PHYSICAL PERFORMANCE AND BODY FORM AS RELATED TO PHYSICAL ACTIVITY OF COLLEGE WOMEN

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Patricia Ruth Conger

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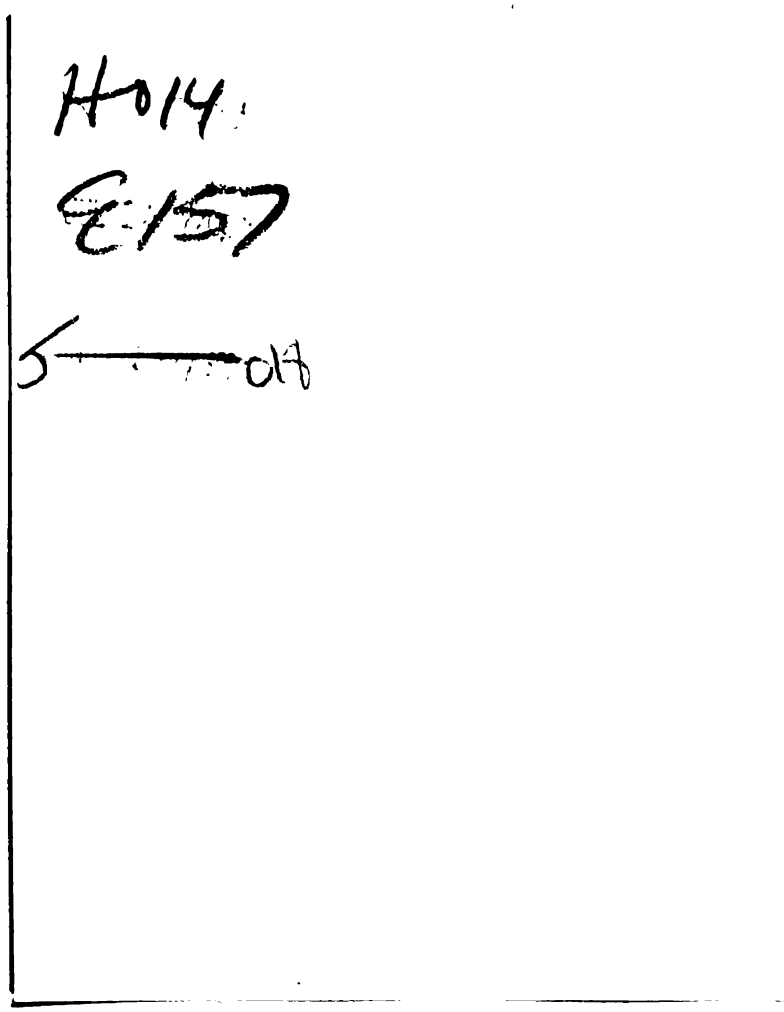
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ABSTRACT

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by Patricia Ruth Conger

Statement of the Problem

It was the purpose of this study to investigate the interrelationships of selected functional and body form measures, and to investigate the effects of habitual physical activity upon these parameters.

Procedure

Thirty-five college women ranging in ages from 18 to 22 participated in this study. Certain subjects were placed in activity groups determined by an activity-history recall questionnaire and termed "most active" and "least active". Functional measures included strength and flexibility tests; and body form measures included skinfold fat, widths, girths, height, weight, and selected derived measures. The range, mean, and standard deviation was computed for all parameters. The Pearson Product-Moment Correlation was employed to determine interrelationships of all parameters. Elementary Linkage Analysis was performed on the inter-correlation matrix for the purpose of clustering related parameters. Difference

between variances of selected parameters was determined by the F test; t tests were used to determine the difference between means of selected variables in the activity groups.

Conclusions

From the statistical analysis of data, the following conclusions were drawn:

1. Significant differences at the .10 level were found between the variances of percent body fat, specific gravity and trunk strength in the two groups.
2. Significant differences at the .05 level of confidence were found between the means of weight, lean body mass, specific gravity, arm and shoulder and trunk strength in the two activity groups.
3. No significant difference between the means of percent fat, ponderal index, hip and leg strength, total strength, shoulder flexibility, trunk flexibility, ankle flexibility, hip flexibility and total flexibility was found.
4. The most active group was heavier, had greater lean body mass, showed lower specific gravities and exhibited greater arm and shoulder and trunk strength.
5. Higher mean values for the most active subjects in all strength measurements except shoulder extension were recorded, however no significance was found.
6. Higher mean values for the most active subjects were found in all body form measures except knee width, knee, suprailiac, pubis skinfolds. These values were not significant.

7. The Elementary Linkage Analysis showed weight and hip girth as the parameters characteristic of the most variables.

Recommendations

1. A valuable tool is needed to assess habitual physical activity.
2. Examination of the results revealed a tendency for active subjects to be larger, stronger, less fat, and more flexible than sedentary subjects. Further investigation with:
   a. larger samples and an analysis of extreme activity levels, and
   b. matched groups undergoing difficult training programs is recommended.
3. A larger number of randomly selected subjects is needed to establish norms.

PHYSICAL PERFORMANCE AND BODY FORM AS RELATED TO PHYSICAL ACTIVITY OF COLLEGE WOMEN

By

Patricia Ruth Conger

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I wish to sincerely thank Dr. Janet Wessel for her guidance and assistance in the preparation of the thesis.

Gratitude is also extended to Dr. William Heusner for his interest and suggestions.

DEDICATION

Dedicated to my mother and father
for their faith and encouragement.

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CHAPTER I

INTRODUCTION

The importance of frequent and regular exercise and activity in modern day living cannot be minimized. Most authorities agree that vigorous physical activity increases ones functional efficiency and postpones the degenerate changes of the aging process. Medical authorities in the field of hygiene postulate,

> Appropriately selected exercise can result in the following favorable effects: increase in the size of muscles, increases in power, improvement of muscular control and coordination, increase in the tone of muscles, prevention of abnormal postural deformities, increase in reserve power of the heart and lungs, increased activity of the internal organs, stimulation of the growth process and action as a mental restorative, and a stimilus to mental activity. (1)

Well documented evidence exists in the literature indicating that exercise increases strength of muscles and range of motion of joints, whereas, lack of exercise causes a reduction of those qualities.

Numerous studies have appeared in the literature in recent years in functional capacity and body form. The majority of these studies have been with men and concerned with establishing normative standards in strength, flexibility and body form and relating these factors with abilities and specific sport activities. Little research was reported

identifying the effects of habitual physical activity upon body functions in men or women. No research studies were found investigating the effects of activity habitus and body form measures of women.

Purpose and Need for the Study

The primary purpose of this study was two fold: (1) to investigate the interrelationship of selected strength and flexibility and body form parameters, and (2) to investigate the effects of habitual physical activity upon these parameters.

Studies in human biological individuality are needed to enhance our understanding of human differences, to establish normative data, and to exhibit aging trends in women. By analyzing the differences in sedentary and active individuals, the values of exercise and habitual physical activity can be explored and further justified. Furthermore, information gained from observing differences in human biology as it relates to activity can be used to guide physical educators in effective program planning. It is the desire of the author that by means of this study a contribution might be made toward a knowledge, awareness and realization of the differences in body form and functional capacity with regard to level of habitual physical activity of young women.

Limitations

1. Level of habitual physical activity was assessed by a five day activity-history recall questionnaire. This was a subjective measure wholly dependent upon the individuals ability to accurately recall and record their activities for a five day period.

2. The sample was a non-randomized sample and research was based on volunteers.

3. The size of the sample was limited by practical problems.

CHAPTER II

REVIEW OF RELATED LITERATURE

Research studies reported in this chapter will be presented under three topics: (1) strength, (2) flexibility, (3) body form.

Strength

It was concluded from one study of girls in grades 1-9 that grip strength was related to anthropometric measures for all age groups studied. (26)

Another study relating strength to anthropometric measures is reported by Clarke (1954). Clarke reported a high relationship between the girth of the upper arm (flexed-tensed) and several strength test variables and arm strength criteria. Among the correlations were the following: .52 with shoulder-flexion strength; .49 with McCurdy's pulling strength test; .47 with shoulder extension strength. (6)

There have been a few studies in which groups of women physical education majors are compared with non-physical education majors with regard to physical performance. Among these is the work of Mynatt (1960) who investigated differences in these two groups on a seven item physical performance test battery. Her conclusion indicated that physical education majors were superior in performance on the entire battery. (15)

A similiar study points out that women physical education majors were superior to non-physical education majors in motor ability as measured by the jump and reach test and the Brace scale. (7)

Haymes (1962) examined quite extensively the relationships between certain anthropometric measures and certain tests of strength and motor ability among physical education majors and non-physical education majors. The anthropometric measures used were height, weight, bi-acromial shoulder width, bi-iliac hip width, neck girth, waist girth, and breathing capacity. Strength tests included grip strength, pushing and pulling strength, back lift, leg lift, and total strength. (22) The obstacle race, basketball throw for distance, and standing the broad jump comprised the motor ability tests. The results of her study is as follows:

1. Physical education majors appeared heavier and larger body builds but differences as measured by hip width/ shoulder width index was not significant.
2. Little or no difference in mean heights and hip widths.
3. Majors tended to have wider shoulders, and neck and waist girths were larger.
4. Majors had significantly higher scores on all six strength tests.
5. A substantial positive relationship was found between the ponderal index and pushing strength and a slight relationship found with pulling strength and total strength in the major group.

6. The ponderal index was not related to strength or motor ability in the non-major group.
7. Significant differences between groups were found between mean weights, shoulder width, neck girth, waist girth, breathing capacity and ponderal index.
8. Physical education majors were larger women as measured by weight, shoulder width, neck girth and waist girth than non-majors.
9. Physical education majors were stronger and had more motor ability than non-majors.

One study dealing in somatotypes and performance found that women physical education majors performed better in strength tests as compared with non-physical education majors. (17)

It would seem from the studies comparing women physical education majors to non physical education majors that the physical education majors perform better than non majors on tests of physical skill.

Flexibility

One study indicated 27 of 30 measures of flexibility significantly increased with activity. It was further noted that flexibility is not particularly related to age, but to a specificity of the skill involved. (11)

In testing differences in flexibility in groups of athletes and non-athletes, Fisher (1938) found athletes to be generally superior to non-athletes. (23)

Further relating flexibility to activity, Kingsley (1952) found significant increases in 18 of 30 flexibility measures employed before and after a 20 week tumbling unit. (24)

Betty McCue (1952) analyzed the flexibility of college women in which she tested twelve joint movements. The women studied were physical education majors and non-physical education majors. She divided these women in two activity groups determined by a questionnaire. These two groups were termed "most active" and "least active". Eight flexibility measures were taken and it was found that three of the measures were statistically significant at the .01 level of confidence and five measures were statistically significant at the .05 level of confidence. No significance was found in the major-non-major groups. (25)

An additional study by McCue (1953) in which she administered five tests of flexibility to college women before and after a mild exercise period lasting three weeks showed significant increases in flexibility. Eight weeks after the completion of the exercise period three of the five movements remained at significant difference levels. (13)

Relating flexibility to anthropometric measures, it was noted that no significant relationships existed between three tests of flexibility adapted from Kraus-Weber floor touch test, Wells sit and reach test and Leighton's flexibility tests and three anthropometric measures (distance from the greater trochanter to the floor, standing reach and standing height). (12)

Body Form

Edwards (1951) showed a relationship between body weight and total subcutaneous tissue thickness and explained that an adult female 64 inches tall would have no subcutaneous fat at eighty pounds and with an increase in weight above this, the amount of subcutaneous fat increases proportionately with weight. (8)

When examining fat weight and fat placement in women it was indicated that the median weight for fat was 13.7 kg. and the percentage of fat for women was 23.7% of their body weight. (9)

Charlotte Young and associates (1961) are responsible for much of the work in body form of young women. When correlating skinfold thicknesses they found that sites on the lower trunk, especially the pelvic region (pubis measurement) had a correlation of .9020 with total skinfold thickness. Correlations on other lower trunk positions, supra-iliac, umbilicus, and waist, were also high but slightly less. Of the upper trunk measurements, that of the lower ribs correlated best with total skinfold, the relationship being .8883. (20)

Measuring density or specific gravity of the body is considered the most reliable indirect means of estimating body fatness. This was a conclusion drawn from an additional investigation by Young and her associates (1962). When correlating skinfold with specific gravity, the

relationship was .6518; skinfold correlated with percentage of standard weight was .7133. The relationship between determined specific gravity and specific gravity based on the formula derived in the study was .6990. When standard weight is included as a variable there is no significant advantage in predicting specific gravity by using twelve, six, or two skinfolds over using one. (21)

Few studies were reported examining the interrelationships of anthropometric measures.

Reynolds (1950) found the calf girth-weight relationship to be -.79. (18)

Turner (1943) related weight to height, hip width, chest depth, chest width, and shoulder width and found an r of .8195. He further related weight to bi-acromial, bi-iliac, bi-trochanter widths and wrist, knee and ankle girths and found an r of .81. (19)

CHAPTER III

METHODOLOGY

The measures in this study were obtained on thirty-five college women at Michigan State University. The subjects were selected from women participating in the major and required physical education programs. The research relied on volunteer subjects whose ages ranged from eighteen to twenty-two.

General Procedure

Each subject reported to the laboratory at two time intervals of one hour in length. Each appointment was made at the subjects convenience. At one appointment the body form measures were taken and at the remaining appointment the functional capacity measures were taken. Each subject was given an activity history recall questionnaire at the first appointment and instructed to keep an accurate record of activity during a five day period.

The functional capacity measurements were taken with the subject wearing shorts, blouse, socks and tennis shoes. The body form measures were taken with the subjects clothed in underwear. Sample selection of clothing and shoes were measured and used as a correction factor in calculating relative weight.

Where measurements were limited to one side of the body, the dominant side was selected. All measurements were taken by the author with an assistant.

Specific Procedures

Strength

The T5 Cable Tensiometer was used for all tests. The strength tests included: shoulder extension, elbow extension, ankle extension, elbow flexion, shoulder horizontal flexion, hip flexion, hip extension, shoulder flexion, trunk flexion, trunk extension, knee extension, in the order administered. Measures were taken at least twice at each site according to instructions outlined by Clarke (1953). (3) If the second measure differed from the first by more than 2.0 points additional measures were made until two of the measures differed by not more than 2.0 kg. when corrected. The first of the two measures differing by not more than 2.0 kg. were averaged and recorded.

Flexibility

The Leighton Flexometer was used for all measures of flexibility. The procedure for testing trunk flexion, trunk extension, ankle flexion, and ankle extension was similar to that of Leighton (1955), with the exception that separate measurements were recorded for flexion and extension, as opposed to the full range of motion. (10) The procedure for testing the balance of the flexibility measures was adapted from information obtained from verbal

discussions at the University of Michigan. Two trials of each movement were allowed and in the case of a difference of more than three degrees, a third trial was allowed. If the third measurement differed by more than three degrees, additional measures were taken until two of the measures differed by not more than three degrees. The first two measures differing by not more than three degrees were averaged and recorded. The body line for the adapted flexibility measures is shown in figure 1.

Shoulder Flexion (Figure 2). -Shoulder flexion is measured with the subject lying in a supine position on a table with the dominant shoulder joint over the edge of the table to provide maximum flexion of that joint. The flexometer is attached to the upper arm midway between the elbow and shoulder joint with the dial pointing forward and locked. The subject's hand is resting on the side of the thigh. The subject is instructed to raise the hand with the thumb held up and the elbow straight to maximum reach. The subject's hand and elbow must be held in the correct position throughout the movement. The examiner should guide the arm through the motion, preventing rotation of the shoulder joint. When maximum reach has been attained the pointer is locked, the subject relaxes, and the reading on the flexometer is recorded.

Shoulder Extension (Figure 3). The position of the subject and the attachment of the flexometer is that

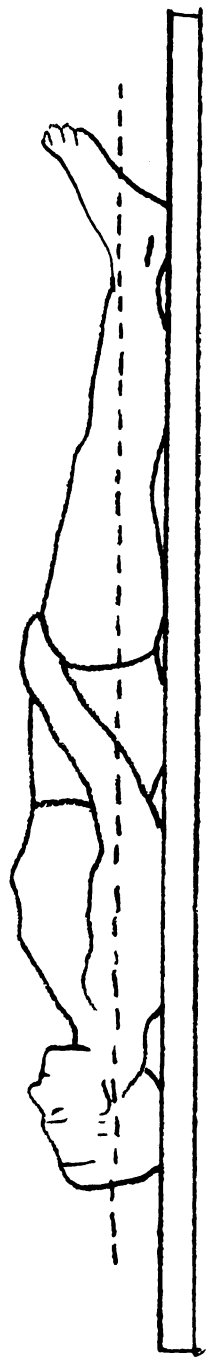

Figure 1. 0° Body Line.

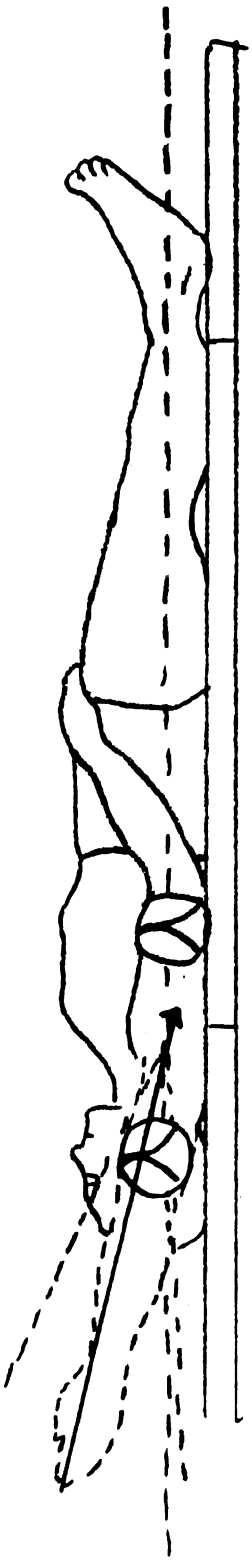

Figure 2. Shoulder Flexion.

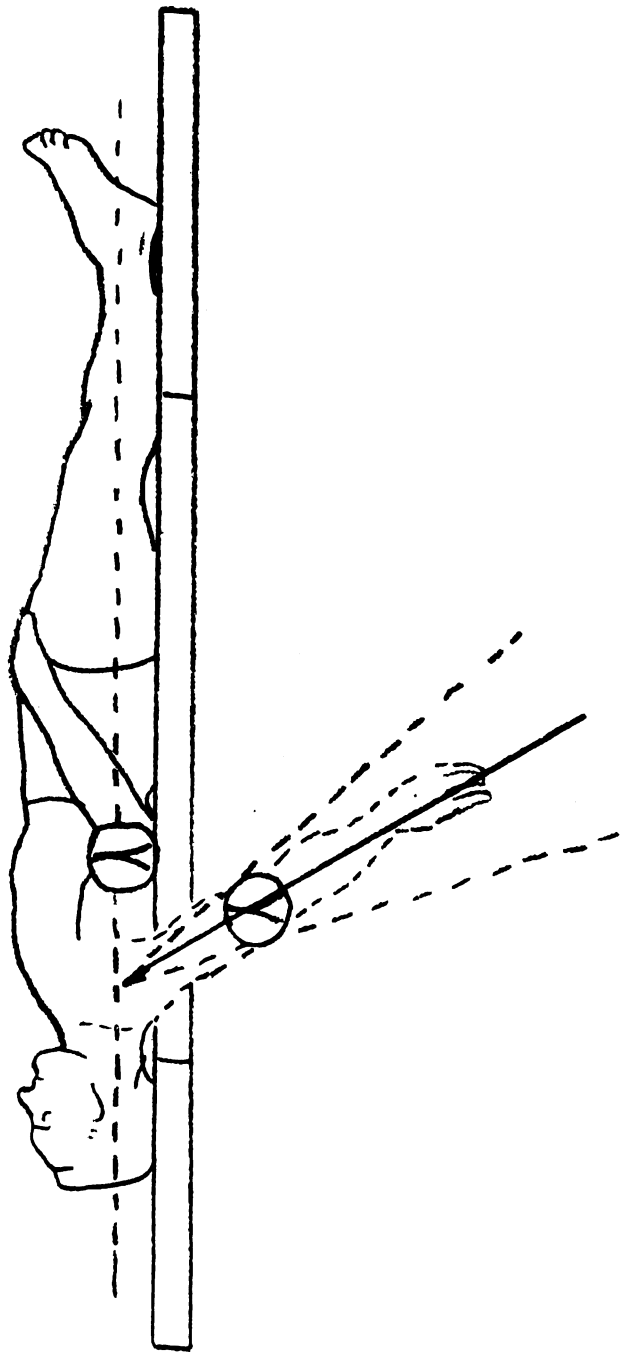

Figure 3. Shoulder Extension.

described for shoulder flexion. The subject is instructed to extend the hand downward, with the thumb held up and the elbow straight to maximum extension. The examiner should guide the hand and elbow through the movement, keeping the arm in the correct position and preventing any rotation of the shoulder joint. When the maximum reach has been attained the pointer is locked, the subject relaxes and the reading on the flexometer is recorded.

Shoulder Inward Rotation (Figure 4). The measurement is taken with the subject lying in a supine position on the table with the dominant shoulder joint over the edge of the table. The upper arm is raised horizontally to a 90° angle, the forearm raised vertically with the elbow at a 90° angle, the palm of the hand facing toward the feet. The flexometer is attached to the side of the forearm midway between the elbow and the wrist, the dial of the flexometer facing toward the examiner and locked. The subject is instructed to rotate the forearm downward and backward as far as possible. The examiner guides the forearm through the movement, keeping the arm in the correct position and preventing the upper arm from raising or lowering. The subject's shoulder and elbow must remain at 90° angles throughout the movement. When maximum rotation has been attained, the pointer is locked, the subject relaxes and the reading is recorded.

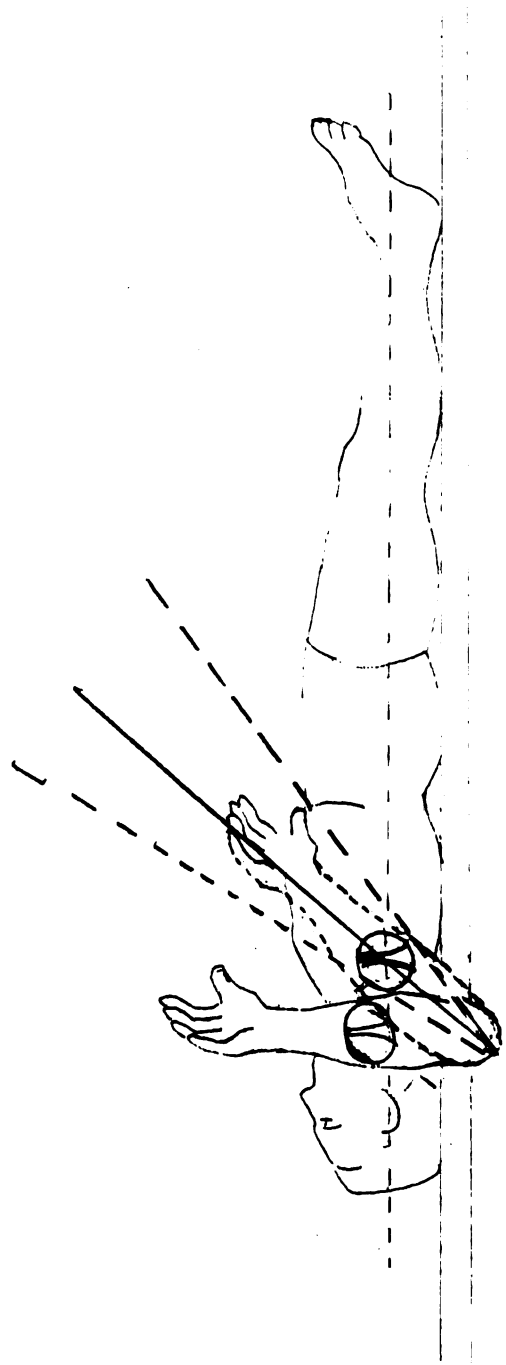

Figure 4. Shoulder Inward Rotation.

Shoulder Outward Rotation (Figure 5). The position of the subject and the attachment of the instrument is that described for shoulder inward rotation. The subject is instructed to rotate the forearm back toward the head as far as possible. The examiner guides the forearm through the movement, keeping the arm in the correct position and preventing the upper arm from raising or lowering. The subject's shoulder and elbow must remain at 90° angles throughout the movement. When maximum rotation has been attained, the pointer is locked, the subject relaxes and the reading is recorded.

Hip Flexion (Figure 6). This measurement is taken with the subject lying in a supine position on a table with the hands resting palm down at the sides. The flexometer is attached to the dominant thigh, midway between the knee and trochanter, with the dial at the outside of the leg. The subject is instructed to flex the hip bringing the knee toward the head. The knee is bent at a 90° angle. The position of the rest of the body is held stable by the examiner. When maximum flexion has been attained, the pointer is locked, the subject relaxes, and the reading on the flexometer is recorded.

Ankle Flexion (Figure 7). This measurement is taken with the subject sitting upright on the table, with the dominant foot extended beyond the end of the table and held upright at 90°. The flexometer is attached to the instep of

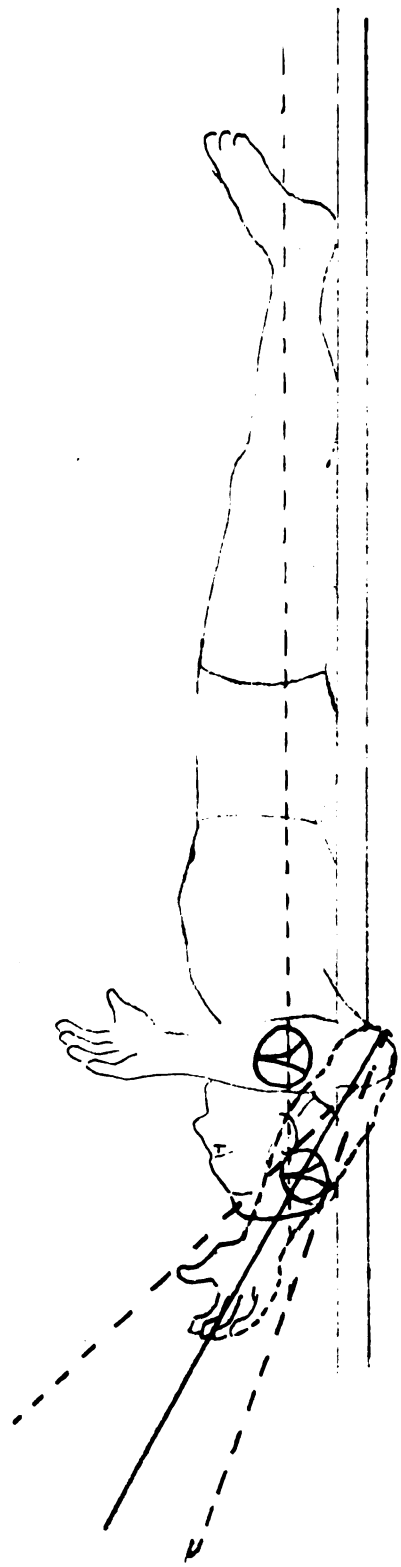

Figure 5. Shoulder Outward Rotation.

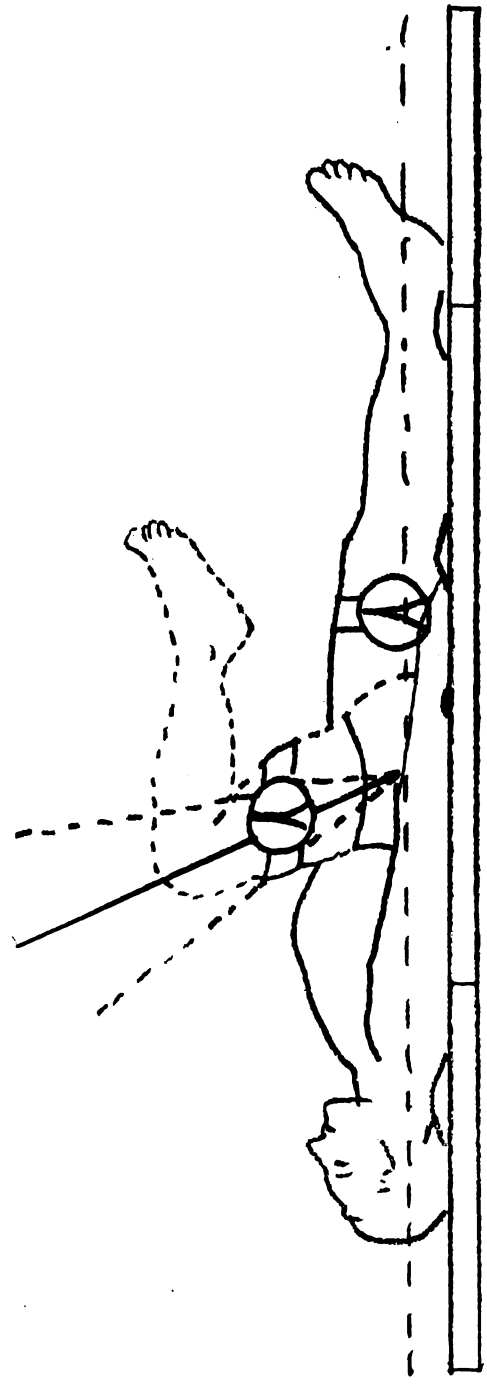

Figure 6. Hip Flexion.

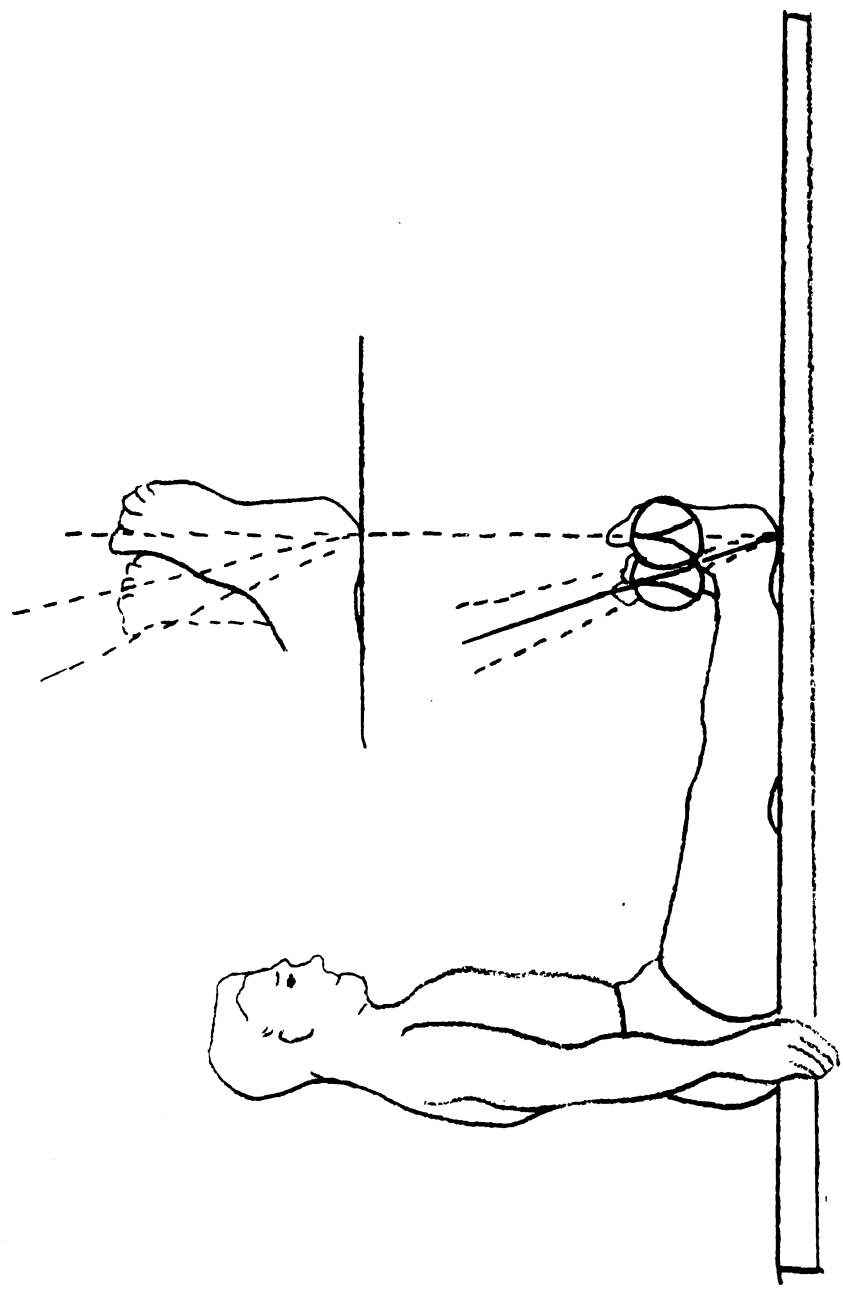

Figure 7. Ankle Flexion

the foot, the dial on the outside of the foot. The subject is instructed to flex the ankle toward the head as far as possible. The examiner should prevent the knee from bending and should hold the body position stable. When maximum flexion is reached, the pointer is locked and the subject relaxes. The reading on the flexometer is recorded.

Ankle Extension (Figure 8). The position of the subject and the attachment of the instrument is that described for ankle flexion. The subject is instructed to extend the foot downward as far as possible. The examiner should prevent the knee from bending and hold the body position stable. When maximum extension is attained, the pointer is locked, the subject relaxes, and the reading is recorded.

Trunk Flexion (Figure 9). This measurement is taken with the subject in a standing position, feet together and parallel. The flexometer is attached to the upper trunk with the strap of the flexometer at the level of the arm pits and the dial at the side of the trunk. The subject is instructed to bend forward at the waist, with the arms held overhead as far as possible. The examiner should prevent the subject's knees from locking or bending, and prevent any lateral movement of the trunk. When maximum flexion is attained, the pointer is locked, the subject relaxes and the reading is recorded.

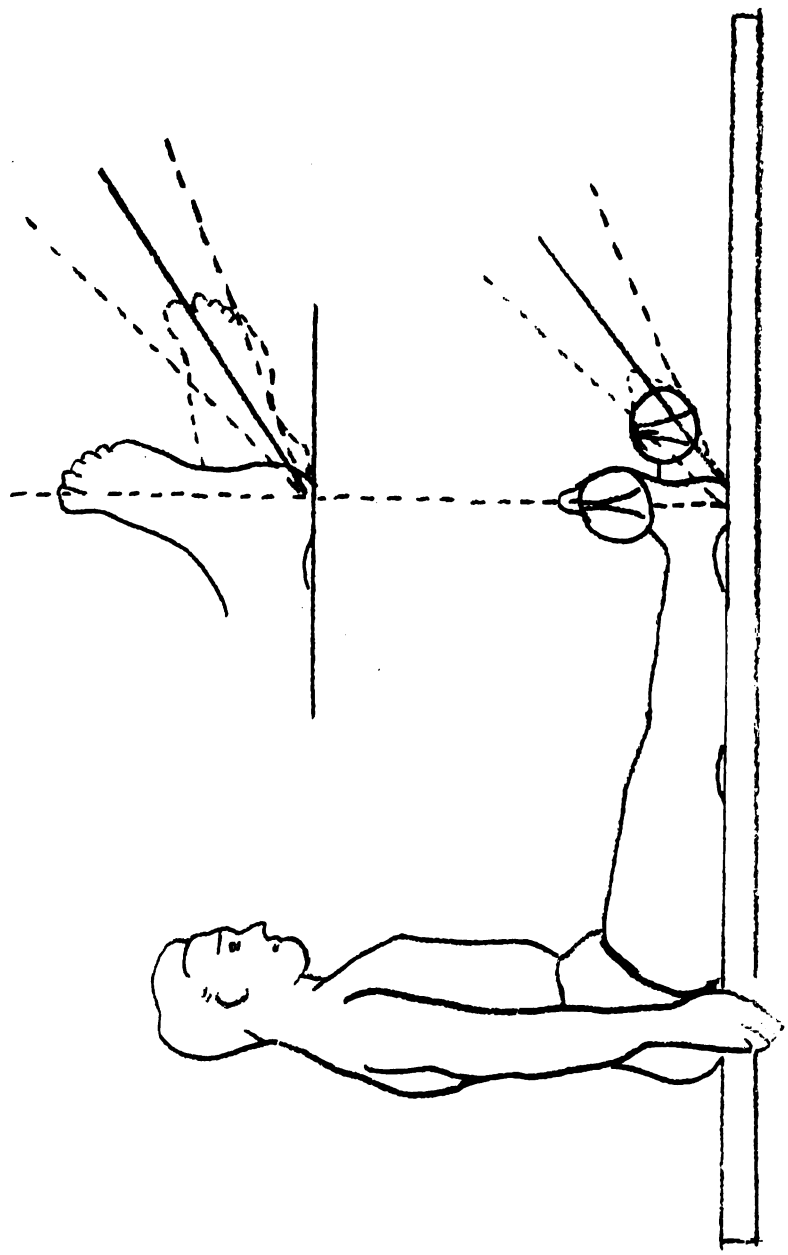

Figure 8. Ankle Extension

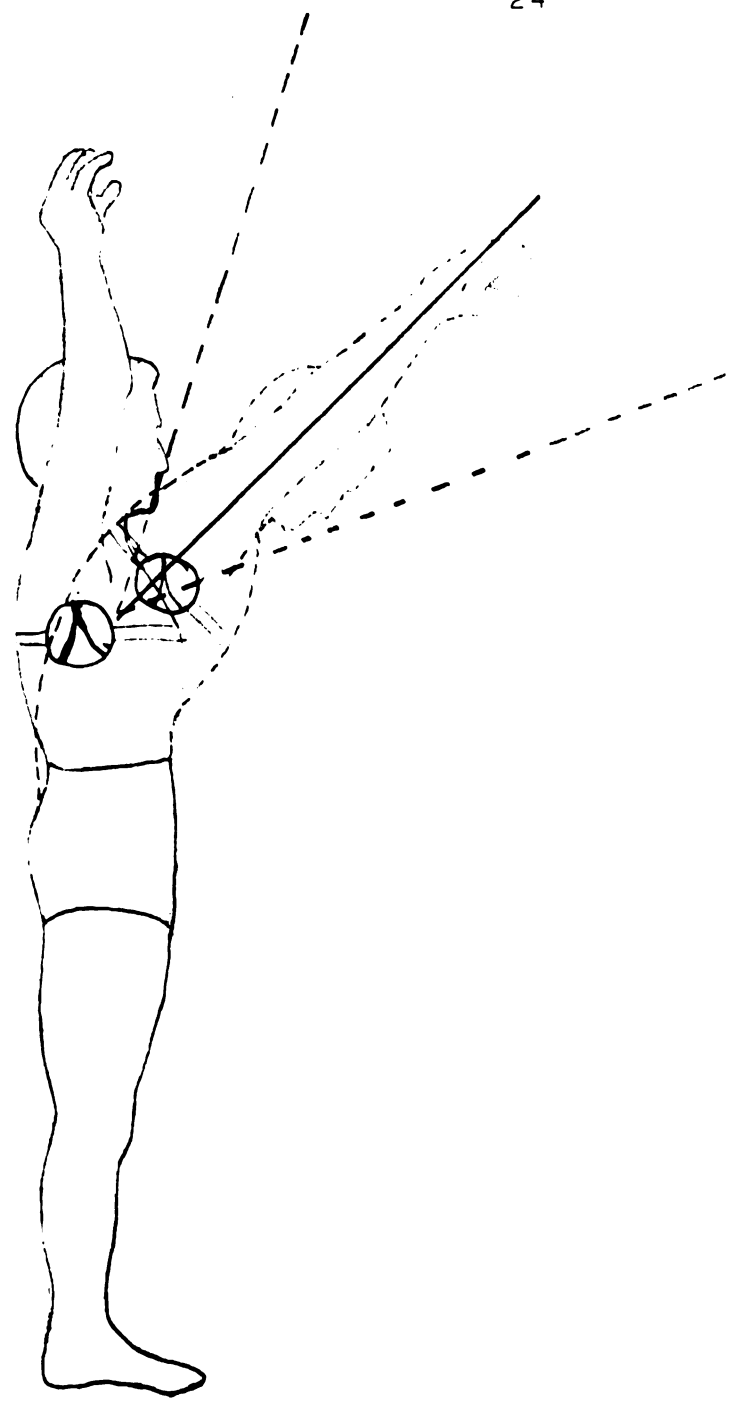

Figure 9. Trunk Flexion.

Trunk Extension (Figure 10). The position of the subject and the attachment of the flexometer is that described for trunk flexion. The subject is instructed to bend backward as far as possible with the arms held overhead. The examiner should prevent the subject's knees from bending and prevent any lateral movement of the trunk. When maximum extension has been reached, the pointer is locked, the subject relaxes and the flexometer reading is recorded.

Height and Weight

Each subject's height was measured with the subject standing against a rigid platform on which a calibrated centimeter scale was attached. A triangle was placed against the calibration on the backboard above the head of the subject. It was brought down until it fitted firmly against the top of the subject's head. The reading was taken at the lower edge of the triangle. Height was recorded to the nearest quarter centimeter. Weight was recorded to the nearest 100th kilogram. The correction factors of one inch and two pounds were added to each subject's height and weight in order to make the figures in the present study comparable to the height and weight presented in the Build and Blood Pressure Study (1959) since these figures include indoor clothing and shoes. (2)

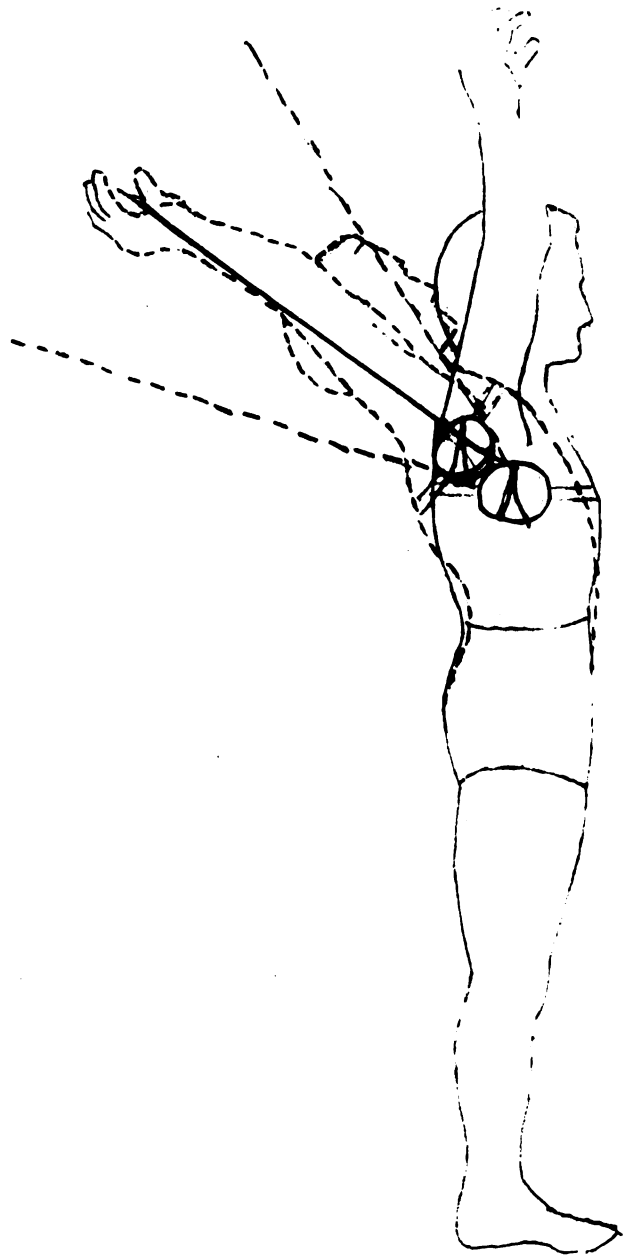

Figure 10. Trunk Extension

Skinfolds

The Lange skinfold caliper was used for all skinfold measures. The caliper was calibrated to exert a pressure of ten grams per square millimeter of jaw surface. Three successive measures were taken at each site. The skinfold thickness was determined by an average of the three measures, converted to millimeters and recorded. All measures except the umbilicus and pubis were taken with the subject standing relaxed. The umbilicus and pubis skinfolds were taken with the subject in a supine position. The technique for measuring skinfold fat was that recommended by the Committee on Nutritional Anthropometry of the Food and Nutrition Board of the National Research Council (1956). (4) The skinfolds included: triceps, scapula, chest, lower ribs, waist, supra-iliac, knee, umbilicus, and pubis.

Bony Widths

The sliding caliper (vernier) was used for all width measurements except chest depth which was measured by a spreading caliper, calibrated in millimeters. Three successive measures were taken at each site, the final recorded measurement determined by an average of the three measures. The measurement was converted to centimeters and recorded. All measurements were taken with the subject standing in a relaxed position. The technique followed that referred to for skinfold measures. The width measures

included: humerus, bi-acromial, bi-iliac, bi-trochanter, knee, chest width, and chest depth.

Girths

All girth measures were taken with a steel flexible tape measure. Three successive measurements were taken at each site. The average of the three was recorded in centimeters. All measurements were taken with the subject standing. The technique was that referred to for skinfold measures. The girth measures included: upper arm tensed, upper arm relaxed, chest (ax), waist, abdomen, hips, thigh, and calf.

Derived Measures

Percent standard weight was computed by dividing the predicted weight into the actual weight. The predicted weight was obtained from the Body Build and Blood Pressure Study (1959).

Specific Gravity was obtained by the formula devised in the Young study (1962). The formula is as follows:

S.G. = 1.0884 - .0004231(x1) - .0003401(x13)

x1--pubis skinfold

x13--percent standard weight

Percent fat was determined from a conversion table of values of specific gravity to fat content on the basis of the equation:

%fat = 100 (5.548/(specific gravity) - 5.044)

Pounds fat was determined by multiplying percent fat by weight (kg.). Lean body mass was determined by subtracting the pounds fat (kg.) from the weight (kg.).

Ponderal index was recorded as height divided by the cube root of weight.

Habitual Physical Activity

An activity--history recall questionnaire was adopted to assess habitual physical activity. Each subjects' activities were recorded over a consecutive five day period and classified as to type, i.e. mildly active, moderately active, and active. Energy expenditure was obtained by assessing an average value to each activity class and was calculated for each subject in terms of calories per hour per body weight. (16) The "most active" group consisted of the women (top nine) whose average energy expenditure over a five day period was the highest. Conversely, the "least Active" group included those women (bottom nine) whose average energy expenditure over a five day period was the lowest.

Statistics Employed

1. Mean, standard deviation and range was calculated for all parameters of all subjects and activity groups.

2. Pearson Product-Moment Intercorrelation between all parameters was computed for all subjects.

3. Elementary Linkage Analysis for Isolating Orthogonal and Oblique Types and Typal Relevancies was performed on the inter-correlation matrix. (14)

4. The F test of significance between variances in selected parameters of activity groups was determined.

5. The t test of significance between means in selected parameters of activity groups was determined.

CHAPTER IV

ANALYSIS OF DATA

All subjects completed an activity history recall questionnaire in which they recorded their activity for a consecutive five-day period. The subjects were listed in rank order according to the average energy expended in activity over the five-day period. The top nine and bottom nine subjects were placed into two groups termed "most active" and "least active".

Comparative Data of Body Form Measures

The means, standard deviations and ranges of the body form measures found in this study and comparable data reported in Young's study for young women are presented in Table I. In general the body form data of this study is similar to those reported by Young et al. (1961). (20) It was observed that:

1. Largest girths were found at the hip, abdomen and chest, respectively. Differences found in chest and abdominal girths were due to the location of the measurement.

2. Largest body widths were found at the bi-acromial and trochanter sites. The bi-iliac width showed the greatest difference.

3. Largest skinfolds were found at the umbilicus, pubis, and triceps sites. The chest, lower ribs and scapula skinfolds most resembled Young's data

COMPARATIVE BODY FORM MEASURES

Characteristics	Young's Study M.	Young's Study S.D.	Present Study M.	Present Study S.D.	Range
Age (yrs.)	20.36	1.95	19.94	1.34	18 - 22
Ht. (cm.)			164.37	4.83	
Wt. (kg.)	58.96	6.45	59.00	6.19	48 -69
Girths (cm.)					
upper arm (T)	27.25	4.99	27.77	3.16	23 -37
upper arm (R)	25.55	5.81	25.66	3.13	22 -36
*chest	73.44	4.57	83.71	4.05	77 -91
waist			62.34	4.45	54 -72
*abdomen	89.64	5.28	82.34	5.74	71 -97
hips	97.36	4.64	94.46	3.97	86 -103
thigh	57.26	3.37	56.94	3.99	48 -65
calf	35.55	1.99	35.00	2.20	30 -40
Widths (cm.)					
humerus			5.97	.038	5 - 7
bi-acromial	37.24	1.74	38.40	1.44	36 -43
chest	25.38	2.89	26.94	1.39	25 -30
chest depth			17.46	1.50	14 -20
bi-iliac	28.50	1.42	26.69	1.58	23 -30
bi-trochanter	31.75	1.60	31.86	1.57	29 -35
knee	8.71	.372	9.34	.079	8 -11
Skinfolds (mm.)					
triceps	25.43	6.83	15.91	4.69	10 -31
scapula	12.07	4.10	10.06	2.89	6 -17
chest	8.67	3.53	7.40	2.55	5 -15
lower ribs	10.46	4.12	8.86	3.31	5 -15
waist	14.65	6.89	8.74	2.93	5 -16
supra-iliac	20.74	8.55	9.57	3.78	5 -22
knee	11.34	3.80	7.43	2.87	4 -14
umbilicus	22.93	6.60	16.43	5.29	5 -28
pubis	33.04	10.43	10.40	6.46	3 -36
Percent Body Fat	28.55	4.86	24.86	2.49	21 -32
Lean Body Mass	42.15	6.07	44.37	4.01	37 -51
Specific Gravity	1.0408	.0094	1.0488	.0049	1.035-1.057
Ponderal Index			12.82	.492	11.66-13.94

*Difference in location of sites

while the triceps, waist, supra-iliac, knee, umbilicus, and pubis skinfolds were considerably less in the present study. This dissimilarity may have been due to homogeneous subjects and/or the small number of subjects used in this study.

The differences found in specific gravity, lean body mass and percent body fat for young women in this study and those reported by Young et al. (1961) were due to the pubic skinfold data. (20) Prediction of body fat from skinfold data is based on this pubic site. (21)

Intercorrelations of the skinfolds found in this study and those reported by Young et al. (1961) are presented in Table II. In general it may be seen that the relationships found are similar with the exception of the interrelationships of the pubis skinfold and the knee skinfold with the chest, lower ribs, waist, triceps, and supra-iliac. The differences found may be due to more active subjects and/or a small number of subjects used in the present study.

Functional Measures

Flexibility

The data on flexibility are shown in Table III. Shoulder flexibility was the area of the body that exhibited the highest mean score; shoulder flexion showed the largest mean measure of shoulder flexibility. Shoulder outward rotation was greater than shoulder inward rotation. Trunk flexion was greater than trunk extension; ankle extension

TABLE II

COMPARATIVE DATA OF SKINFOLD CORRELATIONS*

	Chest	Lower Ribs	Waist	Umbilicus	Pubis	Supra-iliac	Triceps	Knee
Scapula	.6548	.7224	.6549	.6693	.6266	.6756	.5902	.3804
	.7690	.7062	.6509	.5805	.4371	.6713	.4950	.3682
		.8493	.7903	.7154	.7148	.7358	.6131	.3992
Chest		.7377	.5747	.3934	.3576	.6122	.5677	.1402
Lower			.8346	.8100	.7609	.8010	.6234	.3749
Ribs			.8103	.6460	.3402	.6763	.5408	.1479
				.7775	.8043	.8416	.6211	.6051
Waist				.7371	.3981	.7762	.3744	.1794
					.8591	.7621	.6549	.2870
Umbilicus					.3901	.6622	.4194	.2062
						.7909	.7094	.2896
Pubis						.2493	.0822	.2512
Supra-							.6347	.3053
ilin							.3296	.0301
								.4373
Triceps								.2211

*Top line--Young's Data; 94 subjects
Bottom line--Present Study; 35 subjects

TABLE III

RANGE, MEAN, STANDARD DEVIATION OF FLEXIBILITY MEASURES

Flexibility (Degrees)	Range	M.	S.D.
Shoulder Flexion	113-202	173.48	18.76
Shoulder Extension	23-88	56.88	17.92
Shoulder Inward Rotation	39-121	79.17	19.99
Shoulder Outward Rotation	38-142	110.80	23.62
Hip Flexion	20-171	118.94	22.94
Ankle Flexion	10-72	24.20	12.60
Ankle Extension	16-82	49.14	13.02
Trunk Flexion	104-178	154.11	19.19
Trunk Extension	16-110	53.54	21.21
Total Flexibility	688-967	818.14	68.82
Shoulder Flexibility	392-506	420.34	41.35
Trunk Flexibility	124-281	207.66	33.62
Ankle Flexibility	55-97	73.29	10.15

was greater than ankle flexion. Trunk flexion was the second highest flexibility measure followed by hip flexion. The large variation in the scores of shoulder flexion, shoulder inward and outward rotation, hip flexion, and trunk extension may have been caused by the difficulty which the examiner experienced in measuring these movements.

Numerous studies appear in the literature using a variety of techniques and instruments, however, no comparative data for women exists for measures of flexibility using the technique of the present study. Standardized procedures for testing flexibility are needed in order to make the results of flexibility testing comparable for both sexes.

Strength

The data on strength are presented in Table IV. In general it can be seen that:

1. Greatest strength scores were found for the hip, leg, and ankle with arm and shoulder strength next highest (flexion scores were higher than extension scores).

2. Trunk extension scores were greater than trunk flexion strength.

Unfortunately, the results of this study cannot be compared with any other study due to the lack of similar strength studies reported in the literature. None of the few strength studies reported on women employ the cable-tension technique of measuring strength. It would seem from this observation that there is a need for cable-tension strength studies using women subjects.

TABLE IV

RANGE, MEAN, STANDARD DEVIATION OF STRENGTH MEASURES

Strength (kg.)	Range	M.	S.D.
Shoulder Extension	13-48	25.800	6.944
Elbow Extension	10-27	17.286	4.144
Ankle Extension	22-74*	41.428	12.199
Elbow Flexion	15-34	27.457	6.362
Shoulder Horizontal Flexion	11-25	17.228	4.078
Hip Flexion	30-63	41.314	11.815
Hip Extension	22-58	35.971	12.198
Shoulder Flexion	15-43	28.000	6.697
Trunk Flexion	14-60	29.143	10.243
Trunk Extension	12-72*	34.543	14.181
Knee Extension	24-74*	44.943	15.937
Arm and Shoulder Strength	67-166	115.20	22.88
Trunk Strength	28-121	63.86	19.48
Hip and Leg Strength	129-215	161.60	24.11
Total Strength	245-428	339.48	46.42

*A technical error is suspected in the extreme high values.

Correlations and Intercorrelations

The Pearson Product-Moment Coefficient of Correlation was employed to estimate interrelationships of parameters. In this study the .05 level of confidence was accepted. A statistically significant correlation at the .05 level of confidence required a correlation of .337. The results are indicated in Table V.

Elementary Linkage Analysis for Isolating Orthogonal and Oblique Types and Typal Relevancies was performed on the intercorrelation matrix for the purpose of clustering related parameters. (14) Elementary linkage is defined as the largest index of association which a variable has with any or all of the other variables. Every variable is assigned to a type or cluster in terms of its highest index of association. Each variable in a type has a higher correlation with some other variable in that type than it has with any variable not in the type. A prototype is the characteristic common to all members of the cluster. The present intercorrelation matrix yielded nine types, all with prototypes of r = .800 and above. The results of elementary linkage is presented in Table VI, figures 11-19.

As indicated in figure 11, Type 1 showed percent body fat and specific gravity as the reciprocal pair of variables with the highest index of association, the relationship was r = -.992. This very high negative relationship showed that the high values in one variable were related to the low

	1 Weight	2 Upper arm (T) Girth	3 Upper arm (R) Girth	4 Chest Girth	5 Waist Girth	6 Abdomen Girth	7 Hip Girth	8 Thigh Girth	9 Calf Girth	10 Humerus Width
Upper arm (T) Girth	.6990									
Upper arm (R) Girth	.5775	.9517								
Chest Girth	.8498	.5185	.4960							
Waist Girth	.8153	.4363	.4552	.8127						
Abdomen Girth	.7735	.4137	.4190	.7401	[illegible]					
Hip Girth	.9173	.5139	.4998	.7668	.8220	.7803				
Thigh Girth	.8516	.6835	.6640	.7329	.7670	.7119	.8457			
Calf Girth	.7480	.5000	.5046	.6556	.6171	.5627	.6896	[illegible]		
Humerus Width	.4533	.2192	.2819	.3126	.2632	.4278	.4292	[illegible]	[illegible]	
Bi-acromial Width	.5618	.2587	.3029	.4851	.3673	.4197	.4938	.3775	[illegible]	.2372
Chest Width	.6498	.1527	.1788	.6145	.6399	.6747	.5633	.4164	.4922	[illegible]
Chest Depth	.7206	.6245	.5440	.7501	.6965	.5739	.7947	.6546	[illegible]	.1758
Bi-iliac Width	.3182	-.0291	-.0044	.3113	.4948	.5598	.2962	.2691	.3361	.2725
Bi-trochanter Width	.7264	.2523	.2745	.6086	.7191	.6969	.7949	.5146	.3633	.5242
Knee Width	.4555	.2255	.2664	.3603	.5592	.5157	.5421	.5088	.5410	.3205
Triceps Skinfold	.4733	.3182	.3951	.4147	.5067	.4617	.5163	.5955	.4534	.2571
Scapula Skinfold	.3719	.2313	.2374	.5052	.6236	.5337	.4096	.4402	.3229	.1327
Chest Skinfold	.3597	.1851	.2562	.4304	.5313	.4750	.4077	.3081	.2237	.2196
Lower Ribs Skinfold	.4778	.1390	.1983	.4874	.6936	.6686	.5019	.4441	.3609	.2573
Waist Skinfold	.2158	.0913	.1055	.3016	.5001	.5133	.2755	.3222	.2211	.0132
Supra-iliac Skinfold	.0562	-.0249	-.0220	.2156	.3605	.4097	.1692	.1356	.0617	[illegible]
Knee Skinfold	.0997	.1775	.1909	.0522	.2011	.0865	.0956	.3167	.3572	-.1471
Umbilicus Skinfold	.2358	.2160	.1933	.2570	.4276	.3879	.3135	.4459	.3045	.0061
Pubis Skinfold	.1781	.1234	.1339	.3123	.2521	.0966	.0933	.2519	.1827	-.0775
Sh. Ext. Strength	.2753	.3817	.2935	.2507	.0337	-.0413	.2367	.2494	.3211	.0131
Elbow Ext. Strength	.4713	.4496	.3704	.3739	.2629	.2182	.4300	.4369	[illegible]	.1516
Ankle Ext. Strength	.2615	.1268	.1017	.2989	.1537	.0240	.2323	.2338	.3444	-.0135
Elbow Flex. Strength	.4434	.4127	.3288	.3762	.2328	.1358	.4072	.3672	.3688	.1723
Sh. Hor. Flex. Strength	.4223	.3739	.2855	.3116	.2052	.1017	.2956	.3099	.3626	.0796
Hip Flex. Strength	.3610	.2226	.1440	.2679	.1285	.0358	.3556	.3143	.3274	[illegible]
Hip Ext. Strength	.4049	.2705	.2870	.2409	.1425	.1216	.4042	.3643	.3658	.2706
Sh. Flex. Strength	.3537	.3898	.3144	.2768	.1468	.0684	.2649	.2617	[illegible]	[illegible]
Trunk Flex. Strength	.1524	.0663	.0166	.3647	.1319	.1518	.1292	.0723	.2268	.1269
Trunk Ext. Strength	.4057	.2461	.2758	.2676	.1652	.1729	.3902	.4136	.3653	.3397
Knee Ext. Strength	.6264	.5172	.4754	.5778	.3474	.3136	.5378	.5636	.5613	.3565
Sh. Flex. Flexibility	-.0248	.0105	.0072	.0435	.1240	.1582	.0836	.1121	.1432	[illegible]
Sh. Ext. Flexibility	-.1703	.0867	.0364	-.1467	-.2760	-.2136	-.1323	-.1427	[illegible]	.1053
Sh. In. Rot. Flexibility	.0711	-.1720	-.1253	-.0026	.1379	.2020	.0455	-.0142	.1740	.1208
Sh. Out. Rot. Flexibility	-.1110	-.0608	-.0939	-.1962	-.1098	-.0537	-.2018	-.1737	-.2151	.1760
Hip Flex. Flexibility	-.2339	-.2736	-.1874	-.2687	-.4181	-.4539	-.1563	.4012	.2227	[illegible]
Ankle Flex. Flexibility	.4604	.3064	.2245	.4244	.3433	.2744	.1956	.4296	.3619	.0473
Ankle Ext. Flexibility	-.3365	-.1567	-.1647	-.2315	-.4065	-.3012	-.3740	-.2377	-.0657	.0765
Trunk Flex. Flexibility	.2977	-.0440	-.1100	.3384	.0642	.0204	.2366	.1757	.2561	.1546
Trunk Ext. Flexibility	.2652	.1215	.0677	.2524	.0741	.0003	.2893	.2133	.2953	.0598
Percent Body Fat	.5331	.4458	.4080	.6084	.6042	.4742	.4643	.5567	.5688	.0971
Lean Body Mass	.9425	.5228	.5150	.7434	.6958	.7015	.8610	.7384	.6437	.4733
Specific Gravity	-.5844	-.4641	-.4362	-.6447	-.6409	-.5208	-.5559	-.6932	-.6028	-.1948
Ponderal Index	-.5565	-.5725	-.5352	-.6023	-.6456	-.5464	-.5829	-.7092	-.6007	-.1752
Arm and Sh. Strength	.4469	.4751	.3798	.3647	.1984	.1087	.3466	.3977	.4132	.1464
Trunk Strength	.3975	.2262	.2219	.3963	.2047	.2221	.3622	.3558	.2755	.3146
Hip and Leg Strength	.4390	.2456	.2631	.3260	.1493	.0999	.3179	.3432	.4648	.2502
Total Strength	.4836	.3818	.2962	.3524	.1563	.1159	.4093	.4063	.4435	.2733
Total Flexibility	-.0937	-.1354	-.1127	.0045	-.1621	-.1272	.0057	-.0850	.1041	.0772
Shoulder Flexibility	-.1541	-.3206	-.0642	-.1572	-.0504	.0862	-.1543	-.1165	[illegible]	.0373
Trunk Flexibility	.3372	.0487	-.0201	.3523	.0834	.0119	.3118	.2660	.3345	.1278
Ankle Flexibility	.1956	.2165	.1657	.2143	-.0306	.0175	.2145	.2878	.4329	.1589

	11 Bi-acromial Width	12 Chest Width	13 Chest Depth	14 Bi-iliac Width	15 Bi-trochanter Width	16 Knee Width	17 Triceps Skinfold	18 Scapula Skinfold	19 Chest Skinfold	20 Lower Ribs Skinfold	21 Waist Skinfold	22 Supra-iliac Skinfold	23 Knee Skinfold	24 Umbilicus Skinfold	25 Pubis Skinfold	26 Sh. Ext. Strength
Chest Width	[illegible]															
Chest Depth	[illegible]	[illegible]														
Bi-iliac Width	[illegible]	[illegible]	[illegible]													
Bi-trochanter Width	[illegible]	[illegible]	[illegible]	[illegible]												
Knee Width	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											
Triceps Skinfold	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]										
Scapula Skinfold	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									
Chest Skinfold	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]								
Lower Ribs Skinfold	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]							
Waist Skinfold	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						
Supra-iliac Skinfold	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					
Knee Skinfold	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.0321				
Umbilicus Skinfold	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.2062			
Pubis Skinfold	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.2493	.2512	.3901		
Sh. Ext. Strength	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-.1447	-.1843	-.0148	.0483	
Elbow Ext. Strength	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-.1159	.1509	-.0416	.7436
Ankle Ext. Strength	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.1514	.3084	[illegible]
Elbow Flex. Strength	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.1423	[illegible]
Sh. Hor. Flex. Strength	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.1419	[illegible]
Hip Flex. Strength	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-.1977	-.2041	[illegible]	[illegible]	[illegible]	[illegible]
Hip Ext. Strength	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-.2714	[illegible]	[illegible]
Sh. Flex. Strength	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Trunk Flex. Strength	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Trunk Ext. Strength	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Knee Ext. Strength	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sh. Flex. Flexibility	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sh. Ext. Flexibility	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sh. In. Rot. Flexibility	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sh. Out. Rot. Flexibility	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Hip Flex. Flexibility	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ankle Flex. Flexibility	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ankle Ext. Flexibility	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Trunk Flex. Flexibility	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Trunk Ext. Flexibility	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Percent Body Fat	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lean Body Mass	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Specific Gravity	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ponderal Index	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Arm and Sh. Strength	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Trunk Strength	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Hip and Leg Strength	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total Strength	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total Flexibility	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Shoulder Flexibility	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Trunk Flexibility	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ankle Flexibility	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Ankle Ext. Strength 28	Elbow Flex. Strength 29	Sh. Hor. Flex. Strength 30	Hip Flex. Strength 31	Hip Ext. Strength 32	Sh. Flex. Strength 33	Trunk Flex. Strength 34	Trunk Ext. Strength 35	Knee Ext. Strength 36	Sh. Flex. Flexibility 37	Sh. Ext. Flexibility 38	Sh. In. Rot. Flexibility 39	Sh. Out. Rot. Flexibility 40	Hip Flex. Flexibility 41	Ankle Flex. Flexibility 42	Ankle Ext. Flexibility 43	Trunk Flex. Flexibility 44	Trunk Ext. Flexibility 45	Percent Body Fat 46	Lean Body Mass 47	Specific Gravity 48	Ponderal Index 49	Arm and Sh. Strength 50	Trunk Strength 51	Hip and Leg Strength 52	Total Strength 53	Total Flexibility 54	Shoulder Flexibility 55	Trunk Flexibility 56
.5791																												
.5918	.6798																											
.5022	.6682	.6306																										
.2908	.4116	.5963	.5229																									
.4826	.5786	.6998	.5710	.5516																								
.3960	-.0102	.1531	.2470	.1460	.1662																							
.2867	.2715	.4370	.4219	.5368	.3631	.2811																						
.5514	.6035	.5883	.6286	.6445	.5522	.2550	.5198																					
-.3265	-.0370	-.1254	-.2438	-.0924	-.1559	-.2303	-.2180	-.0758																				
.1062	-.0289	.1442	-.1626	.0216	.0097	.0927	.0186	-.0319	.0210																			
-.2006	.0337	-.0061	-.0922	-.0256	-.1645	-.4212	-.1569	-.1036	.2175	.2090																		
-.0085	-.0146	-.0407	.0625	.0208	-.1779	-.0049	.1145	.1146	.0268	-.1403	-.1605																	
-.0825	-.0233	-.0716	.0240	.0176	-.1592	-.0045	.0506	-.0614	-.2496	.2331	.0157	.0801																
.2857	.2358	.4898	.2400	.5058	.3211	.3806	.2041	.4659	.0106	.1584	-.0217	-.2433	.1364															
-.2633	-.0760	-.2556	-.1357	-.2778	-.2483	-.2857	-.0341	-.2139	.1179	.1951	.2134	.1172	.0161	-.6068														
.2571	.2969	.2979	.2450	.1432	.1487	.1899	.2484	.2575	-.0475	.2083	.0621	-.2015	.2359	.3166	-.0827													
.1432	.2298	.4329	.3613	.2954	.0951	.0776	.4265	.4619	.0380	.2100	.1475	.1216	.3711	.2991	.0665	.4836												
.3808	.3148	.2935	.2942	-.0515	.1287	.1534	-.0043	.3633	.0719	.0829	-.1110	.1036	-.3840	.2653	-.2359	.2747	.1033											
.1218	.3945	.3584	.2951	.4605	.3417	.0857	.4479	.5617	-.0301	.0404	.1297	.1613	-.0442	.4119	-.2757	.2354	.2669	.2319										
-.3872	-.3139	-.3043	-.3046	-.0032	-.1328	-.1767	-.0148	-.3861	-.0716	.0777	.1219	.1291	.3590	-.3135	-.2879	-.2912	-.0954	-.9915	-.2413									
-.3050	-.3088	-.3197	-.1830	-.0121	-.2528	-.1109	-.0461	-.3456	-.1437	.4550	-.0130	.2635	.4549	-.3700	.2117	-.1414	-.1734	-.7997	-.2269	.8160								
.6544	.8113	.9014	.6897	.5695	.8406	.1882	.4341	.6417	-.1590	.2516	-.0547	-.1776	-.1090	.4403	-.2059	.3157	.2551	.2657	.4026	-.2762	-.3695							
.4029	.1847	.3873	.4240	.4620	.3411	.7174	.8695	.5081	-.2743	.0376	-.3135	.0795	.2518	.3513	-.1700	.2260	.3465	.0851	.3768	-.1123	-.1152	.4018						
.6429	.6224	.6887	.7898	.7132	.6120	.3021	.4849	.8269	-.2014	.1430	-.0635	.1446	-.0416	.4132	-.1766	.2325	.4527	.2658	.3742	-.3354	-.2757	.3024	.5011					
.6334	.6239	.7528	.7566	.6943	.6784	.4110	.6129	.7576	-.2300	.2252	-.1135	.0664	-.0443	.4412	-.1729	.1959	.4483	.2336	.4029	-.2665	-.2367	.5016	.6494	.9616				
-.0354	.1273	.1934	.0728	.1979	-.1070	-.0352	.1696	.1717	.3563	.4437	.4048	.2567	.5210	.2431	.2264	.4742	.6569	-.1627	.0797	.1597	.1134	.1009	.1020	.2395	.2427			
-.2040	-.0189	-.0206	-.1899	-.0330	-.2477	-.2707	-.1013	-.0328	.5843	.7446	.1837	.4446	.0412	-.0643	.3529	-.2126	.2732	-.1268	-.1106	.1521	.0632	-.0977	-.2236	-.0157	-.0453	.7139		
.2371	.3116	.4432	.3677	.2681	.1449	.1574	.4108	.4384	-.0333	.4470	.1630	-.0384	.3720	.3938	-.3347	.2126	.8448	.2200	.3927	-.2053	-.2746	.3618	.3761	.4734	.5082	.6879	.1628	
.0421	.2037	.2489	.1212	.2642	.0273	.1353	.1603	.3465	.1703	.7467	.2504	-.1544	.3526	.3677	.3443	.2407	.4010	.1126	.1363	-.1056	-.2477	.2407	.1852	.3554	.3224	.5153	.3419	.4041

TABLE VI

ELEMENTARY LINKAGE ANALYSIS

Note: $\rightleftarrows$ indicates reciprocal pairs of variables

$\longrightarrow$ means that the variable at the tail of the arrow is highest related to the one at the head, but the one at the head is not highest with the one at the tail.

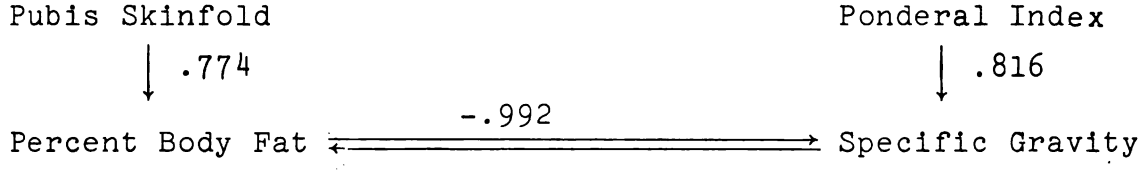

Figure 11. Elementary Linkage Analysis Type I, Percent Body Fat and Specific Gravity.

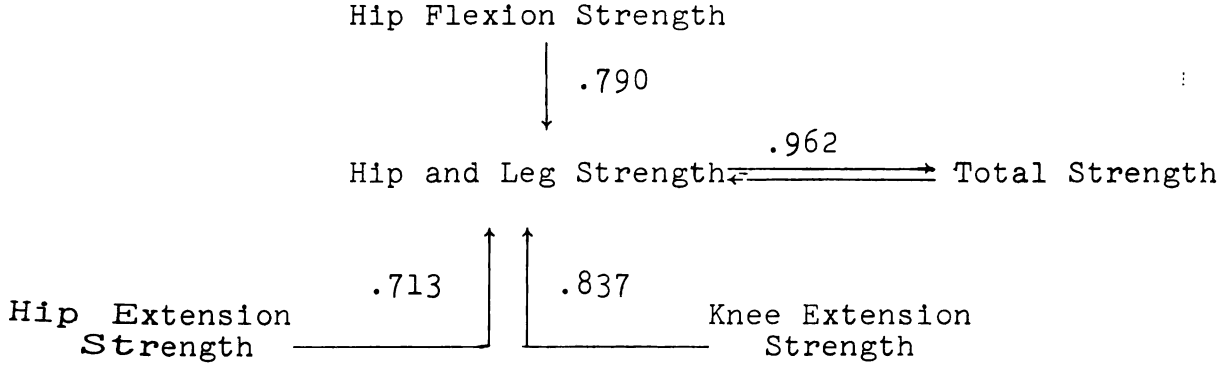

Figure 12. Elementary Linkage Analysis Type II, Hip and Leg Strength and Total Strength.

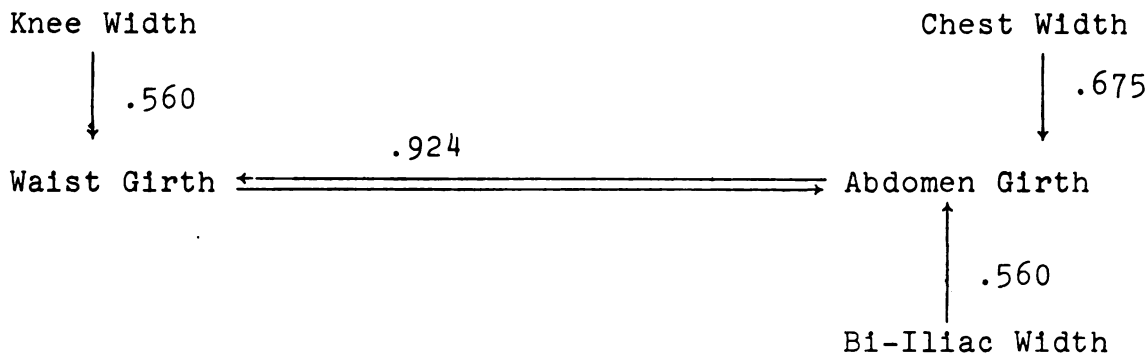

Figure 13. Elementary Linkage Analysis Type III, Girth.

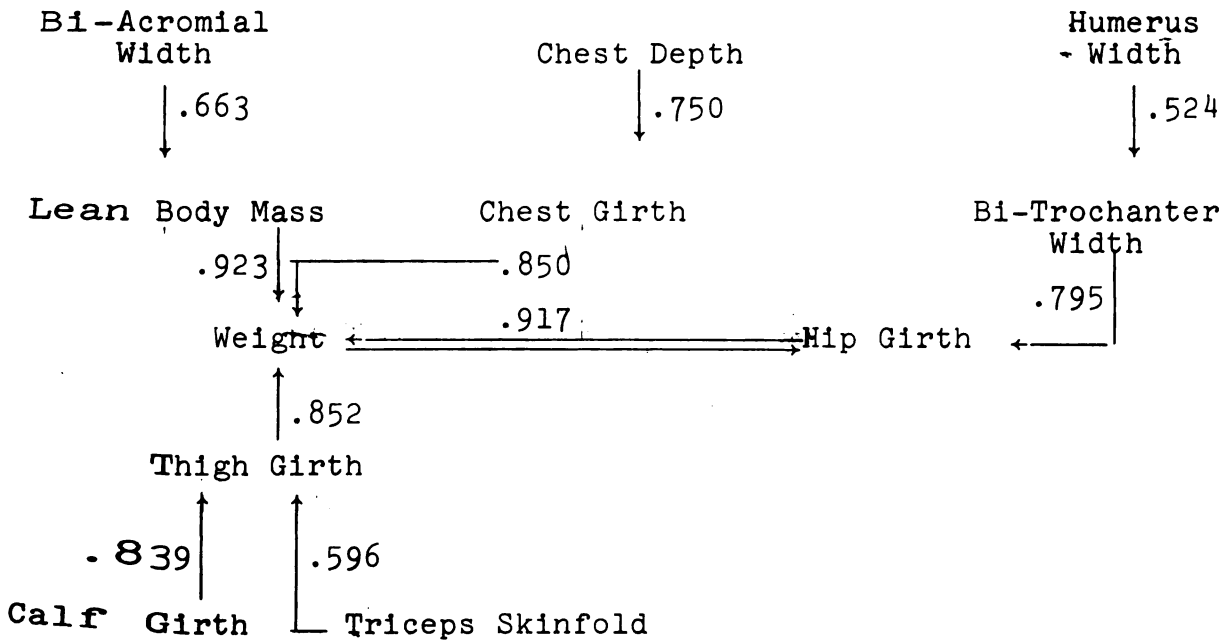

Figure 14. Elementary Linkage Analysis Type IV, Weight and Hip Girth

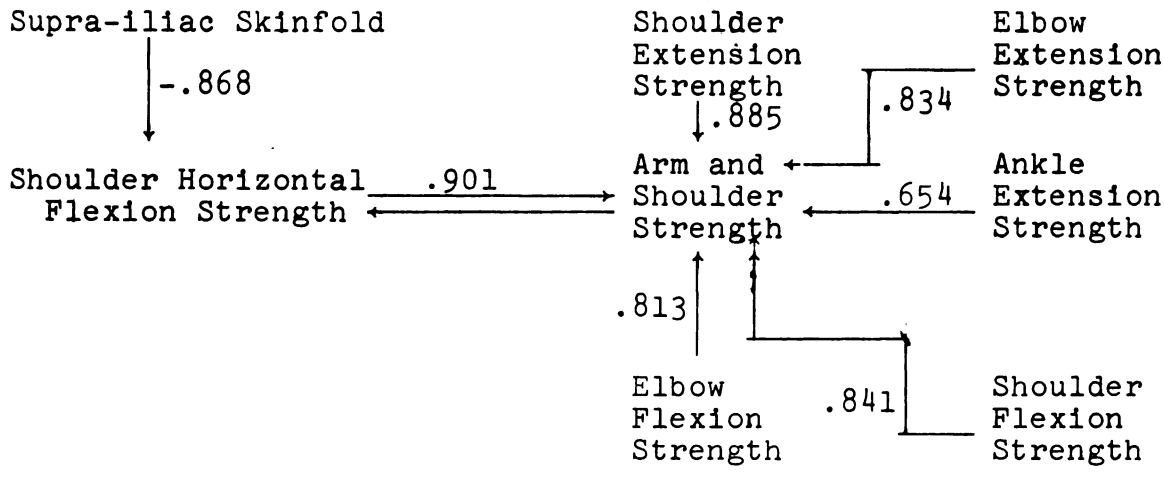

Figure 15. Elementary Linkage Analysis Type V, Specific Strength and Arm and Shoulder Strength.

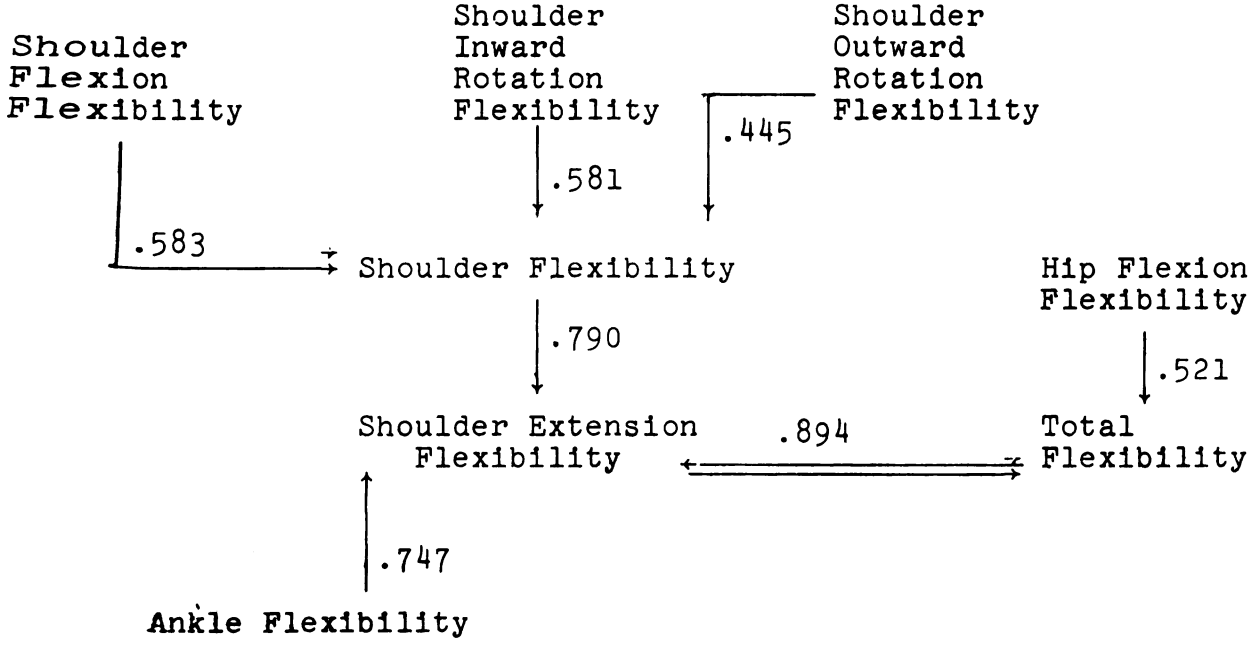

Figure 16. Elementary Linkage Analysis Type VI, Specific Flexibility and Total Flexibility.

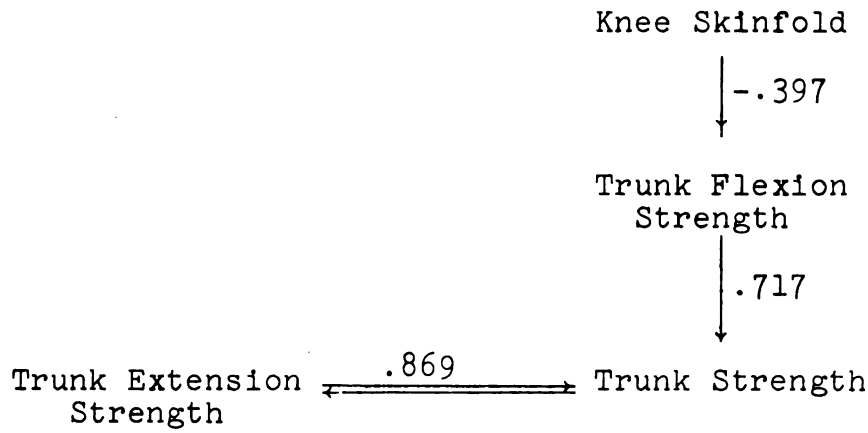

Figure 17. Elementary Linkage Analysis Type VII, Specific Strength and Trunk Strength

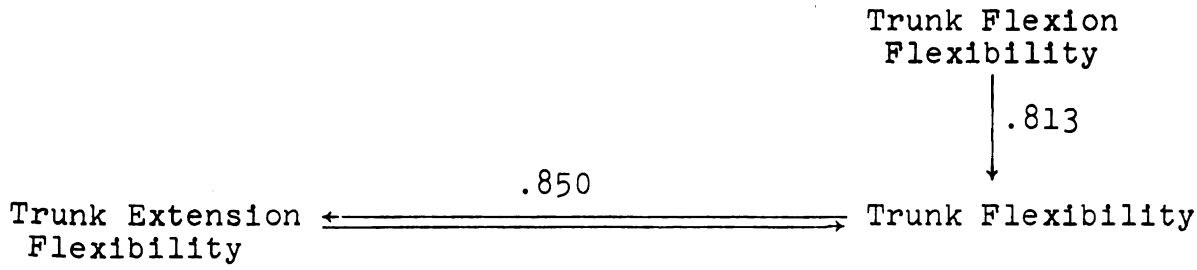

Figure 18. Elementary Linkage Analysis Type VIII, Specific Flexibility and Trunk Flexibility

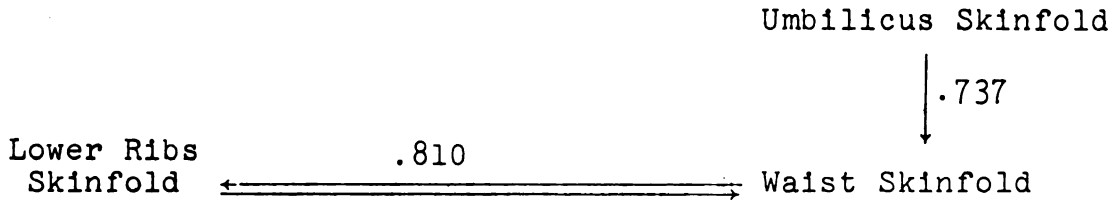

Figure 19. Elementary Linkage Analysis Type IX, Skinfold Fat

values in the other variable. Pubis skinfold related highest with percent fat. This is comparable to Young's data which reported the pubis skinfold as the skinfold best predicting total body fat. (21) The variable most related to ponderal index was specific gravity.

The parameters exhibiting the second highest index of association were hip and leg strength and total strength, as shown in Figure 12. A correlation of .962 showed that hip and leg strength was the best indicator of total strength. Hip flexion, hip extension and knee extension were the three variables which related highest with hip and leg strength. No other variable showed total strength as its highest index of association.

Figure 13 indicated girths of the waist and abdomen as the reciprocally related pair of variables with the third highest index of association. The variable most related to the width of the knee was waist girth which showed a moderate correlation. Chest width and bi-iliac width were variables more related to the girth of the abdomen than any other variable.

Figure 14 showed weight and hip girth as the parameters characteristically related by the most variables. Lean body mass, chest girth and thigh girth were variables that related highest with weight. Bi-acromial width was most related to lean body mass. Chest depth was most related to chest girth. Calf girth and triceps skinfold correlated highest with thigh

girth. Bi-trochanter width was most related to hip girth; the width of the humerus was most related to bi-trochanter width. The unusual correlation between triceps skinfold and thigh girth ($r = .596$) showed, in general terms, a moderate relationship between appendage skinfold and appendage girth. However, this relationship might have been more definite if thigh skinfold and triceps girth were measured.

The reciprocal pair of variables with the fifth highest index of association were arm and shoulder strength and shoulder horizontal flexion strength, as shown in Figure 15. Surpa-iliac skinfold was most related to shoulder horizontal flexion, and showed a negative correlation (less skinfold fat, greater the strength). Five strength measures were all more related to arm and shoulder strength than they were to any other variable. The high correlation ($r = -.868$) found between supra-iliac skinfold and shoulder horizontal flexion strength showed the type of relationship between a skinfold fat measure and a strength measure; the high values in one variable were related to the low values in the other variable.

Total flexibility and shoulder extension flexibility exhibited the sixth highest index of association. As seen in Figure 16 shoulder extension flexibility was the variable that shoulder flexibility and ankle flexibility were most related to. The parameters more related to shoulder flexibility than any other variable were shoulder flexion,

shoulder inward rotation and shoulder outward rotation. Hip flexibility correlated highest with total flexibility. It was noted that all flexibility measures did not correlate highest with strength or body composition measures but were clustered together.

Figure 17 showed trunk strength and trunk extension as the reciprocal pair of variables with the seventh highest index of association. Trunk strength was the variable most related to trunk flexion strength. Knee skinfold related highest with trunk flexion, this was a negative correlation (less skinfold fat, greater the strength). No variable related highest with trunk extension strength. Although the knee skinfold--trunk flexion relationship was low ($r = -.397$), trunk flexion was the variable knee skinfold related highest with. This correlation showed an additional strength-skinfold negative relationship. From observing this and the similar result shown in Type V a need for a more extensive study of strength-skinfold relationships would seem justified.

Figure 18 indicated trunk flexibility and trunk extension flexibility as the reciprocal pair of variables with the eighth highest index of association. Trunk flexibility was the variable most related to trunk flexion. No variable related highest with trunk extension flexibility.

Lower ribs skinfold and waist skinfold exhibited the ninth highest index of association as shown in Figure 19.

Umbilicus skinfold was related highest to waist skinfold. No variable correlated highest with lower ribs skinfold.

It was noted that all variables in Type II were strength measures; Type VI and VIII clusters were all measures of flexibility. Flexibility did not relate to strength or body composition measures, emphasizing perhaps the specificity of flexibility. The three variables in Type IX were skinfold fat measures. In addition, variables of the same type dominated the clusters of Types V and VII.

Significance Between Variables for Two Activity Groups

The F-test of the hypothesis that the variances of two normal independent populations are equal was calculated on selected parameters using the data collected on the most active and least active subjects. In this study the .10 level of confidence was accepted. The parameters selected were percent fat, weight, lean body mass, specific gravity, ponderal index, arm and shoulder strength, trunk strength, hip and leg strength, total strength, shoulder flexibility, trunk flexibility, ankle flexibility, hip flexibility, and total flexibility. These selections were based on the observation of the greatest variability in standard deviations of the two groups. Also, these were the parameters most pertinent in light of the purposes of the study. The results of this test are shown in Table VII. It was noted that significance was found in body fat, specific gravity and

TABLE VII

F RATIO OF SIGNIFICANCE BETWEEN VARIANCES OF ACTIVITY GROUPS 8,8 df., F.10, 3.44

Parameter	Variance	F
Percent Body Fat	2.247	
	11.713	5.221*
Weight	11.136	
	35.51	3.136
Lean Body Mass	4.986	
	7.728	1.550
Specific Gravity	.000009	
	.000048	5.333*
Ponderal Index	.217	
	.5069	2.34
Arm and Shoulder Strength	421.07	
	569.30	1.35
Trunk Strength	370.56	
	24.40	15.19*
Hip and Leg Strength	2372.66	
	2038.52	1.16
Total Strength	7433.89	
	5599.53	1.33
Shoulder Flexibility	1815.61	
	1304.65	1.39
Trunk Flexibility	794.68	
	1346.89	1.80
Ankle Flexibility	105.34	
	42.25	2.50
Hip Flexibility	460.10	
	1181.30	2.57
Total Flexibility	6222.05	
	5478.96	1.14

*Significant at .10 level of confidence

trunk strength at the .10 level of confidence. The null hypothesis that the variances are equal was therefore rejected and the alternative hypothesis that the variances are unequal was accepted. The variances were assumed to be equal for the other parameters studied.

The Cochran-Cox test of the hypothesis that the means of two normal independent populations are equal when the variances are unequal was applied to the parameters of percent fat, specific gravity and trunk strength. A .05 level of confidence was accepted in this study. The results are shown in Table VIII.

The t-test of the hypothesis that the means of two normal independent populations are equal when the variances can be assumed to be equal was applied to the balance of selected parameters. The results of these tests are presented in Table IX. A .05 level of confidence was accepted in this study.

As indicated in Tables VIII and IX, weight, lean body mass, specific gravity, arm and shoulder strength, and trunk strength were significantly different in the two samples at the .05 level of confidence. The null hypothesis that the means are equal was therefore rejected and the alternate hypothesis that the means are unequal was accepted. There were no significant differences observed between the means for the parameters of percent body fat, ponderal index, hip and leg strength, total strength, shoulder flexibility,

TABLE VIII

COCHRAN-COX TEST OF SIGNIFICANCE BETWEEN MEANS OF ACTIVITY GROUPS

Parameter	M.	S.D.	t.	df.	t.
Percent Body Fat	24.78 25.56	3.43 1.50	- 1.24	12	2.18
Specific Gravity	1.0492 1.0469	.0069 .0030	383.33	9	2.26*
Trunk Strength	49.22 70.33	4.94 19.25	- 48.09	18	2.10*

*Significant at .05 level of confidence

Note: top line inactive group
bottom line active group

TABLE IX

t TEST OF SIGNIFICANCE BETWEEN MEANS OF ACTIVITY GROUPS

Parameter	Mean	S. D.	t	t
Weight	54.78 64.56	5.96 3.34	-4.29	2.12*
Lean Body Mass	41.22 48.11	2.78 2.23	-5.79	2.12*
Ponderal Index	12.839 12.625	.712 .466	.238	2.12
Arm and shoulder strength	109.11 115.67	23.86 20.52	-6.25	2.12*
Hip and Leg Strength	155.21 174.66	19.15 28.71	- .878	2.12
Total Strength	308.67 347.00	44.83 46.22	-1.01	2.12
Shoulder Flexibility	423.78 397.00	36.12 42.61	1.44	2.12
Trunk Flexibility	184.44 212.44	36.70 28.19	-1.80	2.12
Ankle Flexibility	73.78 75.56	6.25 10.26	- .440	2.12
Hip Flexibility	109.78 120.67	34.37 21.45	- .807	2.12
Total Flexibility	790.89 805.67	74.02 78.88	- .410	2.12

*Significant at .05 level of confidence

Note: Top line--inactive Group
Bottom line--active group

trunk flexibility, ankle flexibility, hip flexibility, and total flexibility. It is concluded therefore, that the most active subjects were heavier, had greater lean body mass, showed lower specific gravities, and exhibited greater arm and shoulder and trunk strength than the least active subjects. However, no cause and effect of activity is indicated by this study. It may be that individuals exhibiting certain body compositions tend to be more active. Further investigation is essential to determine causual effects.

Non-Statistical Observations

Although the means were not statistically different, higher mean values were observed in the most active subjects for all body form measures except knee width and knee, suprailiac, and pubis skinfolds. In addition, the most active subjects were less ponderous than the least active subjects. Higher mean values, although not statistically significant were observed for all strength measures except shoulder extension in the most active subjects. Higher flexibility mean measures were observed in the most active subjects for the majority of the flexibility measures; these were not statistically significant. It would seem from these observations that active subjects might tend to be larger, stronger, and more flexible than sedentary subjects. However, further investigation with: (1) larger samples and an analysis of extremes in activity levels, and (2) matched groups undergoing difficult training programs appears to be warranted.

CHAPTER V

SUMMARY, CONCLUSIONS, RECOMMENDATIONS

Summary

It was the purpose of this study to investigate:

1. the interrelationships of selected functional and body form measures, and

2. the effects of habitual physical activity upon these parameters. Functional measures included strength and flexibility tests; body form measures consisted of skinfold fat, girth, width, lean body mass, specific gravity, percent body fat, and ponderal index.

Thirty-five college women ranging in age from eighteen to twenty-two participated in the study. Nine subjects each were placed in two activity groups determined by habitual physical activity as measured by an activity history recall questionnaire. These groups were termed "most active" and "least active".

The Pearson Product-Moment Correlation Coefficient was employed to estimate interrelationships between variables. Elementary Linkage Analysis was performed on the intercorrelation matrix for the purpose of clustering related parameters. Differences between variances of selected parameters

were determined by the F-test. Appropriate t-tests were used to determine the differences between means of selected parameters in the two groups.

Conclusions

From the statistical analysis of data, the following conclusions were drawn:

1. The most active subjects were heavier, had greater lean body mass, had lower specific gravities, and exhibited greater arm and shoulder and trunk strength than the least active subjects.

2. No differences existed in the measures of percent body fat, ponderal index, hip and leg strength, total strength, shoulder flexibility, trunk flexibility, ankle flexibility, hip flexibility, and total flexibility between the most active and least active subjects.

3. Percent fat and specific gravity were more highly related than any other reciprocal pair of variables; as percent fat increased, specific gravity decreased.

4. Percent fat was the variable with the highest relationship to pubis skinfold; as the pubis skinfold increased, percent fat increased.

5. Ponderal index was most related to specific gravity; specific gravity increased with a higher ponderal index.

6. Weight and hip girth were the parameters characteristic of the most variables. Lean body mass, chest girth,

and thigh girth were most related to weight; as lean body mass and the girths increased, weight increased. Bi-trochanter width correlated highest with hip girth; as bi-trochanter width increased, hip girth increased.

7. Hip and leg strength was the strength measure correlating highest with total strength.

8. Shoulder extension was the flexibility measure correlating highest with total flexibility.

9. Largest girths were found at the hip, abdomen, and chest respectively. Differences found in chest and abdominal girths in Young's study and the present study were due to the location of the measurement.

10. Largest bony widths were found at the bi-acromial and bi-trochanter sites.

11. Largest skinfolds were found at the umbilicus, pubis and triceps sites. Chest, lower ribs, and scapula skinfolds were similar in the present study and Young's study. Differences in triceps, waist, supra-iliac, knee, umbilicus, and pubis skinfolds may have been due to homogeneous subjects and/or small number of subjects used in the present study.

12. The differences found in specific gravity, lean body mass, and percent body fat for women in this study and those reported by Young were due to the pubic skinfold data.

13. Differences in the interrelationships of the pubis skinfold and knee skinfolds with the chest, ribs, waist, triceps, supra-iliac in the present study and Young's study

may have been due to more active subjects and/or the small number of subjects used in the present study.

Recommendations

1. A valuable tool is needed to assess habitual physical activity.

2. Examination of the results revealed a tendency for active subjects to be larger, stronger, less fat, and more flexible than sedentary subjects. Further investigation with:

   a. larger samples and an analysis of extreme activity levels, and

   b. matched groups undergoing difficult training programs is recommended.

3. A larger number of randomly selected subjects is needed to establish norms.

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APPENDICES

APPENDIX A

RAW DATA ON SUBJECTS

TABLE X

RAW DATA ON PHYSICAL CHARACTERISTICS AND AVERAGE COLORIC EXPENDITURE OF SUBJECTS

Subject Number	Age (Yrs. & Mo.)	Height (cm.)	Height (in.)	Weight (kg.)	Weight (lb.)	Relative Wt. (Percent Standard Wt.)	Average Caloric Expenditure in Activity
+* 1	18-4	165.25	65.06	59.00	129.80	99.80	2095.30
* 2	20-2	162.00	63.77	56.50	124.30	99.40	1252.21
+* 3	21-5	167.50	65.94	67.60	148.72	112.70	2592.77
* 4	18-0	166.00	65.35	56.25	123.75	95.10	1376.80
+ 5	18-9	158.25	62.30	61.16	134.55	119.07	2150.10
6	18-10	169.75	66.83	55.38	121.84	95.93	1272.72
# 7	18-6	150.00	59.05	56.56	124.43	121.99	733.46
* 8	22-4	167.75	66.04	63.90	140.58	103.36	1735.16
* 9	20-9	161.75	63.68	54.35	119.57	95.65	1681.64
*10	18-7	166.00	65.35	60.25	132.55	101.90	1960.25
11	21-9	167.25	65.80	64.40	143.80	108.90	1732.38
12	20-6	160.25	63.09	54.00	118.80	95.04	1260.11
*13	18-8	175.50	69.09	65.43	143.93	97.91	1854.67
#14	19-6	163.75	64.47	53.88	118.54	98.78	620.91
+*15	21-8	171.50	67.52	66.08	145.36	103.80	3018.42
#16	18-8	168.50	66.34	49.28	108.42	85.30	370.81
#*17	18-11	165.75	65.25	50.08	110.05	84.65	1195.92
18	18-9	158.50	62.40	48.18	105.99	93.79	1380.80
*19	19-11	169.50	66.73	62.25	143.55	107.10	1566.70
#20	19-10	160.50	63.19	49.02	107.84	92.96	614.06
*21	18-6	159.00	62.60	50.03	110.07	91.70	1571.50
*22	18-5	162.50	63.78	52.48	115.45	93.10	1623.10
+*23	19-5	169.75	66.83	60.03	132.07	98.50	2208.34
#24	18-11	156.75	61.71	67.70	148.94	128.39	1075.64
#*25	19-1	165.00	64.96	60.98	134.14	105.60	991.95
+*26	18-8	170.00	66.93	68.68	151.08	112.70	2772.09
#*27	19-11	157.50	62.00	52.00	114.40	101.23	1114.03
*28	18-5	166.50	65.50	63.03	138.65	106.60	1649.15
+*29	18-5	155.50	61.22	63.78	140.30	120.90	2260.98
*30	18-7	160.25	63.08	63.00	138.60	111.70	1429.23
#31	18-4	155.50	61.22	53.03	116.66	107.02	651.24
+*32	19-5	165.50	65.17	67.38	148.22	114.00	2688.06
+33	18-0	176.25	69.39	66.25	145.75	105.61	2201.17
*34	19-6	172.25	67.81	62.45	137.39	99.55	1590.86
*35	18-11	166.25	65.45	60.58	133.26	102.50	1784.12

*Physical Education Major
+Active Subjects
#Inactive subjects

TABLE XI

RAW DATA ON BONY WIDTHS

Subject Number	Humerus	Bi-Acromial	Chest Width	Chest Depth	Bi-Iliac	Bi-Trochanter	Knee
1	6.07	40.03	27.84	16.80	26.15	31.37	8.27
2	5.69	36.05	28.35	17.73	27.91	31.31	10.28
3	6.54	40.17	28.02	18.67	28.09	33.02	10.27
4	5.86	39.03	25.57	15.73	26.70	31.86	7.65
5	5.87	36.28	26.88	19.73	26.33	33.02	8.66
6	5.67	37.34	26.15	17.73	27.35	31.71	9.19
7	6.04	37.47	26.33	17.87	25.44	32.00	10.74
8	6.32	39.12	27.43	18.10	25.43	30.48	10.11
9	6.22	38.14	25.70	16.73	26.14	31.73	9.27
10	6.35	38.82	25.95	18.13	25.02	31.65	8.47
11	5.50	38.86	27.42	19.10	25.57	32.60	9.48
12	5.91	39.85	25.53	16.57	24.96	30.46	9.27
13	5.80	43.43	29.46	18.54	30.25	34.69	9.65
14	6.10	38.02	26.20	16.03	27.08	30.95	9.27
15	6.05	40.28	28.56	18.50	23.24	33.72	9.19
16	5.72	37.92	26.54	14.27	27.26	30.72	9.04
17	5.78	37.55	25.99	16.33	26.31	32.47	8.72
18	5.84	37.96	25.53	17.40	25.53	29.38	9.27
19	6.08	38.08	27.12	18.93	27.03	34.42	9.19
20	5.36	38.06	25.15	16.00	25.51	29.24	9.40
21	5.46	35.50	25.91	15.67	25.78	28.98	7.58
22	5.59	37.47	24.96	14.40	25.76	30.55	7.96
23	6.05	38.55	27.05	16.77	28.85	33.08	9.17
24	6.12	37.93	29.63	19.60	29.21	33.55	10.41
25	6.27	38.35	26.17	18.17	26.48	30.12	9.61
26	6.08	38.61	26.20	18.87	27.22	32.94	9.17
27	5.80	36.36	25.23	15.97	25.30	29.66	9.34
28	6.56	39.84	26.88	17.03	27.29	34.21	9.76
29	5.93	40.07	27.47	18.67	28.64	32.85	10.33
30	5.76	38.98	25.95	19.13	26.28	31.08	9.69
31	5.40	36.70	25.56	16.50	25.53	30.08	9.72
32	6.80	38.80	28.91	18.13	29.59	33.46	11.18
33	6.39	39.27	29.89	16.80	26.46	32.89	9.80
34	5.90	38.63	30.13	17.40	30.30	32.54	9.57
35	6.46	38.27	26.65	18.43	26.40	33.13	9.82

Note: Measured in centimeters.

TABLE XII

RAW DATA ON GIRTHS

Subject Number	Upper Arm (T)	Upper Arm (R)	Chest	Waist	Abdomen	Hips	Thigh	Calf
1	26.63	25.00	85.67	59.77	78.37	92.23	55.87	36.27
2	25.25	24.03	86.73	64.23	79.83	91.90	54.96	34.73
3	31.40	28.53	90.83	66.00	86.57	99.23	62.43	39.17
4	26.37	24.20	81.60	59.40	80.30	90.93	55.47	34.00
5	28.00	25.40	88.10	67.50	89.10	97.67	57.13	34.23
6	26.00	22.90	82.03	60.33	80.83	91.67	51.13	31.63
7	29.33	26.57	80.93	61.97	80.33	97.07	57.67	36.33
8	29.07	25.90	87.40	63.47	83.87	96.03	60.13	36.40
9	27.40	24.93	80.03	60.20	80.53	91.83	55.43	32.67
10	37.40	35.57	85.97	61.67	83.30	93.93	57.83	33.97
11	29.90	26.97	87.47	62.60	80.63	95.93	59.33	37.00
12	26.40	24.90	80.17	59.40	75.47	88.87	52.50	33.10
13	28.30	24.93	87.93	66.83	89.30	99.73	56.50	34.03
14	24.17	22.97	78.70	59.73	81.63	91.00	53.43	34.07
15	29.17	27.00	89.00	65.70	86.00	100.00	57.77	33.77
16	23.47	22.07	77.87	56.93	73.43	86.47	48.10	30.03
17	24.00	23.03	77.40	60.00	81.17	92.17	52.40	30.57
18	24.93	22.33	79.56	54.33	75.83	88.10	51.30	31.33
19	28.07	25.00	86.13	64.00	79.50	98.03	56.07	35.00
20	24.13	22.03	78.33	53.57	70.80	88.00	50.67	33.57
21	26.56	23.53	78.47	57.30	73.83	87.93	54.30	33.50
22	24.03	22.03	80.07	55.97	74.60	91.73	55.23	34.93
23	26.60	23.50	81.07	61.50	81.87	96.60	59.30	33.83
24	31.80	27.80	90.70	71.80	99.00	102.50	64.50	38.90
25	37.00	34.10	82.27	59.90	80.00	94.90	60.73	36.27
26	29.30	26.43	87.17	66.17	55.70	101.30	63.00	36.00
27	26.57	22.53	76.53	55.57	77.00	89.63	52.57	33.93
28	27.37	25.53	86.90	63.59	85.43	101.57	59.33	36.67
29	30.30	28.97	88.07	69.80	92.67	102.00	62.53	37.23
30	30.03	26.60	86.16	64.00	82.70	96.56	59.60	36.03
31	25.77	24.47	84.93	64.17	81.27	92.83	58.63	35.53
32	30.97	29.93	87.13	69.93	91.20	98.17	62.33	40.13
33	27.00	25.80	83.13	60.43	82.27	101.87	59.13	37.93
34	25.17	23.00	85.17	67.33	93.23	96.37	56.10	36.27
35	27.00	25.50	81.17	66.13	83.88	97.49	60.37	34.87

Note: Measured in centimeters.

TABLE XIII

RAW DATA ON SKINFOLD FAT MEASUREMENTS

Subject Number	Triceps	Scapula	Chest	Lower Ribs	Waist	Supra-iliac	Knee	Umbilicus	Pubis
1	12.7	6.3	5.0	5.0	5.0	6.3	3.7	14.7	5.7
2	15.7	16.3	14.0	12.7	13.0	14.0	4.7	19.7	36.0
3	19.7	8.0	4.5	7.0	5.7	5.3	5.3	11.0	5.7
4	17.0	7.3	5.3	5.7	6.0	8.7	5.3	14.7	15.3
5	21.0	15.7	13.0	15.0	16.0	22.3	4.0	26.3	9.0
6	11.7	9.0	10.0	9.7	7.0	10.0	4.7	12.0	3.0
7	16.4	13.3	9.0	10.3	10.7	14.7	6.7	25.7	11.0
8	22.7	12.0	7.0	10.0	10.7	11.0	7.0	21.0	5.0
9	18.3	8.0	5.0	8.7	8.7	8.7	5.0	23.0	6.0
10	12.7	8.7	6.7	8.0	9.0	10.3	4.7	15.7	14.3
11	12.0	9.0	6.0	7.0	4.7	8.0	6.0	18.3	14.0
12	12.0	9.0	6.0	7.0	8.7	6.3	8.7	12.0	16.0
13	15.0	9.0	7.7	6.0	5.0	7.0	5.0	9.0	7.0
14	13.0	9.0	7.0	7.0	8.0	12.3	4.3	5.0	5.0
15	15.0	8.7	9.0	11.7	9.7	7.0	5.3	14.0	11.7
16	10.0	8.7	5.0	5.0	5.0	7.0	12.3	9.0	5.0
17	11.3	7.0	6.0	6.0	7.0	6.0	4.0	14.0	7.0
18	14.0	10.0	7.0	7.0	10.0	11.3	5.0	19.3	12.0
19	12.7	10.0	6.0	7.0	5.0	6.0	10.0	10.3	5.0
20	15.0	7.0	6.0	7.7	8.0	7.3	9.7	16.3	9.7
21	10.3	6.7	5.0	5.0	5.7	6.3	5.7	10.7	5.0
22	13.0	9.7	6.0	6.0	7.0	6.7	7.7	10.3	4.0
23	16.3	7.7	4.7	5.0	6.7	7.7	9.0	16.3	10.9
24	14.0	14.3	9.0	13.7	15.7	14.0	14.3	25.0	21.6
25	16.3	10.0	6.7	5.3	5.7	6.3	11.7	14.3	8.0
26	15.0	14.7	7.7	11.3	8.7	7.0	8.7	19.7	18.7
27	12.0	7.0	4.7	5.0	9.0	7.7	6.7	14.3	5.0
28	16.0	7.7	5.7	7.0	7.0	6.3	5.0	15.0	5.7
29	31.33	16.7	14.7	15.0	11.7	16.3	11.7	20.7	6.3
30	24.0	12.0	9.0	11.7	7.0	10.0	6.3	16.0	17.0
31	16.0	12.0	5.3	7.7	9.7	14.0	12.7	23.0	16.7
32	25.0	13.0	10.3	11.7	9.3	6.7	10.7	19.3	9.3
33	19.0	7.0	9.0	10.0	7.7	10.3	9.0	15.0	11.0
34	9.7	11.0	6.0	15.0	11.7	15.0	4.7	19.7	5.0
35	21.7	9.0	7.7	15.0	13.7	11.0	9.0	23.3	12.7

Note: Measured in millimeters.

TABLE XIV

RAW DATA ON PONDERAL INDEX, SPECIFIC GRAVITY, PERCENT BODY FAT AND LEAN BODY MASS

Subject Number	Ponderal Index	Specific Gravity	Percent Body Fat	Fat (kg.)	Lean Body Mass (kg.)
1	12.88	1.052	23.0	13.57	45.43
2	12.81	1.039	29.6	16.72	39.78
3	12.46	1.048	25.0	16.90	50.70
4	13.15	1.049	24.5	13.78	42.47
5	12.17	1.044	27.0	16.51	44.65
6	13.50	1.055	21.5	11.91	43.47
7	11.86	1.042	28.0	15.84	40.72
8	12.72	1.051	23.5	15.02	48.88
9	12.94	1.053	22.5	12.23	42.12
10	12.84	1.048	25.0	15.06	45.19
11	12.58	1.045	26.5	17.33	48.07
12	12.85	1.049	24.5	13.23	40.77
13	13.21	1.052	23.0	15.05	50.37
14	13.13	1.053	22.5	12.12	41.76
15	12.91	1.048	25.0	16.52	49.55
16	13.94	1.057	20.5	10.10	39.18
17	13.62	1.057	20.5	10.26	39.82
18	13.22	1.051	23.5	11.32	36.86
19	12.76	1.050	24.0	14.94	47.31
20	13.30	1.053	22.5	11.04	37.98
21	13.07	1.055	21.5	10.76	39.27
22	13.12	1.055	21.5	11.28	41.19
23	13.29	1.050	24.0	14.41	45.62
24	11.66	1.035	31.7	21.43	46.27
25	12.69	1.049	24.5	14.94	46.03
26	12.58	1.042	28.0	19.23	49.44
27	12.78	1.052	23.0	11.96	40.04
28	12.69	1.050	24.0	14.89	47.13
29	11.80	1.044	27.0	17.22	46.55
30	12.22	1.043	28.5	17.95	45.05
31	12.57	1.045	26.5	14.05	38.97
32	12.32	1.046	26.0	17.52	49.85
33	13.22	1.048	25.0	16.56	49.69
34	13.17	1.052	23.0	14.36	48.09
35	12.83	1.048	25.0	15.14	45.43

TABLE XV

RAW DATA ON FLEXIBIBILITY MEASURES

Subject Number	Shoulder Flexion*	Shoulder Extension	Shoulder Inward Rotation	Shoulder Outward Rotation	Hip Flexion	Ankle Flexion*	Ankle Extension	Trunk Flexion*	Trunk Extension	Shoulder Flexibility	Trunk Flexibility	Ankle Flexibility	Total Flexibility
1	176	61	82	42	124	20	63	171	54	361	225	83	793
2	177	56	89	111	128	18	51	169	66	433	235	69	865
3	186	73	76	112	122	72	22	177	81	447	258	94	921
4	171	42	63	126	131	24	45	166	47	402	213	69	815
5	157	70	47	118	127	39	37	150	43	392	193	76	788
6	157	31	82	129	157	20	36	142	37	399	179	56	791
7	175	88	86	38	138	53	24	170	62	387	232	77	834
8	185	61	81	48	103	16	56	167	45	375	212	72	786
9	186	84	73	131	121	12	61	173	52	474	225	66	893
10	154	80	63	112	116	19	54	137	32	409	169	73	767
11	190	47	90	111	129	28	59	178	57	438	235	87	889
12	201	56	75	124	117	15	40	149	30	456	179	55	807
13	194	77	121	114	127	40	37	178	69	506	247	77	957
14	169	48	113	91	94	15	59	132	16	421	148	74	737
15	155	33	41	126	128	24	39	136	74	355	210	63	756
16	172	71	80	121	141	17	54	146	38	444	184	71	840
17	169	61	88	98	128	25	44	104	20	416	124	69	737
18	195	49	39	120	121	10	63	165	54	403	219	73	816
19	145	35	84	94	119	23	46	161	73	358	234	69	780
20	113	65	59	120	121	11	49	158	21	357	179	60	717
21	196	51	75	142	110	24	49	114	84	464	198	73	845
22	183	80	101	111	120	15	82	135	64	475	199	97	891
23	166	31	55	124	116	21	51	154	21	376	175	72	739
24	194	56	80	110	120	20	50	140	18	440	158	78	688
25	174	60	64	122	114	26	52	122	58	420	180	78	792
26	151	23	57	98	92	46	16	177	54	329	231	62	714
27	178	80	98	139	116	17	66	170	72	495	242	83	936
28	150	75	81	111	128	29	54	178	76	417	254	83	882
29	185	30	109	108	107	28	42	144	42	432	186	70	795
30	146	73	101	124	140	21	66	171	110	444	281	87	853
31	202	41	64	127	116	25	49	159	54	434	213	74	837
32	188	50	71	113	99	15	57	136	49	422	185	72	778
33	173	77	89	120	171	31	57	172	77	459	249	88	967
34	183	40	120	122	109	11	50	149	69	465	218	61	853
35	176	36	74	121	113	17	40	144	55	407	199	57	776

Note: Measured in degrees.

*This represents total flexibility in these areas.

TABLE XVI

RAW DATA ON STRENGTH MEASURES

Subject Number	Shoulder Extension	Elbow Extension	Ankle Extension	Elbow Flexion	Shoulder Horizontal Flexion	Hip Flexion	Hip Extension	Shoulder Flexion
1	21.25	15.75	36.25	25.75	15.50	41.75	45.62	32.00
2	22.00	11.88	40.50	23.00	18.62	42.75	38.00	24.62
3	32.50	25.38	42.75	26.50	23.88	50.00	58.00	37.25
4	27.00	16.25	34.87	25.87	15.75	50.82	42.25	27.62
5	26.50	16.75	51.75	22.25	15.25	46.38	27.25	25.38
6	17.88	15.25	42.88	29.25	14.25	45.25	30.38	32.50
7	33.00	26.88	52.89	32.00	23.00	44.25	39.88	29.25
8	21.87	16.50	26.50	20.00	12.50	32.00	23.37	28.00
9	33.00	24.25	42.88	30.25	23.50	48.13	37.50	43.38
10	33.92	19.50	40.88	27.62	16.00	38.50	29.00	25.50
11	38.38	23.75	59.25	32.50	24.65	60.54	44.00	35.50
12	19.50	15.25	44.89	29.25	11.88	37.50	27.75	29.25
13	29.75	19.25	36.00	34.37	19.75	42.50	46.75	25.87
14	28.89	15.25	36.75	23.00	18.63	44.00	37.25	25.88
15	26.25	15.75	45.50	32.00	20.63	51.84	47.25	32.00
16	13.00	12.00	26.25	14.75	12.38	29.58	34.38	15.25
17	15.25	9.75	23.50	21.25	12.25	36.75	47.63	29.25
18	19.75	9.75	25.75	21.75	11.75	42.38	30.25	17.88
19	34.87	20.37	43.37	33.50	23.00	47.97	51.87	37.37
20	32.00	17.00	62.75	25.50	16.25	52.25	39.50	26.63
21	26.63	19.50	50.63	25.13	21.75	41.88	39.11	26.63
22	30.25	16.00	38.50	25.50	16.25	56.70	46.25	26.62
23	21.75	14.75	24.25	25.88	15.25	50.00	47.25	20.88
24	25.00	22.37	57.25	32.50	20.12	47.87	41.25	31.30
25	29.75	15.00	36.88	33.38	20.00	49.59	53.00	37.38
26	31.25	20.00	61.65	30.25	22.50	63.32	55.00	42.88
27	21.75	16.25	23.88	21.25	14.75	46.38	42.75	23.50
28	30.25	20.62	74.42	35.75	19.50	57.72	43.50	32.00
29	13.88	13.00	22.00	21.75	11.88	36.00	39.00	19.75
30	25.12	19.50	39.00	31.00	18.88	38.88	24.75	25.50
31	23.25	13.00	41.38	25.13	10.75	44.50	34.88	20.00
32	25.00	20.00	38.50	27.00	16.00	48.62	42.50	33.00
33	22.25	18.63	45.50	25.89	17.00	54.25	48.63	21.25
34	20.63	15.25	31.50	23.50	13.13	42.25	31.13	18.13
35	17.75	12.37	36.25	23.75	15.75	37.75	29.37	20.00

TABLE XVI (Continued)

Subject Number	Trunk Flexion	Trunk Extension	Knee Extension	Arm and Shoulder Strength*	Trunk Strength*	Hip and Leg Strength*	Total Strength
1	25.75	20.00	48.50	109	46	195	350
2	35.38	20.62	47.50	101	56	216	373
3	42.75	57.88	73.72	146	101	266	513
4	51.50	52.00	45.00	113	104	218	435
5	60.00	14.75	49.88	106	75	180	361
6	27.63	24.63	54.43	108	53	211	372
7	26.88	23.00	40.25	144	50	219	413
8	33.37	41.75	26.25	100	75	129	304
9	18.88	50.63	43.75	154	70	202	426
10	38.12	50.62	41.59	124	89	208	421
11	24.68	37.88	71.25	166	63	267	496
12	16.25	11.75	34.63	105	28	189	322
13	28.87	21.62	49.00	130	51	215	396
14	24.63	15.25	47.00	110	40	168	318
15	38.63	44.38	64.09	127	83	254	464
16	24.75	19.50	30.63	67	45	131	243
17	24.63	29.38	41.25	87	54	150	291
18	33.00	25.75	39.13	82	59	159	300
19	21.62	42.25	40.59	149	64	246	459
20	28.00	24.50	40.50	118	53	201	372
21	31.00	40.13	43.75	121	71	211	400
22	25.50	38.50	51.84	115	65	235	415
23	18.75	35.38	46.38	99	54	173	326
24	29.75	24.25	40.67	131	54	237	422
25	20.00	22.75	60.21	135	43	255	433
26	40.88	52.88	72.63	147	94	315	556
27	27.00	23.50	46.63	98	51	272	494
28	49.12	72.16	61.61	139	121	312	572
29	14.13	22.50	52.25	81	43	154	272
30	20.88	45.50	46.70	121	67	204	392
31	29.38	23.75	57.25	92	53	187	332
32	27.25	46.25	47.26	121	73	221	415
33	18.63	44.78	58.41	105	64	237	406
34	23.25	34.88	30.18	91	58	186	335
35	16.00	49.13	39.87	90	65	183	338

*This represents total strength in these areas.

Note: Measured in kilograms.

APPENDIX B

MEAN, STANDARD DEVIATION, RANGE OF MEASURES FOR ACTIVITY GROUPS

TABLE XVII

MEAN, STANDARD DEVIATION, RANGE OF BODY FORM MEASURES FOR THE MOST ACTIVE GROUP

Variable	M.	S.D.	Range
Weight	64.56	3.34	59-69
Girths (cm.)			
Upper Arm (T)	28.78	1.55	27-31
Upper Arm (R)	26.89	2.13	24-30
Chest (Ax.)	87.78	2.87	81-91
Waist	65.33	3.65	60-68
Abdomen	86.00	4.47	78-93
Hips	97.78	2.15	92-99
Thigh	59.89	3.51	56-63
Calf	36.44	2.14	34-40
Widths (cm.)			
Humerus	6.11	.31	6-7
Bi-Acromial	39.11	1.20	38-40
Chest Width	27.89	1.20	27-30
Chest Depth	18.33	1.05	17-19
Bi-Iliac	27.11	2.02	23-30
Bi-Trochanter	32.89	.74	31-34
Knee	9.44	.83	8-11
SkinFolds (mm.)			
Triceps	19.33	5.52	15-31
Scapula	11.00	4.00	6-17
Chest	8.78	3.36	5-15
Lower Ribs	10.22	3.61	5-15
Waist	9.33	2.98	5-16
Supra-Iliac	9.78	5.29	5-22
Knee	7.56	2.91	4-12
Umbilicus	17.44	4.24	11-26
Pubis	10.11	3.73	6-19
Percent Body Fat	25.56	1.50	23-28
Lean Body Mass (kg.)	48.11	2.23	45-51
Specific Gravity	1.0469	.003	1.042-1.052
Ponderal Index	12.625	.466	11.78-13.29

TABLE XVIII

MEAN, STANDARD DEVIATION, RANGE OF BODY FORM MEASURES FOR THE LEAST ACTIVE GROUP

Variable	M.	S.D.	Range
Weight (kg.)	57.78	5.96	49-68
Girths (cm.)			
Upper Arm (T)	27.33	4.37	23-37
Upper Arm (R)	25.11	3.73	22-34
Chest (Ax.)	80.89	4.36	77-97
Waist	60.56	4.97	54-72
Abdomen	80.44	6.74	71-99
Hips	92.33	3.94	86-99
Thigh	55.56	5.17	48-65
Calf	34.44	2.59	30-39
Widths (cm.)			
Humerus	5.78	.04	5-6
Bi-Acromial	37.56	.07	36-38
Chest Width	26.33	1.41	25-30
Chest Depth	16.78	1.62	14-20
Bi-Iliac	26.33	1.16	25-29
Bi-Trochanter	31.00	1.41	29-34
Knee	9.56	.07	9-11
Skinfolds (mm.)			
Triceps	13.67	2.16	10-16
Scapula	9.78	2.53	7-14
Chest	7.56	1.50	5-9
Lower Ribs	7.56	2.79	5-14
Waist	8.89	3.07	5-16
Supra-Iliac	9.89	3.57	6-16
Knee	9.22	3.61	4-14
Umbilicus	16.44	7.10	5-26
Pubis	10.00	5.60	5-22
Percent Body Fat	24.78	3.43	21-32
Lean Body Mass (kg.)	41.22	2.78	38-46
Specific Gravity	1.0492	.007	1.035-1.057
Ponderal Index	12.839	.712	11.86-13.94

TABLE XIX

MEAN, STANDARD DEVIATION, RANGE OF FUNCTIONAL CAPACITY MEASURES FOR THE MOST ACTIVE GROUP

Variable	M.	S.D.	Range
Strength (kg.)			
Shoulder Extension	24.56	5.36	14-33
Elbow Extension	17.89	3.45	13-25
Ankle Extension	41.11	11.99	22-61
Elbow Flexion	26.44	3.06	22-32
Shoulder Horizontal Flexion	17.44	3.98	12-23
Hip Flexion	45.12	11.90	33-63
Hip Extension	36.64	10.72	27-58
Shoulder Flexion	29.33	7.59	20-43
Trunk Flexion	32.00	13.98	14-60
Trunk Extension	37.78	14.38	15-58
Knee Extension	51.90	14.58	46-73
Arm and Shoulder Strength	115.67	20.52	81-146
Trunk Strength	70.33	19.25	43-94
Hip and Leg Strength	174.66	28.71	154-185
Total Strength	347.00	46.22	327-418
Flexibility (Degrees)			
Shoulder Flexion	170.78	13.40	151-188
Shoulder Extension	49.78	1.59	23-76
Shoulder Inward Rotation	69.67	2.06	41-109
Shoulder Outward Rotation	106.78	24.28	42-126
Hip Flexion	120.67	21.45	92-171
Ankle Flexion	32.89	1.66	15-72
Ankle Extension	42.67	1.52	16-63
Trunk Flexion	157.44	17.08	136-177
Trunk Extension	55.00	1.83	21-80
Shoulder Flexibility	397.00	42.61	329-459
Trunk Flexibility	212.44	28.19	175-258
Ankle Flexibility	75.56	10.26	62-94
Total Flexibility	805.67	78.88	714-967

TABLE XX

MEAN, STANDARD DEVIATION, RANGE OF FUNCTIONAL CAPACITY MEASURES FOR THE LEAST ACTIVE GROUP

Variable	M.	S.D.	Range
Strength			
Shoulder Extension	24.67	6.75	13-33
Elbow Extension	16.33	4.94	10-27
Ankle Extension	40.22	13.80	23-63
Elbow Flexion	25.44	5.89	21-41
Shoulder Horizontal Flexion	16.22	3.94	11-23
Hip Flexion	44.67	12.06	30-59
Hip Extension	36.44	8.72	21-50
Shoulder Flexion	26.44	6.02	15-31
Trunk Flexion	26.22	2.78	20-30
Trunk Extension	23.00	3.59	15-30
Knee Extension	39.44	14.67	26-63
Arm and Shoulder Strength	109.11	23.86	67-144
Trunk Strength	49.22	1.94	40-83
Hip and Leg Strength	155.21	19.15	131-170
Total Strength	308.67	44.83	268-401
Flexibility			
Shoulder Flexion	171.78	23.41	113-202
Shoulder Extension	63.33	1.40	41-88
Shoulder Inward Rotation	81.33	1.65	59-113
Shoulder Outward Rotation	107.33	28.15	38-139
Hip Flexion	109.78	34.37	93-141
Ankle Flexion	23.22	1.16	11-53
Ankle Extension	49.77	1.09	24-66
Trunk Flexion	144.55	21.13	104-170
Trunk Extension	39.89	2.07	16-72
Shoulder Flexibility	423.78	36.12	357-495
Trunk Flexibility	184.44	36.70	124-242
Ankle Flexibility	73.78	6.25	60-83
Total Flexibility	790.89	74.02	688-936

APPENDIX C

FORMULAS USED FOR PERCENT BODY FAT, LEAN BODY MASS, RELATIVE WEIGHT

TABLE XXI

FORMULAS USED FOR PERCENT BODY FAT, LEAN BODY MASS, RELATIVE WEIGHT

(1) Percent Body Fat

$$\text{Percent Fat} = 100\left(\frac{5.548}{\text{Specific Gravity}} - 5.044\right)$$

(2) Lean Body Mass

$$\text{Lean Body Mass} = \frac{\text{Wt. Kg.}}{} - \frac{\text{lbs. Fat}}{\text{Kg.}}$$

(3) Relative Weight

$$\text{Relative wt.} = \frac{\text{Actual Weight}}{\text{Standard Weight}}$$