	7	8	7.6
Post chest skinfold	6.6	6.6	10	7.6	6.6	6.6	7	6.6	4.3	4.6	7.6
Pre iliac skinfold	21.6	16	32	19	38	16.3	30	32	24	23	31
Post iliac skinfold	22	11.3	30.6	16	29	18	20	23	19	21	28.3
Pre abdomen skinfold	15	12.6	24	18	25	25	18	23	20	18	17
Post abodmen skinfold	16	14.3	23.3	14	25.3	14	18.3	24	24.3	13.6	20
Pre scapula skinfold	15	16	18	15.3	26	15	14	25	21	15	18

Code Number:	1	2	3	4	5	6	7	8	9	10	11	12	13
Group: Control or Experiment	C		E		E	C	C	C	E	E		C	
Post scapula skinfold	12.6		21		12	21	11.6	23	21.3	14.3		19.6	
Pre thigh skinfold	30		36		26.5	45	20.6	40	20.6	40		40	
Post thigh skinfold	30.6		33		26	42.5	22	23.6	42.6	29.3		39	
Hypertrophy: pre shoulder hypertrophy	16		16.25		17	15.5	15.75	15.5	16.5	16.25		17.25	
post shoulder hypertrophy	16		16.5		16	15	15.5	15	16.5	15		16.25	
pre chest hypertrophy	32.5		34.75		31.5	34.5	32.5	33.75	34.25	31		34.88	
post chest hypertrophy	31.75		34		32.5	34	32.5	25.25	35	30.5		32.5	
pre buttocks hypertrophy	35		39		36.25	40	35	38.25	37.75	35.75		40.88	
post buttocks hypertrophy	35.75		37		37.5	39.25	35	38	29.75	35		40	
pre abdomen hypertrophy	32.5		34.25		30.5	37.75	30.75	36	36	30		36	
post abdomen hypertrophy	32.75		32.75		32.75	37	30.36	36	37.5	30		37.75	

Code Number:	14	15	16	17	18	19	20	21	22	23	24
Group: Control or Experimental	E	C	C	E	C	E	C	C	C	E	C
Post scapula skinfold	13	12	16	15.3	21.6	15	10.3	20.3	16.3	15.6	21
Pre thigh skinfold	21.3	30	30	35	40	40	35	40	33	40	35.6
Post thigh skinfold	27.6	28.6	30	34.3	37	34	23	40	31.6	35.3	40
Hypertrophy: pre shoulder hypertrophy	15	15	15.73	15.75	16	15	16.5	14.75	16.5	15	17.25
post shoulder hypertrophy	15.25	14.5	16.25	16.5	16	15.5	16.5	16	16.5	15.75	17
pre chest hypertrophy	33.5	30.5	32.75	30.5	33	32.5	32	31.5	36	32	35
post chest hypertrophy	34	31.5	33	30.5	32.75	32.75	32.25	32.5	34.63	33.63	35.5
pre buttocks hypertrophy	34	33.5	36.75	37.25	39.5	35.25	36.25	36.5	38.75	36.5	39.75
post buttocks hypertrophy	34	35	36.75	37.5	39.5	36	36	37.36	40.75	37	39.5
pre abdomen hypertrophy	30.36	28.5	33.25	33.25	36.75	32.25	31.25	31	33	31.5	36.5
post abdomen hypertrophy	30.5	29.75	33.5	33	37	32	31.13	33	37.5	32.25	36

Code Number:	1	2	3	4	5	6	7	8	9	10	11	12	13
Group: Control or Experimental	C	E		E	C	C	C	E	E		C		
pre thigh hypertrophy	20.5	24		23	24.85	19.75	21.75	22.5	21		25.38		
post thigh hypertrophy	21.75	23		22.5	24.75	21.13	21	23	21.13		23.5		
pre calf hypertrophy	13	14.25		14.5	14.5	13.5	12.75	13.5	14.25		14.5		
post calf hypertrophy	13.75	14		14	14.5	13.5	12.5	14	14		14		
pre bicep hypertrophy	10	11		10	11	9.75	10	11	10		10.38		
post bicep hypertrophy	10	11.25		10.75	10.75	10	10.25	11.75	11.25		10.25		
pre forearm hypertrophy	9.13	9.75		9	9.5	9	10	10	10		9.25		
post forearm hypertrophy	9.5	9.75		9.25	9.5	9.5	9.5	10	10		9.5		
strength: pre bench press	80	90		75	92.5	110	70	80	90		65		
post bench press	77.5	97.5		82.5	90	122.5	72.5	85	85		65		
pre military press	75	85		70	70	80	62.5	75	85		67.5		
post military press	80	95		80	70	80	62.5	85	85		67.5		

Code Number:	14	15	16	17	18	19	20	21	22	23	24
Group: Control or Experimental	E	C	C	E	C	E	C	C	C	E	C
pre thigh hypertrophy	20	20.25	21	21.5	23.38	20.5	22	22.5	22.75	22	24.25
post thigh hypertrophy	20	21	21	21.5	23.75	21.5	21.86	23	22.75	23.5	25
pre calf hypertrophy	14	13.13	13	13.25	15	12.5	13.25	13.25	14.86	14	16.13
post calf hypertrophy	14	13	13	13.5	15.25	12.63	13.75	13.5	15	14.25	15.25
pre bicep hypertrophy	9.25	8.63	9.25	10	11.25	10	10	10.5	11.5	10	12
post bicep hypertrophy	9.5	9	9.25	10	11.5	10	10.5	10.5	11	10.5	12
pre forearm hypertrophy	9	8.5	9	8.75	9.75	9	9	9.25	9.25	9.13	10.25
post forearm hypertrophy	9.25	8.75	9	8.75	9.75	9	9.13	9.75	9.25	9.5	10.5
strength: pre bench press	95	67.5	65	67.5	65	72.5	70	62.5	80	60	82.5
post bench press	110	70	65	72.5	67.5	75	72.5	65	75	75	82.5
pre military press	80	65	70	70	67.5	75	67.5	60	60	60	82.5
post military press	90	65	65	72.5	75	77.5	70	70	62.5	65	85

Code Number:	1	2	3	4	5	6	7	8	9	10	11	12	13
Group: Control or Experimental	C		E		E	C	C	C	E	E		C	
pre latissimus pull	70		82.5		75	87.5	107.5	72.5	70	70		67.5	
post latissimus pull	77.5		90		85	87.5	125	75	100	100		67.5	
pre curls	40		45		40	37.5	45	42.5	50	50		32.5	
post curls	35		52.5		40	35	45	45	60	60		35	
pre leg press	150		270		350	405	397	255	240	240		257.5	
post leg press	160		390		365	342.5	405	270	270	270		210	
pre knee extensor	37.5		95		175	140	145	70	80	80		80	
post knee extensor	37.5		130		177.5	135	145	55	155	110		145	
pre knee flexor	30		50		75	80	62.5	50	50	65		62.5	
post knee flexor	22.5		55		75	75	60	40	75	75		60	
pre under-water weight			6.033		6.133				5.266	6.100			
post under-water weight			6.217		5.683				5.616	6.166			

Code Number:	14	15	16	17	18	19	20	21	22	23	24
Group: Control or Experimental	E	C	C	E	C	E	C	C	C	E	C
pre latissimus pull	92.5	70	65	70	75	70	75	75	70	67.5	85
post latissimus pull	105	70	67.5	82.5	77.5	75	75	75	70	77.5	85
pre curls	45	30	30	30	35	42.5	35	42.5	35	35	40
post curls	52.5	25	30	35	35	45	35	42.5	35	40	35
pre leg press	300	320	225	270	315	270	400	240	285	247.5	287.5
post leg press	400	335	235	335	250	360	245	242.5	280	345	292.5
pre knee extensor	105	75	120	80	82.5	115	105	97.5	150	95	92.5
post knee extensor	122.5	90	110	92.5	67.5	120	95	82.5	135	130	95
pre knee flexor	70	40	62.5	45	52.5	45	60	40	80	50	60
post knee flexor	75	40	60	50	55	50	45	32.5	72.5	55	60
pre under-water weight	6.533			5.466		5.566				5.600	
post under-water weight	6.133			5.483		5.766				5.700	

APPENDIX D

TABLE 4

Means for All Variables and Mean Differences Between Pre-tests and Post-tests

Variable	Means			Difference	
	Control group (N = 12)	Experimental group (N = 8)	Combined groups (N = 20)	Control group	Experimental group
Age (years)	20.917	22.750	21.650		
Height (cm)	160.814	160.734	160.782		
Abdomen hypertrophy (cm)*	85.355	81.955	83.995	1.799	.833
	87.154	82.788	85.407		
Abdomen skinfold (mm)	20.708	19.912	20.390	.792	-2.524
	21.500	17.388	19.855		
Bench press (kg)	34.397	34.870	34.586	.567	3.544
	34.964	38.414	36.344		
Biceps hypertrophy (cm)	26.258	25.559	25.978	.200	.793
	26.458	26.352	26.416		
Body density					
Buttocks hypertrophy (cm)	95.276	92.631	94.218	.583	.635
	95.859	93.266	94.821		

(continued next page)

*Footnote: The first of each double-listed variable is a pre-test measurement; the second is a post-test measurement.

TABLE 4

Standard Deviations for All Variables and Standard Deviation Differences Between Pre-tests and Post-tests

Variable	Standard deviations		
	Control group (N = 12)	Experimental group (N = 8)	Combined groups (N = 20)
Age (years)	4.944	4.400	4.705
Height (cm)	7.046	3.551	5.778
Abdomen hypertrophy (cm)	7.472	5.368	6.772
	7.402	5.750	6.980
Abdomen skinfold (mm)	6.465	6.670	6.384
	5.188	7.187	6.236
Bench press (kg)	6.403	5.170	5.800
	7.346	5.859	6.848
Biceps hypertrophy (cm)	2.532	1.689	2.210
	2.155	2.173	2.105
Body density			
Buttocks hypertrophy (cm)	5.954	3.936	5.292
	5.184	4.444	4.953

(continued next page)

TABLE 4

Minimum and Maximum Values for All Variables Between Pre-tests and Post-tests.

Variable	Values					
	Control group (N = 12)		Experimental group (N = 8)		Combined groups (N = 20)	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Age (years)	18.000	35.000	18.000	32.000	18.000	35.000
Height (cm)	152.400	172.720	154.940	166.370	152.400	172.720
Abdomen hypertrophy (cm)	72.390	95.885	76.200	91.440	72.390	95.885
	75.565	95.885	76.200	95.250	75.565	95.885
Abdomen skinfold (mm)	8.600	33.000	14.300	34.000	8.600	34.000
	10.000	27.000	13.600	35.000	10.000	35.000
Bench press (kg)	28.350	49.895	27.216	43.091	27.216	49.895
	29.483	55.565	32.885	49.895	29.483	55.565
Biceps hypertrophy (cm)	21.407	30.480	23.495	27.940	21.407	30.480
	22.860	30.480	23.495	29.845	22.860	30.480
Body density						
Buttocks hypertrophy (cm)	85.090	103.822	86.360	99.060	85.090	103.822
	88.900	103.505	86.360	100.965	86.360	103.505

(continued next page)

TABLE 4 (continued)

Variable	Means			Difference	
	Control group (N = 12)	Experimental group (N = 8)	Combined groups (N = 20)	Control group	Experimental group
Calf hypertrophy (cm)	35.322 35.348	34.687 34.727	35.068 35.100	.026	.040
Chest hypertrophy (cm)	84.429 82.153	82.471 83.463	83.645 82.677	-2.276	.992
Chest skinfold (mm)	8.3 0 7.392	6.825 6.238	7.740 6.930	-.958	-.587
Forearm hypertrophy (cm)	23.680 24.156	23.376 23.733	23.558 23.987	.476	.357
Hamstring: knee flexors (kg)	25.326 23.625	25.515 28.917	25.401 25.741	-1.701	3.402
Iliac skinfold (mm)	27.333 23.025	22.025 20.063	25.210 21.840	-4.308	-1.962
Latissimus dorsi pulls (kg)	34.775 36.004	33.878 39.122	34.416 37.251	1.229	5.244
Leg press (kg)	129.916 123.509	127.715 163.577	129.036 139.536	-6.407	35.862

(continued next page)

TABLE 4 (continued)

Variable	Standard Deviations		
	Control group (N = 12)	Experimental group (N = 8)	Combined groups (N = 20)
Calf hypertrophy (cm)	2.695 2.319	1.661 1.469	2.307 2.001
Chest hypertrophy (cm)	4.103 6.406	3.979 4.190	4.068 5.537
Chest skinfold (mm)	1.811 2.275	1.411 1.230	1.794 1.973
Forearm hypertrophy (cm)	1.229 1.184	1.099 1.221	1.159 1.186
Hamstring: knee flexor (kg)	6.861 7.298	5.387 5.522	6.161 7.011
Iliac skinfold (mm)	8.004 7.114	4.929 5.550	7.291 6.547
Latissimus dorsi pulls (kg)	5.326 7.108	3.902 5.143	4.716 6.439
Leg press (kg)	32.010 29.636	16.139 21.047	26.276 32.822

(continued next page)

TABLE 4 (continued)

Variable	Values					
	Control group (N = 12)		Experimental group (N = 8)		Combined groups (N = 20)	
	Mininum	Maximum	Minimum	Maximum	Mininum	Maximum
Calf hypertrophy (cm)	32.385	40.957	31.750	36.830	31.750	40.957
	31.750	38.735	32.067	36.195	31.735	38.735
Chest hypertrophy (cm)	77.470	91.440	77.470	88.265	77.470	91.440
	64.135	90.170	77.470	88.900	64.135	90.170
Chest skinfold (mm)	4.000	10.300	4.000	8.300	4.000	10.300
	4.300	12.000	4.300	7.600	4.300	12.000
Forearm hypertrophy (cm)	21.590	26.035	22.225	25.400	21.590	26.035
	22.225	26.670	22.225	26.035	22.225	26.670
Hamstring: knee flexors (kg)	13.608	36.287	20.412	34.019	13.608	36.287
	10.206	34.019	22.680	34.019	10.206	34.019
Iliac skinfold (mm)	11.000	38.000	16.300	32.000	11.000	38.000
	11.300	31.600	15.300	32.600	11.300	32.600
Latissimus dorsi pulls (kg)	29.483	48.761	30.617	41.957	29.483	48.761
	30.617	56.699	34.019	47.627	30.617	56.699
Leg press (kg)	68.039	183.705	108.862	158.757	68.039	183.705
	72.575	183.705	122.470	190.509	72.575	90.509

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TABLE 4 (continued)

Variable	Means			Difference	
	Control group (N = 12)	Experimental group (N = 8)	Combined groups (N = 20)	Control group	Experimental group
Mid-upper-arm muscle circumference (cm)	18.475 19.261	17.984 18.620	18.278 19.005	.786	.636
Military press (kg)	31.279 32.224	32.744 35.862	31.865 33.679	.945	3.118
Percent body fat					
Quadriceps:knee extensors (kg)	44.981 42.619	48.194 58.825	46.266 49.101	-2.362	10.631
Scapula skinfold (mm)	20.125 17.108	16.550 15.938	18.695 16.640	-3.017	-.612
Shoulders hypertrophy (cm)	40.587 40.322	40.243 40.322	40.450 40.322	-.265	.079
Skinfold percent fat	29.500 27.292	26.688 26.563	28.375 27.000	-2.208	-.125
Thigh hypertrophy (cm)	56.806 57.256	55.404 55.920	56.245 56.721	.450	.516

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TABLE 4 (continued)

Variable	Standard deviations		
	Control group (N = 12)	Experimental group (N = 8)	Combined groups (N = 20)
Mid-upper-arm muscle circumference (cm)	1.946 1.321	.941 1.447	1.606 1.373
Military press (kg)	3.260 3.366	3.807 4.809	3.469 4.292
Percent body fat			
Quadriceps: knee extensors (kg)	15.603 14.970	13.755 11.931	14.604 15.765
Scapula skinfold (mm)	5.769 4.538	4.473 3.435	5.465 4.077
Shoulder hypertrophy (cm)	1.998 1.866	1.977 1.518	1.945 1.693
Skinfold percent fat	4.980 4.195	3.419 3.739	4.545 3.934
Thigh hypertrophy (cm)	4.675 3.733	3.390 3.000	4.169 3.440

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TABLE 4 (continued)

Variable	Values					
	Control group (N = 12)		Experimental group (N = 8)		Combined groups (N = 20)	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Mid-upper-arm muscle circumference (cm)	15.124 17.245	21.670 21.181	15.955 16.803	19.117 21.242	15.124 16.803	21.670 21.242
Military press (kg)	27.216 28.350	37.421 38.555	27.216 29.483	38.555 43.091	27.216 28.350	38.555 43.091
Percent body fat						
Quadriceps: knee extenstors (kg)	17.010 17.010	68.039 65.771	36.287 41.957	79.379 80.513	17.010 17.010	79.379 80.513
Scapula skinfold (mm)	11.500 10.300	31.000 23.000	11.500 12.000	24.000 21.300	11.500 10.300	31.000 23.000
Shoulders hypertrophy (cm)	37.465 36.830	43.815 43.180	38.100 38.100	43.180 41.910	37.465 36.830	43.815 43.180
Skinfold percent fat	19.250 20.250	36.500 32.500	24.000 23.500	33.500 35.000	19.250 20.250	36.500 35.000
Thigh hypertrophy (cm)	50.165 53.340	64.452 63.500	50.800 50.800	60.960 59.690	50.165 50.800	64.452 63.500

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TABLE 4 (continued)

Variable	Means			Difference	
	Control group (N = 12)	Experimental group (N = 8)	Combined groups (N = 20)	Control group	Experimental group
Thigh skinfold (mm)	34.933 32.325	34.475 32.762	34.750 32.500	-2.608	-1.713
Triceps skinfold (mm)	24.775 22.908	24.112 24.612	24.510 23.590	-1.867	.500
Two arm underhand curls (kg)	16.821 16.348	17.718 20.837	17.180 18.144	-.473	3.119
Weight (kg) Dry body weight	60.677 60.329	57.379 57.674	59.358 59.267		
Testosterone: T1	51.667	46.125	49.450		
T2		48.750			
T3	44.250	39.500	42.350		
T4		38.875			

TABLE 4 (continued)

Variable	Standard deviations		
	Control group (N = 12)	Experimental group (N = 8)	Combined groups (N = 20)
Thigh skinfold (mm)	6.651 7.263	7.149 5.231	6.670 6.377
Triceps skinfold (mm)	5.583 5.179	4.332 4.897	5.007 5.010
Two arm underhand curls (kg)	2.259 2.624	2.420 3.782	2.306 3.788
Weight (kg) Dry body weight	9.163 8.364	4.548 5.253	7.680 7.243
Testosterone: T1	16.827	10.288	14.515
T2		13.709	
T3	13.157	7.838	11.338
T4		9.523	

TABLE 4 (continued)

Variable	Values					
	Control group (N = 12)		Experimental group (N = 8)		Combined groups (N = 20)	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Thigh skinfold (mm)	20.600	45.000	21.300	42.000	20.600	45.000
	22.000	42.500	26.000	42.600	22.000	42.600
Triceps skinfold (mm)	14.000	32.000	17.600	30.000	14.000	32.000
	16.300	30.000	19.300	34.000	16.300	34.000
Two arm underhand curls (kg)	13.608	20.412	13.608	20.412	13.608	20.412
	11.340	20.412	15.876	27.216	11.340	27.216
Weight (kg)	46.266	72.235	51.369	66.111	46.266	72.235
Dry body weight	47.514	73.029	49.442	68.039	47.514	73.029
Testosterone: T1	22.000	79.000	32.000	66.000	22.000	79.000
T2			34.000	78.000		
T3	28.000	66.000	28.000	51.000	28.000	66.000
T4			25.000	48.000		

TABLE 5

t-tests; Pearson Product-Moment Correlations for Testosterone (T_1-T_3) and All Variables; Plus Pearson Product-moment Correlations of Changes in Testosterone and Changes in All Variables

Variable	Control			Experimental		
	t-test	Pearson Product-Moment	Correlation of Changes	t-test	Pearson Product-Moment	Correlation of Changes
Abdomen hypertrophy (cm)+	1.16	-.0667 .0393	.1594	-0.80	-.5668 .0232	-.0119 -.0614
Abdomen skinfold (mm)	-0.73	-.0311 -.1012	.5672*	1.67	-.1709 .1695	.2304 .1539
Bench press (kg)	-1.00	.2941 .2458	.0145*	-4.69*	.6689 -.6042	-.7711* -.7209*
Biceps hypertrophy (cm)	-0.90	.4594 .3198	.0326	-2.76*	-.5966 -.3195	-.0534 -.1349
Body density				-0.03	.5722 .4256	.1469 .2648
Buttocks hypertrophy (cm)	-0.91	-.0154	-.1588	-0.58	-.5218 .0482	.0248 .1273
Calf hypertrophy (cm)	-0.80	.2240	-.2263	-0.13	-.1636 -.6692*	-.1730 .1256
Chest hypertrophy (cm)	1.20	.0308 .3413	.1860	-1.35	-.5138 -.6637	-.5653 -.5246

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+Footnote: The first of each double-listed variable is a pre-test measurement; the second is a post-test measurement.

*$t_{.05}$ (11 df) $\pm$ 2.201; $t_{.05}$ (7 df) $\pm$ 2.365; $r_{.05}$ (11 df) $\pm$ .553; $r_{.05}$ (7 df) $\pm$ .666

TABLE 5 (continued)

Variable	Control			Experimental		
	t-test	Pearson Product-Moment	Correlation of Changes	t-test	Pearson Product-Moment	Correlation of Changes
Chest skinfold (mm)	1.28	-.5603* -.4381	-.1716	1.04	-.5214* .2289	.5925 .4864
Forearm hypertrophy (cm)	-3.32*	.2949 .2368	.1188	-2.55*	-.5843 .3934	-.5727 .5287
Hamstring (leg flexors) (kg)	1.99	.1744 .530	.7953*	-2.81*	-.2040 .2640	.3789 .5564
Iliac skinfold (mm)	3.96*	.0529 -.1147	.4055	1.84	-.4342 -.1512	-.1155 -.1144
Latissimus dorsi pull (kg)	-1.82	.4678 .3833	-.0369	-4.08*	-.3304 -.2733	.2788 .4327
Leg press (kg)	1.49	.2396 .2872	-.1486	-5.75*	-.1099 -.0324	-.3534 -.2953
MAMA: Mid-upper-arm muscle circumference (cm)	-2.29	.4372 .0970	.1599	-2.11	-.5002 -.2537	.3117 -.0051
Military Press (kg)	-1.82	-.0445 .2392	-.3223	-5.60*	-.7565* -.3288	.2099 .1245
Percent Body fat				0.04	-.6668*	
Quadricept - leg extensors (kg)	1.72	.4106 .3058	.4505	-2.71	-.0280 -3.38	.0516 .1853

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TABLE 5 (continued)

Variable	t-test	Pearson Product-Moment	Correlation of Changes	t-test	Pearson Product-Monent	Correlation of Changes
Scapula skinfold (mm)	3.54*	.0951 .1787	-.1137	1.25	-.6058 -.1881	-.3223 -.4661
Shoulder hypertrophy (cm)	0.63	-.2924 .1846	-.3585	-0.12	-.6694* -.1525	-.4575 -.2584
Skinfold percent fat	3.77*	.1066 .0731	.1286	.15	-.6483 -.1901	.4019* -.6882*
Thigh hypertrophy (cm)	-0.69	-.1006 .1851	-.3885	-0.72	-.5131 -.3868	-.6887* .4112
Thigh skinfold (mm)	1.55	-.0709 .2237	.3421	-1.19	.0741 -.0183	.1083 .2207
Triceps skinfold (mm)	2.82*	.1776 .3448	-.2288	-0.55	-.3943 .1642	-.3831 .1308
Two arm underhand curls (kg)	1.33	.6083* .3724	.1199	-3.27*	-.4466 -.2104	.3276 .5114
Weight (kg)	0.59	.0104 .0104	-.5532*	-0.34	-.6042 -.3523	-.5623 -.3507
Testosterone $T_1 - T_3$ $T_2 - T_4$	2.84			1.33 1.67		