CALIFORNIA STATE UNIVERSITY, NORTH RIDGE

THE EFFECT OF BODY CONDITIONING ON BODY COMPOSITION,
STRENGTH, AND CARDIO-VASCULAR FITNESS

A thesis submitted in partial satisfaction of the requirements for the degree of Master of Arts in
Physical Education

by

Carol Anne Gulyas

June, 1972
The thesis of Carol Anne Gulyas is approved:

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ABSTRACT

THE EFFECT OF BODY CONDITIONING ON BODY COMPOSITION,
STRENGTH, AND CARDIO-VASCULAR FITNESS

by

Carol Anne Gulyas

Master of Arts in Physical Education

June, 1972

The purpose of this investigation was to determine the effects of body conditioning, as experienced by participants in a body conditioning program, on selected parameters of body composition, strength, and cardio-vascular fitness.

Seventy female volunteers from physical education body conditioning classes served as subjects for this study. Body composition, the principle criterion for this investigation, was determined through the underwater weighing of each subject and the subsequent calculation of body fat from body density. A modified strength index, including one minute push-ups, one minute sit-ups, and grip strength, was utilized to indicate strength. Cardio-vascular fitness was determined by a one minute step test, which included the monitoring of resting, immediate post work, and thirty, sixty, and ninety second recovery heart rates. All of the measures were tested
at the beginning, middle, and end of the thirteen week experimental period.

The data determined from the above tests were statistically analyzed through analysis of variance (F test) to determine the significance of the within group differences which occurred between pre, middle, and post test results for each of the selected parameters.

The following general conclusions appear to be justified:

1. Body conditioning, as experienced in a one semester program, does significantly change body composition as shown by decreases in per cent body fat and total body fat, and increases in total body density and lean body mass.

2. Although body conditioning does appear to improve muscular strength, no significant improvement in cardio-vascular fitness was indicated.
CHAPTER I

INTRODUCTION

It is generally accepted by Physical Educators that participation by college women in body conditioning courses involves an intrinsic desire in each student to invoke some physical change in the fitness dimension of her body. Although the change may not be clearly delineated by each student, it is assumed that this desire for change does exist. There are several physiological functions which are usually assumed to undergo adaptation during one’s participation in such courses. For the purposes of this study, selected parameters of body composition, strength, and cardiovascular fitness were monitored to determine if any changes occurred.

The effects of body conditioning activities on body composition, strength, and cardiovascular fitness have been studied through various methods by several investigators. Findings have generally indicated that through exercise an individual may increase his lean body mass and decrease fat, increase strength, and improve cardiovascular fitness (4, 10, 29, 37, 56, 63).

It has been shown that the intensity and duration of physical activity is one factor that influences the fitness aspect of the body throughout life (1). Studies involving athletes, a population which is assumed to be physically active, have shown that they tend to have
a greater body density, less body fat, and greater lean body mass than non-trained individuals (10, 48, 53, 71, 72). In an investigation involving activity groups based on "least" and "greatest" activity classifications, Conger noted that the more active an individual was, the greater was his strength, lean body mass, and specific gravity (85). Similar to Conger's study, Darwick investigated physical education majors, non-physical education majors, and activity groups in the parameters of strength, body composition, and maximum work capacity. Results again indicated that most active subjects possessed more fat free weight, exhibited greater maximum oxygen consumption, and were significantly stronger than less active subjects (86).

Selected exercise and body conditioning programs have been examined to determine if body composition changes occur from one's participation in such programs. Programs which included strenuous workloads of treadmill running (45), calisthenics, gymnastics, track and field, weight lifting, swimming, games and dancing (37), maximum movement exercises, progressive resistive exercises, and individual and dual sports (26) have all resulted in the participants significantly decreasing body fat and increasing lean body mass. In accordance with these studies, this investigation sought to determine if changes in physiological parameters would occur as a result of body conditioning.
The Problem

Statement of the Problem

The problem of this study was to investigate the possible physiological changes occurring during one semester of participation in body conditioning activities.

Statement of the Purpose

The specific purpose of this investigation was to determine what, if any, changes occurred in body composition, strength, and cardio-vascular fitness of women students participating in a one-semester conditioning program at San Fernando Valley State College (California State University, Northridge).

Importance of the Study

The importance of this study is predicated on the thesis that qualitative and quantitative changes can take place in body tissues and physiological functions as a result of body conditioning activities (25, 29, 37, 45, 48, 56). Traditionally, change in total body weight has been employed as an indication of changes in body compartments (15). Body composition measurements of specific gravity, per cent body fat, and lean body mass give a more accurate index of the quality of tissue changes than the standard tables which are interpreted in relation to height and weight. This appraisal can be pragmatically utilized by students of body conditioning classes in order to more precisely realize what physiological changes are occurring as a result of body conditioning activities.
Hypothesis

This investigation was designed to answer the following experimental question: Does participation in a body conditioning class for one semester achieve any of the assumed objectives of altering body composition, and of improving strength and cardiovascular fitness?

Scope and Limitations

The subjects of this study were seventy students who volunteered from women's body conditioning classes at San Fernando Valley State College. The investigation was conducted over a thirteen week time period during the Fall semester, 1971. Subjects in each class were given a general group orientation to the study at the first class meetings, at which time they were requested to designate a time when the initial hydrostatic weighing could be completed. Initial cardio-vascular fitness and strength tests were administered during the second class meetings. Subjects were again tested in the three selected parameters at mid-semester and at the end of the semester.

It was necessary to determine the residual lung volume of each subject in order to calculate the amount of air remaining in the lungs during underwater weighing. Immediately before hydrostatic weighing, the vital capacity of each subject was determined by having the subject exhale maximally into a wet spirometer. The
average of three trials was multiplied by a constant factor in order to estimate the residual volume of air in the lungs which would be present after the subject's maximal exhalation during underwater weighing (30, 87).

A caloric intake history was recorded by subjects of the study for seven days in the first third of the experimental period. The subjects indicated if the record was typical of their dietary habits and made comments in regard to what type of caloric intake they anticipated for the remainder of the study. For the purposes of this investigation, there was no attempt to control caloric intake since it was assumed that inherent variations normally occur in students participating in such body conditioning classes.

The investigation included seventy subjects from a pool of 143 students (49 per cent) enrolled in body conditioning classes. Because of the panel design of the study, it would be inappropriate to generalize from the findings of this investigation. Therefore, the interpretation of results was restricted to the particular population examined.

**Definition of Terms**

For the purposes of this study, the following terms were defined:

**Gross Body Composition.** Compartmentalization of the body into water, body fat, mineral, and protein mass. This is often
defined in a two compartment model (fat + lean body mass = total body mass), in which mineral mass is included in the lean body mass, and the body water in both (lhl).

**Lean Body Mass.** Total body weight minus all body fat except indispensable fat (approximately two per cent of the lean body mass (15)).

**Fat Free Body Weight or Fat Free Mass.** Weight of the body less all amounts of fat (lhl).

**Density.** Mass per unit volume, usually expressed in grams per cubic centimeter (lhl).

**Archimedes' Principle.** A body submerged in water displaces a volume equal to its own (11).

**Body Density.** The density of the whole body, according to Keys and Brozek (lhl), is as follows:

... the total weight in the air divided by the total body volume, and the estimation of the latter is determined from its displacement of the water, the difference between the weight in the air and the weight completely submerged in water being the weight of the displaced volume of water.

**Vital Capacity.** Maximum volume of air that can be expelled from the lungs by forceful effort following a maximal inhalation (l1).

**Residual Lung Volume.** Volume of air remaining in the lungs following the greatest possible maximal expiration (76).

**Strength.** Force of muscular contraction (l1), as measured by grip strength, and the number of bent knee sit-ups and modified push-ups executed for one minute.
**Cardio-Vascular Fitness.** Response of heart rate to exercise; measured at rest and immediately following exercise, then thirty seconds, sixty seconds, and ninety seconds after the performance of a one minute step test.

**Organization of the Remaining Chapters**

This thesis is organized into five chapters. The brief explanation offered here indicates the format followed in the thesis.

Chapter II contains a review of related literature pertaining to the rationale for densitometry, physical activity and body composition, and body composition of women.

Chapter III describes the research methodology and design by which the study was conducted.

Chapter IV includes the statistical analyses and interpretation of the data.

Chapter V gives the summary, findings and conclusion of the study, and makes recommendations for further investigation.
CHAPTER II
REVIEW OF RELATED LITERATURE

Investigative interest in human body composition developed mainly from its value as a criterion of man's response to environmental influences, especially those of a nutritional nature (11:19). Body composition measurements provide for meaningful interpretations of body weight, changes in body compartments in different physiological conditions, and relationships of composition of the body to health and fitness (41, 53).

There have been numerous methods for determining body composition, including anthropometry (18), photomapping and roentgenography (30, 65), hydrometry (32), fat soluble indicators (19), skinfold measurements (20, 31), direct and roentgenographic studies of bone mineralization (69, 73), potassium 40 content (68), air displacement (47), and the method employed in this study, densitometry (48, 39, 40, 41, 42, 88).

In reviewing the literature, the rationale for densitometry will be discussed first. Physical activity, in the form of general activity and specialized programs, and its effect on body composition is reviewed second. Finally, studies concerned with body composition of women are presented.
Densitometry

Discovery of the principle of density - a body submersed in water displaces a volume equal to its own - was credited to the Greek scientist Archimedes in about 200 B.C. (11:153). Utilizing his principle, the volume of the body is determined from its displacement of water, the difference between the body's weight in the air and the weight completely submersed in water being the weight of the displaced volume of water (11:1). Although Archimedes made his observations on the human body, subsequent applications primarily used metallic substances until Robertson (59) attempted to estimate the density of ten "middle sized" men who were "bribed" to submerge themselves in a wooden tank filled with water. Accordingly, this initial attempt to determine body density proved to be unsuccessful, but was the forerunner of further research.

Physiological rationale

The rationale for determining fatness or leanness from density is based on the assumption that the body can be considered a two component system with the components being of different, but constant densities (11:266). Thus, the proportions of the two components can be estimated from the density of the whole body. There is considerable evidence to indicate that the fat free body is relatively constant in composition in mature adults (11, 12, 28), with the mean specific gravity of the body being reported at 0.900 g/cc at 37°.
Centigrade (28). Densitometry is based on the assumption that the lower the density of the body, the higher its fat content, since the density of fat is lower than that of other body components (28, 35).

The relationship between density and body composition has been derived from the densities of the two components being considered and incorporating them into a theoretical equation, as done by Keys and Brozek (20, 44). Originally, the two constant density components were fat and the fat-free body (11:154). Behnke (15) introduced the concept of "lean body mass", which included the essential body lipids in addition to the fat-free body. More recently, Keys and Brozek have utilized a two component system, which was calculated on the basis of chemical analysis of cadavers and consisted of a "reference body", which contained 15.3 per cent body fat or "obesity tissue" (20).

The single body component often considered to be an influence on body density is the skeletal structure of the body (11, 22). Although the values of bone density have been reported to vary from 1.7 to 2.0 (8), the density of bone is considered to approximate a true constant (22, 32).

**Water displacement technique**

Following unsuccessful attempts by Robertson (59), Spivak (67), and Boyd (17) to measure body volume by underwater weighing, in 1942 Behnke (15) succeeded in determining body volume corrected for
pneumatic volume at the time of weighing, a factor which had been previously ignored. Behnke demonstrated that underwater weighing could give logical estimates of body composition after correcting for residual lung volume either at the completion of a maximal inhalation, or at the end of a maximal exhalation.

A human body volumeter apparatus for determining water displacement was designed by Allen (13). Fat determinations for eighty-one men were recorded, both with lungs full and less vital capacity. Both experimental conditions showed a ± 1 kilogram of fat duplicate precision.

Katch developed a hydrostatic weighing apparatus which utilized a swimming pool crib (40). The subject lies suspended underwater in a prone position while breathing normally through a skin diver's snorkel. The subject holds a maximal exhalation for approximately five seconds while the scale is damped and underwater weight is determined.

A portable fiberglass densitometric-volumeter was designed and tested by Rich (89). The tank is 30 inches wide, 48 inches long, and 42 inches deep, containing approximately 225 gallons when filled to working depth. Rich found when weighing 198 college age females that the average underwater weight of trials three, four and five yields valid body densities, while measures six through trial ten added no real clinical value.
Considerable research has been conducted in densitometric techniques for determining body composition since Robertson's initial attempt. A position concerning the future of this technique is offered by Brozek:

The densitometric analysis involved a number of qualitative assumptions. Methodologically, progress in this approach to the study of body composition involves two things: (1) increased precision in the quantitative constants used in the development of the estimation equations, and (2) measurement of some of the components that have been estimated only indirectly. (1:19)

**Physical Activity and Body Composition**

One significant factor which influences whole body composition throughout life is the intensity of physical activity (1:161). Original evidence was provided through anthropometric studies by Matiegka, who showed a difference in body composition between "gymnasts" and non-trained individuals (48). Brozek et al. examined male populations engaged in occupations involving muscular work of different intensities (1, 43). These investigators found that when comparing active and sedentary occupations, men performing physical work tended to have less fat than men of the sedentary group. A review of these interrelationships, as studied by other investigators, is presented.

**Effect of participation in sport activity**

The fundamental findings of the marked differences in body composition of trained and non-trained individuals were first established by Behnke et al. (14, 20). These studies indicate that
American football players, all of whom were very physically fit, would have been classified as overweight, and thus unable to serve in the Navy. Behnke determined that specific gravity, or the weight of the tissue per unit volume, gives a more valid index of proper weight than the standard tables which are interpreted in relation to height and weight. Consistent with the findings of studies relating physical activity and body composition, these athletes showed higher specific gravities and lower amounts of adipose tissue.

In three similar investigations concerning athletics, Thompson and Novak studied the body composition of varsity athletes. Novak's investigation concerned itself with the differences in body composition between adolescent boys who participated habitually in high school basketball and football, and other boys who did not participate in sports throughout their high school years. Body density was determined by underwater weighing, and anthropometric measurements were collected to supplement the densitometrical changes in body compartments. Novak found that the participants in athletics had significantly less body fat than the non-participants (53).

Thompson monitored the changes in body fat estimated from skinfold measurements in two related studies of college basketball, hockey, and football players during a season (71, 72). No significant weight losses were found in either study, but in both investigations mean skinfold values decreased significantly.
Parizkova's investigations were concerned primarily with the problem of prolonged physical training and its interruption on changes in body composition in young people. When comparing groups of trained and non-trained individuals of equal height, weight, and age, a higher density (higher fraction of lean body mass), was always found among individuals who were very active (10, 54).

One of Parizkova's investigations involved a longitudinal study of male and female Czechoslovakian gymnasts (54). Measurements were recorded before intensive training for the Olympics, then again sixteen weeks later before departure, and finally after fifteen weeks of relative relaxation from active training. During the preparatory phase, there were no changes in body weight, but there was a 5 per cent and 7 per cent increase in body density among females and males respectively. She also recorded 7 per cent and 10 per cent decreases in skinfold measurements for females and males respectively. After competition and relative relaxation, the body weight of the gymnasts remained constant, but the density decreased 9 per cent in women and 6 per cent in men, while skinfold measurements increased 26 per cent for females and 14 per cent for males. These findings were interpreted as indicating that changes in body density reflect gains in lean body mass during very intensive training and gains in adipose tissue when training is discontinued. These changes may be larger than changes in body weight due to the simultaneous reduction of the other component (1:163).
The body composition of female athletes was examined in a study by Conger, which also considered strength and work capacity of both participants and non-participants in women's intercollegiate sports (85). Specific gravity, per cent body fat, and lean body mass were derived from skinfold data. Results showed that participants were significantly taller, heavier, and had greater lean body mass and total kilograms of body fat. The participants did have significantly less thigh fat as indicated by skinfold measurements.

The findings of the above study were partly repeated in another investigation Conger conducted concerning physical performance and body form as related to physical activity of college women. In this study, activity was based upon average daily caloric expenditure and estimated from an activity recall questionnaire. Strength measures were monitored through the cable tension technique. When "most active" and "least active" college women were compared, significant differences were found in trunk, arm, and shoulder strength, lean body mass, body weight, and specific gravity (23).

Darwick investigated differences between physical education majors, non-physical education majors, and activity groups in the parameters of strength, body composition, physical activity, and maximum work capacity (86). Four activity groups were determined by estimated average daily caloric expenditure. Results showed that "active" subjects (upper 20 per cent), "most active" subjects (upper 10 per cent), and physical education majors possessed more fat-free
weight, exhibited greater oxygen consumption, and were stronger than the "less active" subjects (lower 20 per cent), "least active" subjects (lower 10 per cent), and non-physical education majors respectively.

**Effect of exercise programs on changing body composition**

One of the first investigations relating external fat to physical education activities and fitness tests was conducted by Kirellis et al. (45). The fat loss in three obese subjects was observed through skinfold measurements following six weeks of strenuous treadmill running without parallel weight loss. Although density was not measured, the author postulated that a concomitant increase in lean body mass occurred. In a study concerning cardiac function, body composition and obesity, Taylor maintained that the loss of fat following strenuous workloads was due to body fat being directly related to the basal arterio-venous difference, which is in turn related to basal cardiac work (70).

The Kentucky Physical Fitness Experiment, reported by Jokl (37), is another examination of the effect of exercise on body composition. The experiment evaluated a variety of effects of five months of physical training upon adolescent children. The diversified training program included calisthenics, apparatus, gymnastics, track and field, weight lifting, swimming, games and dancing. At the end of the experimental period, findings showed that the mean weight of the subjects remained constant, but that significant
decreases in external fat (10-60 per cent) and increases in active tissue (up to 30 per cent) occurred, while there were no corresponding changes in the control group.

Anthropometrically, Dempsey observed obese and non-obese young men undergoing a program of vigorous exercise (26). Seven obese subjects participated in the following eighteen week training program: daily training for eight weeks, normal activity for five weeks, and daily training for five weeks. The daily training consisted of one hour sessions of maximum movement exercises, progressive resistive exercises, and individual and dual sports. Results showed a mean decrease in total body weight of 12.30 pounds, total body fat of 17.04 pounds (6.5 per cent), a mean increase in fat free weight of 5.24 pounds, and a mean decrease in skinfold fat of 79.85 mm and abdominal girth 1.00 inches. All of these findings were significant at the .01 level of confidence.

In a study conducted to determine the effects of two different programs on body composition and dietary patterns of college females, Katch observed ten tennis and five swimming team members (42). Measurements of body density were determined by underwater weighing and skinfold measurements to estimate per cent body fat. A caloric intake history was recorded for seven days for each subject. Measurements were taken during the first, fourth, and sixteenth weeks of training. Contrary to previous findings of other investigators (26, 37, 54), Katch found no significant F ratio (.05) within or between groups for any of the experimental parameters.
He concluded that physical activity without strict dietary control has little effect on modifying body composition or dietary patterns. It is this investigator's contention that Katch's findings are not in complete contradiction to previously cited works which reported changes in body composition from physical exercise, but that the nature of the subjects (athletes), and the size of the population studied (n=15), may have influenced his results.

In a further investigation, Katch found dissonant but noteworthy results concerning individual changes in the density of sixty-two young men who participated in a ten week physical conditioning program (39). Changes in body density were shown to be more closely related to changes in residual lung volume (r=.49) than to changes in body weight (r=.31) or underwater weight (r=.26). Katch concluded that discretion should be used when attributing changes in body composition to an experimental variable such as a physical exercise program, especially if an assumed constant value for residual volume is employed to compute density. Observed changes in body density for an individual subject due to an experimental treatment, such as physical conditioning, may be masked by large changes in residual lung volume.

Specificity of body composition changes

The effect of exercise on segmental subcutaneous fat accumulations has been investigated by researchers under various selected experimental treatments. During a six week diet and exercise program
involving thirty students, Carnes (21) studied segmental volume reduction as an effect of localized versus generalized exercise. One group performed generalized exercises while another performed localized exercises for the abdomen, hips and legs (control group: n=8). Carnes' findings showed that there were no significant differences between the two experimental groups, but significant differences did occur between the experimental groups and the control group in respect to body weight and volume for the body segment from within the border of the twelfth rib to the greater trochanter of the femur.

Shade (61) analyzed Carnes' data through the use of planimetric measurements of skeletal areas and transverse linear measurements obtained from pre and post exercise photographs. Shade's analysis indicated that a reduction in local areas had in fact occurred where fat accumulations had been conspicuous, regardless of the type of exercise program.

In a similar study concerning the effects of specific exercise programs, Roby (60) investigated the premise that subcutaneous fat will be reduced in localities where muscles are active, and will be reduced in proportion to their activity. Fifteen male subjects underwent a ten week weight training program which specifically involved the triceps of the dominant arm. The inactive contralateral arm acted as a control. The findings of this study showed no significant change in mean skinfold thickness between the experimental and the control arm, with the "inactive" arm actually showing greater
change. It appears that the use of the contralateral arm as a control was ineffective due to the difficulty in keeping the inactive arm completely uninvolved during training.

Employing a program of isometric exercises, Mohr (52) studied the specific body region changes in the waistline, abdominal girth, and subcutaneous fat. For a period of one month, thirty volunteer women subjects performed six isometric abdominal contractions, each for six seconds. The findings indicated a decrease of .6 inches in waistline and abdominal girth, and a mean decrease of 1.2 mm and 1.6 mm from the waistline and abdominal skinfold measurements respectively. Both results were significant at the .01 level of confidence. Contrary to Roby's research, Mohr concluded that a specified exercise program for a body part could significantly change the girth and skinfold measurements of that part.

Body Composition of Women

Until recently, little data on the body composition of healthy young women has been available. Presented in this final section are studies specifically concerning the body composition of women.

Prediction of specific gravity and body fatness

Much interest in obesity and weight reduction has been shown by Charlotte Young and her associates at the Nutrition Laboratory of Cornell University. One of her original investigations concerned
the problem of indirectly estimating body fatness without the
determinations of density through underwater weighing (83). Young
attempted to predict specific gravity on the basis of skinfold
measurements and "standard weight". Correlations between skinfold
thickness and density were obtained, and linear regression equations
were formulated to predict specific gravity. The sites best
correlated with specific gravity ($r = .746$) were found to be the lower
rib, pubis, supra-iliac crest, chin, chest at pectoralis major, and
knee. The average per cent body fat for the women in this study was
28.69 per cent.

Katch predicted body density in a study involving sixty-four
college women (61). After underwater weighing, six skinfold and
four girth measurements were taken. The highest multiple correlation
with density was from the iliac, tricep and scapula skinfolds, and
the buttock, abdomen and arm girths ($r = .72$). The mean per cent body
fat for this female population studied was 21.5 per cent.

Sloan also studied the possibility of prediction equations
for density from skinfold measurements (65). After taking five
skinfold and five girth measurements, Sloan reported that the triceps
and iliac skinfolds correlated best with body density ($r = .65$). The
per cent body fat of the women in this investigation was reported
as 22.91 per cent.
Normative Data Studies

Young et al. also reported findings on the lean body mass and adipose tissue of 94 normal, middle and upper middle class women, aged 16 to 30 years (82). Her data revealed a mean density of 1.0342 using Rathbun and Pace calculations (58). Per cent body fat of the women studied ranged from 15.81 per cent to 38.62 per cent with a mean of 28.69 per cent. This investigator determined norms for lean body mass by interrelating densitometric analysis of each subject with total body water, skinfold determinations, fat pad measurements of soft tissue x-rays, anthropometric measures (both skeletal and envelope), creatinine excretion, and basal oxygen consumption.

In a second study focused on the body composition of women, Young examined older women, ages 30 to 70 years (84). The findings of the study closely paralleled those of the investigation with young women in that mean per cent body fat was 28.75 per cent, with no significant change in body weight.

Age Trends

Skerlj et al. (63) and Wessel (78) researched the body composition of women considering the effects of age. Wessel reported increases of 15 per cent total skinfold thickness in females from 20 to 69 years of age. Skerlj, in accordance with Young's findings, reported no significant change in body weight in women from 18 to 47 years of age, but an increase in total body fat was reported, apparently at the expense of other tissues.
Summary

Attempts have been made by several investigators to measure fatness in the living human by a number of indirect means. The basic method most frequently used has been to measure the density of the body in which the volume has been determined by underwater weighing. Behnke et al. (15) began the modern application of this technique, and Brozek et al. (20) refined the method and made it more precise by providing for the measurement of residual air in the lungs.

The intensity of physical activity has been found to influence body composition throughout life. Investigators have shown that more physically active individuals tend to be more dense, have a lower per cent body fat and have a greater lean body mass than less active individuals (1, 10, 11, 19, 23, 43, 52, 53, 54, 71, 72, 76, 86).

Attempts have been made to predict specific gravity through skinfold and girth measurements. The highest correlation was reported as .746 and involved the skinfold sites of the lower rib, pubis, supra-iliac, chin, chest, pectoralis major, and knee (83).

Normative and age trend data were also reported and will be further reviewed in the discussion of the findings of this study.
CHAPTER III
RESEARCH METHOD AND DESIGN

The purpose of this investigation was to determine if body conditioning activities would affect the participants' body composition, strength, or cardio-vascular fitness.

Overview of Experimental Design

Selection and Orientation of Subjects

The subjects of this study were seventy female volunteers, ranging in age from 18 to 40 years, who were students in body conditioning classes at San Fernando Valley State College. The subjects were pooled from seven classes taught by three different instructors.

At the first class meeting, each of the subjects was given a general orientation to the study by the investigator, at which time volunteers were requested to indicate times at which they could undergo baseline hydrostatic weighing in the laboratory. Initial cardio-vascular fitness and strength measures were collected during the second meeting of each class.

At the beginning of the experimental period, an orientation lecture was presented by the investigator to the subjects regarding the mechanics of weight control (4;230), and caloric intake history charts were distributed to each subject. Subjects were requested to
record their food intake and comparable caloric values for a one week time period, using the calorie charts for reference. Finally, subjects were requested to indicate whether their weekly food intake was a valid indication of their normal dietary habits, and if a similar intake was anticipated for the remainder of the experimental period. The results of this caloric monitoring are discussed in Chapter V.

**Criterion Measures**

The principal criterion measure for this investigation, body composition, was determined by underwater weighing of each subject and subsequent calculation of body fat from body density. The formula used was Keys and Brozek's (20), with corrections for residual lung volume and gas in the intestinal tract:

\[
D_b = \frac{MA}{MA-MW} \cdot \frac{MA-MW}{DW} - RV + VGI
\]

\[
D_b = \text{Density of body}
\]
\[
MA = \text{Mass in air}
\]
\[
MW = \text{Mass in water}
\]
\[
DW = \text{Density of water}
\]
\[
RV = \text{Residual lung volume}
\]
\[
VGI = \text{Volume of gas in intestinal tract}
\]

Percent body fat = \( \frac{4.570}{D_b} - 4.142 \times 100 \)
Criteria for determining strength included three measures: grip strength, bent knee sit-ups for one minute, and modified knee push-ups for one minute. Grip strength has been shown to correlate .66 with total body strength of male non-athletes (57), and has an objectivity coefficient of .953 for girls (49). Clark has maintained that a correlation of this magnitude is satisfactory for group descriptive and comparative purposes (3). Karpovich reported the necessity of involving muscles of the legs, trunk and arms when measuring total body strength, and included sit-ups and push-ups in his suggested battery of four tests for strength (6).

Cardio-vascular fitness was measured through the use of a one minute step test, as suggested by several investigators (64, 90). Resting, immediate post-work, and recovery heart rates after thirty, sixty, and ninety seconds were recorded. Cardio-vascular fitness and strength were monitored as supportive data to the principal parameter of body composition.

Testing Protocol

Subjects were treated individually in the laboratory on an appointment basis for body composition measurement. Immediately prior to the underwater weighing of each subject, a measurement of vital capacity was made. While standing, the subject was instructed to stretch the upper body and take several deep breaths before
vital capacity was measured, since one of the functions of this measurement appears to be the flexibility of shoulder girdle and thoracic muscles. A noseclip was placed on the subject's nose to prevent the escape of air from the nasal cavity. Encouragement to take the deepest possible inhalation was expressed to each subject, so that the lungs were filled to maximum capacity. Air was then expired steadily, with a maximum exhalation, into the mouthpiece of the wet spirometer (Figure 1). Vital capacity readings were noted, and the average of three trials was used to compute residual volume, as discussed by Wilmore (80).

After being weighed in air on a balance scale, each subject was given preliminary instructions for being weighed underwater. Before the subject entered the tank, the tare weight of the swing and the temperature of the water were recorded. After placing the noseclip on, each subject assumed a sitting position on the side of the tank (Figure 2), and commenced to slowly lower herself into the water to stand straddling the swing. Subjects sat cross legged on the suspended swing platform at approximately neck depth. To completely submerge, the subject held the bottom of the swing and bent forward until the head was well below the water surface (Figure 3). A complete forced expiration was made before and during the submersion until the subject could no longer expire. Because it has been reported that the difference between a half and a maximum expiration could result in a small, but significant (.01) error in body density, it was emphasized to each subject that all of the air
ILLUSTRATIONS

Figure

1. Measurement of Vital Capacity
2. Subject Entering Densitometric Tank
3. Subject Being Weighed Underwater
4. Measurement of Grip Strength
5. Monitoring of Resting Heart Rate at Carotid Artery
6. Subjects Performing One Minute Step Test
in the lungs must be expelled. The investigator controlled the
subjects' movement and reduced the scale oscillation to less than
25 grams by lightly hand damping the scale on the suspended cables.
Each subject wore a light weight nylon tank suit in order to decrease
the possibility of air being trapped by clothing. During the ten
trials, if the investigator noticed air bubbles adhering to the
subject, a request was made that she wipe them off her body or suit,
as suggested by Allen when working with subjects in his water dis-
placement volumeter (13). The average of trials eight, nine, and
ten were employed as the "true" underwater weight (36, 40). All
measurements were taken by the investigator or Dr. George Q. Rich,
designer of the densitometric apparatus.

Measurements of strength were taken during the subjects' respective body conditioning classes. Subjects received an explana-
tion and demonstration of the tests to be performed. It was
explained to the subjects that the sit-ups would be performed with
bent knees and hands clasped behind the head. The modified push-ups
allowed each subject to place her knees on the floor and execute a
push-up from this position. Both push-ups and sit-ups were monitored
for one minute. Subjects were then instructed how to test for grip
strength, holding the grip dynamometer over the head with the
dominant hand, and the contralateral arm behind the back. Instruc-
tions were given to describe a sweeping downward arc with the dyna-
mometer, while gripping maximally with each hand (Figure 4).
Readings were recorded, and the average of three trials was accepted as the grip strength measure (36).

The cardio-vascular fitness measure was also administered during the body conditioning classes. The investigator supervised class testing for both strength and cardio-vascular fitness. The fitness measure involved the performance of a one minute step test to a count of 120 beats per minute, for a rate of thirty complete trips per minute. Subjects sat on chairs located behind a seventeen inch high bench, as partners recorded the resting heart rates at the carotid artery (Figure 5). Pulse was recorded at each selected interval for ten seconds, and conversion of these scores to pulse rate per minute was subsequently completed by the investigator. The subjects then performed the test with a metronome set at 120 beats per minute and the investigator assisted in pace setting by giving the word cues "up, up, down, down" (Figure 6). Subjects returned to the chairs after the test, at which time pulse rate was immediately monitored for a ten second period. Pulse rate was again recorded from 30 to 40 seconds, 60 to 70 seconds, and 90 to 100 seconds post work.

A pilot test was conducted to examine the validity of student testers in monitoring pulse rate from the carotid artery. Twenty-five women volunteers underwent the step test in the exact manner that it was presented during the investigation. To check the validity of the tester, the performer was monitored by an
electrocardiograph, and true pulse rate was compared to the student reported pulse rate. The correlations between each cardio-vascular fitness measure as determined by student testers and electrocardiograms are presented in Table 1. The correlations range from .9245 for post-work heart rate to .9825 for resting heart rate, and were sufficiently high to assume that student testers validly monitored heart rate.

**TABLE 1**

THE VALIDITY COEFFICIENTS FOR HEART RATE AS MONITORED BY STUDENT TESTERS

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Student Mean</th>
<th>EKG Mean</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resting heart rate (trial 1)</td>
<td>82.48</td>
<td>82.80</td>
<td>.9825</td>
</tr>
<tr>
<td>Resting heart rate (trial 2)</td>
<td>81.48</td>
<td>82.20</td>
<td>.9824</td>
</tr>
<tr>
<td>Resting heart rate (trial 3)</td>
<td>81.20</td>
<td>83.32</td>
<td>.9741</td>
</tr>
<tr>
<td>Post-work heart rate</td>
<td>144.72</td>
<td>142.88</td>
<td>.9245</td>
</tr>
<tr>
<td>30 second recovery</td>
<td>119.60</td>
<td>120.64</td>
<td>.9729</td>
</tr>
<tr>
<td>60 second recovery</td>
<td>94.16</td>
<td>14.60</td>
<td>.9586</td>
</tr>
<tr>
<td>90 second recovery</td>
<td>84.44</td>
<td>84.80</td>
<td>.9749</td>
</tr>
</tbody>
</table>
Controls Instituted

Because of the nature and purpose of this investigation, no attempt was made to subject external controls upon the population studied.

Instrumentation

Equipment used to test the three criterion measures included the following:

1. The densitometry tank designed by Dr. George Q. Rich III at the San Fernando Valley State College Human Performance Laboratory was employed to measure body density.

2. An adjustable Stotling grip dynamometer which was utilized to measure grip strength. To insure maximum objectivity, an explanation concerning dynamometer adjustment was given.

3. The one minute cardio-vascular fitness step test utilized a seventeen inch high bench, a clock with a sweep second hand, and a metronome. The validity test of student testers employed an electrocardiograph apparatus with silver chloride electrodes.

Statistical Design

The data derived from the procedures previously outlined were statistically analyzed by use of an $F$ test to determine if significant differences existed between pre, middle, and post test results for the following parameters: body weight; per cent body fat;
kilograms of lean body mass; kilograms of fat; body density; resting, immediate post-work, 30 second, 60 second, and 90 second recovery heart rates; push-ups, sit-ups, and grip strength. The .05 level of confidence was accepted for each statistical analysis as an appropriate measure of significance.
CHAPTER IV
ANALYSIS OF THE DATA

The purpose of the study was to determine whether body conditioning, as experienced by participants in the women's body conditioning program at San Fernando Valley State College, would affect body composition, strength, and cardio-vascular fitness of participants in the program.

Data were analyzed to determine:

1. If significant differences existed among the pre, middle, and post tests for the parameters of body density, per cent body fat, kilograms of lean body weight, kilograms of body fat, and total body weight.

2. If significant differences existed among the pre, middle, and post test scores for the cardio-vascular fitness measures of resting heart rate, immediate post work heart rate, and thirty, sixty, and ninety second recovery heart rates, resulting from a one minute step stool test.

3. If significant differences existed among the pre, middle, and post test scores for grip strength, and push-ups and sit-ups per minute.

Statistical analyses and a summary of the major findings are presented in the above order.
Significance of the Differences Among Groups for Body Composition Parameters

Hydrostatic weighing of each subject was performed during the first, sixth or seventh, and twelfth or thirteenth weeks of the experimental period. Tables 2 through 6 depict the differences which existed among pre, middle, and post tests for the body composition criteria. Differences significant at the .05 level of confidence were found in per cent body fat, body density, lean body weight, and total body fat. Total body weight in kilograms did not show a significant change as a result of the experimental treatment. The significance of each measure is reported, with the .05 level of confidence accepted as an appropriate level of significance.

**TABLE 2**

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN PRE, MIDDLE, AND POST TEST SCORES FOR BODY DENSITY

<table>
<thead>
<tr>
<th>Source</th>
<th>Mean Square</th>
<th>df</th>
<th>F-Ratio</th>
<th>Test</th>
<th>Mean</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>0.0002</td>
<td>209</td>
<td></td>
<td>Pre</td>
<td>1.0415</td>
<td></td>
</tr>
<tr>
<td>Trials</td>
<td>0.0008</td>
<td>2</td>
<td>64.547</td>
<td>Middle</td>
<td>1.0454</td>
<td>.0000</td>
</tr>
<tr>
<td>Error</td>
<td>0.0000</td>
<td>138</td>
<td></td>
<td>Post</td>
<td>1.0482</td>
<td></td>
</tr>
</tbody>
</table>

P < .05
### TABLE 3

**THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN PRE, MIDDLE, AND POST TEST SCORES FOR PER CENT BODY FAT**

<table>
<thead>
<tr>
<th>Source</th>
<th>Mean Square</th>
<th>df</th>
<th>F-Ratio</th>
<th>Test</th>
<th>Mean</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>32.4615</td>
<td>209</td>
<td></td>
<td>Pre</td>
<td>24.6777</td>
<td>0.0000</td>
</tr>
<tr>
<td>Trials</td>
<td>141.0973</td>
<td>2</td>
<td>64.232</td>
<td>Middle</td>
<td>23.0310</td>
<td>0.0000</td>
</tr>
<tr>
<td>Error</td>
<td>2.1967</td>
<td>138</td>
<td></td>
<td>Post</td>
<td>21.8510</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

*P < .05*

### TABLE 4

**THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN PRE, MIDDLE, AND POST TEST SCORES FOR LEAN BODY WEIGHT**

<table>
<thead>
<tr>
<th>Source</th>
<th>Mean Square</th>
<th>df</th>
<th>F-Ratio</th>
<th>Test</th>
<th>Mean</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>25,5868</td>
<td>209</td>
<td></td>
<td>Pre</td>
<td>42.2574</td>
<td>0.0000</td>
</tr>
<tr>
<td>Trials</td>
<td>34.6118</td>
<td>2</td>
<td>38.078</td>
<td>Middle</td>
<td>43.1309</td>
<td>0.0000</td>
</tr>
<tr>
<td>Error</td>
<td>0.9090</td>
<td>138</td>
<td></td>
<td>Post</td>
<td>43.6487</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

*P < .05*
### TABLE 5

**THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN PRE, MIDDLE, AND POST TEST SCORES FOR KILOGRAMS OF BODY FAT**

<table>
<thead>
<tr>
<th>Source</th>
<th>Mean Square</th>
<th>df</th>
<th>F-Ratio</th>
<th>Test</th>
<th>Mean</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>19.0244</td>
<td>209</td>
<td></td>
<td>Pre</td>
<td>14.1097</td>
<td></td>
</tr>
<tr>
<td>Trials</td>
<td>49.5893</td>
<td>2</td>
<td>58.669</td>
<td>Middle</td>
<td>13.1249</td>
<td>.0000</td>
</tr>
<tr>
<td>Error</td>
<td>0.8452</td>
<td>138</td>
<td></td>
<td>Post</td>
<td>12.4350</td>
<td></td>
</tr>
</tbody>
</table>

P < .05

### TABLE 6

**THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN PRE, MIDDLE, AND POST TEST SCORES FOR TOTAL BODY WEIGHT**

<table>
<thead>
<tr>
<th>Source</th>
<th>Mean Square</th>
<th>df</th>
<th>F-Ratio</th>
<th>Test</th>
<th>Mean</th>
<th>Probability</th>
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<tbody>
<tr>
<td>Total</td>
<td>126.9642</td>
<td>209</td>
<td></td>
<td>Pre</td>
<td>55.5424</td>
<td></td>
</tr>
<tr>
<td>Trials</td>
<td>20.8457</td>
<td>2</td>
<td>1.466</td>
<td>Middle</td>
<td>54.6911</td>
<td>.2329</td>
</tr>
<tr>
<td>Error</td>
<td>14.2160</td>
<td>138</td>
<td></td>
<td>Post</td>
<td>54.5253</td>
<td></td>
</tr>
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</table>

P > .05
Significance of the Differences Among Groups for Cardio-Vascular Fitness Measures

A one minute step test was administered to the subjects during the first, sixth or seventh, and twelfth or thirteenth weeks of the experimental period. Resting heart rate, immediate post work heart rate, and thirty, sixty, and ninety second recovery heart rates of the pre, middle, and post tests appear in Tables 7 through 11. A significant decrease at the .10 level was found for heart rate immediately after work, and at the .07 level for sixty second recovery heart rate. None of the above results reached the .05 level of confidence, and thus were not considered significant.

TABLE 7
THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN PRE, MIDDLE, AND POST TEST SCORES FOR RESTING HEART RATE

<table>
<thead>
<tr>
<th>Source</th>
<th>Mean Square</th>
<th>df</th>
<th>F-Ratio</th>
<th>Test</th>
<th>Mean</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>126.9396</td>
<td>179</td>
<td></td>
<td>Pre</td>
<td>86.7833</td>
<td></td>
</tr>
<tr>
<td>Trials</td>
<td>47.6222</td>
<td>2</td>
<td>0.559</td>
<td>Middle</td>
<td>88.2167</td>
<td>.5789</td>
</tr>
<tr>
<td>Error</td>
<td>85.2437</td>
<td>118</td>
<td></td>
<td>Post</td>
<td>86.5833</td>
<td></td>
</tr>
</tbody>
</table>

P > .05
TABLE 10

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN PRE, MIDDLE, AND POST TEST SCORES FOR 60 SECOND RECOVERY HEART RATE

<table>
<thead>
<tr>
<th>Source</th>
<th>Mean Square</th>
<th>df</th>
<th>F-Ratio</th>
<th>Test</th>
<th>Mean</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>301.5450</td>
<td>179</td>
<td></td>
<td>Pre</td>
<td>121.4500</td>
<td></td>
</tr>
<tr>
<td>Trials</td>
<td>318.3500</td>
<td>2</td>
<td>2.595</td>
<td>Middle</td>
<td>119.8000</td>
<td>.0770</td>
</tr>
<tr>
<td>Error</td>
<td>122.6890</td>
<td>118</td>
<td></td>
<td>Post</td>
<td>116.9000</td>
<td></td>
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</table>

P > .05

TABLE 11

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN PRE, MIDDLE, AND POST TEST SCORES FOR 90 SECOND RECOVERY HEART RATE

<table>
<thead>
<tr>
<th>Source</th>
<th>Mean Square</th>
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<th>F-Ratio</th>
<th>Test</th>
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<th>Probability</th>
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</thead>
<tbody>
<tr>
<td>Total</td>
<td>2402.1820</td>
<td>179</td>
<td></td>
<td>Pre</td>
<td>122.0000</td>
<td></td>
</tr>
<tr>
<td>Trials</td>
<td>1607.6223</td>
<td>2</td>
<td>2.129</td>
<td>Middle</td>
<td>108.9000</td>
<td>.1214</td>
</tr>
<tr>
<td>Error</td>
<td>2164.3002</td>
<td>118</td>
<td></td>
<td>Post</td>
<td>105.3667</td>
<td></td>
</tr>
</tbody>
</table>

P > .05
Significance of the Differences Among Groups for Strength Measures

The three selected measures of strength in this investigation included one minute bent knee sit-ups, one minute modified push-ups, and preferred hand grip strength. The results of the pre, middle, and post tests for these measures are presented in Tables 12 through 14. A significant increase at the .05 level of confidence was found in both the sit-up and push-up measurements, while grip strength changes did not reach significance.

TABLE 12

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN PRE, MIDDLE, AND POST TEST SCORES FOR PUSH-UPS FOR ONE MINUTE

<table>
<thead>
<tr>
<th>Source</th>
<th>Mean Square</th>
<th>df</th>
<th>F-Ratio</th>
<th>Test</th>
<th>Mean</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>113.7373</td>
<td>179</td>
<td></td>
<td>Pre</td>
<td>20.0500</td>
<td></td>
</tr>
<tr>
<td>Trials</td>
<td>1220.3722</td>
<td>2</td>
<td>40.188</td>
<td>Middle</td>
<td>24.3500</td>
<td>.0000</td>
</tr>
<tr>
<td>Error</td>
<td>30.3666</td>
<td>118</td>
<td></td>
<td>Post</td>
<td>29.0667</td>
<td></td>
</tr>
</tbody>
</table>

P < .05
### TABLE 13
THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN PRE, MIDDLE, AND POST TEST SCORES FOR SIT-UPS FOR ONE MINUTE

<table>
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P < .05

### TABLE 14
THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN PRE, MIDDLE, AND POST TEST SCORES FOR GRIP STRENGTH IN KILOGRAMS

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P > .05
Summary of the Major Findings

Findings from the analyses are summarized as follows:

1. Significant within group differences were found between pre, middle, and post test scores for body density, per cent body fat, lean body weight, and kilograms of body fat, although no significant change in total body weight was found.

2. No significant within group differences were found between pre, middle, and post test scores for the cardio-vascular fitness measures.

3. Significant within group differences were found between pre, middle, and post test scores for the strength measures of push-ups and sit-ups, although changes in grip strength did not reach significance.
CHAPTER V
SUMMARY AND DISCUSSION

Summary

The purpose of this investigation was to determine the effects of body conditioning, as experienced by participants in a body conditioning program, on selected parameters of body composition, strength, and cardio-vascular fitness.

Seventy female volunteers from physical education body conditioning classes served as subjects for this study. Body composition, the principal criterion for this investigation, was determined through the underwater weighing of each subject and the subsequent calculation of body fat from body density. A modified strength index, including one minute push-ups, one minute sit-ups, and grip strength, was utilized to indicate strength. Cardio-vascular fitness was determined by a one minute step test, which included the monitoring of resting, immediate post work, and thirty, sixty, and ninety second recovery heart rates. All of the measures were tested at the beginning, middle, and end of the thirteen week experimental period.

The data determined from the above tests were statistically analyzed through analysis of variance (F test) to determine the
significance of the within group differences which occurred between pre, middle, and post test results for each of the selected parameters.

Major Findings

1. Significant within group differences were found between pre, middle, and post test scores for body density, per cent body fat, lean body weight, and kilograms of body fat, although no significant change in total body weight was found.

2. No significant within group differences were found between pre, middle, and post test scores for the cardio-vascular fitness measures.

3. Significant within group differences were found between pre, middle, and post test scores for the strength measures of push-ups and sit-ups, although changes in grip strength did not reach significance.

Discussion of the Findings

The seventy subjects for this study were volunteers from seven body conditioning classes taught by three different instructors. Although the methods of instruction, program planning, and motivation differed somewhat among the instructors, all of the instructors were similar in their emphases -- to increase muscular strength and endurance, to improve cardio-vascular endurance, and to
The significant results of the body composition measurements appear to indicate clinical importance. It could be predicted from the statistical results that a 150 pound individual, over the course of thirteen weeks of body conditioning classwork, would decrease 2.68 per cent body fat, 2.35 kilograms of fat, or approximately five pounds of fat, and increase 2.5 pounds of lean body weight. Considering the limited time interval involved -- forty-five minute conditioning classes, two times a week for thirteen weeks -- the quality of the tissue changes invoked can be considered of practical importance.

The results also reflect significance when consideration is given to the lack of dietary control placed upon the subjects. At the beginning of the study, the subjects reported a mean caloric intake of 1381 calories per day, with seventy-seven per cent stating that they planned to maintain the intake reported throughout the experimental period. It was not possible for the investigator to maintain control over the caloric intake of each subject during the entire thirteen week period, so no effort was made in this direction.

A further indication of significance in the findings of this study is the fact that the decrease in per cent body fat was equivalent to the lowest of the means reported for the same variable by Katch (40) and Von Dobeln (74). It was understood that the subjects who were voluntarily enrolled in the body conditioning program desired to bring about a change of some magnitude in body
compartments. The change invoked appears to be important because the final per cent body fat was within 0.35 per cent of the lowest mean of per cent body fat reported for women within the age range of the subjects in the present study.

Wilmore has suggested that when density, per cent body fat and lean body mass are used for research purposes, the direct measurement of residual lung volume should be attempted. Because of the number of subjects and the laboratory time allotment per subject, it was necessary in this study to estimate residual lung volume from vital capacity. Katch reported in October, 1971, (39) that when residual volume is not measured directly, changes in body density for an individual subject, which are considered to be due to an experimental treatment like physical conditioning, may be more related to variability in residual lung volume \( r = .49 \) than to underwater weight change \( r = .26 \). Katch concluded that discretion should be used when attributing changes in body composition to an experimental variable such as a physical exercise program. It was assumed that in this study the measurement error in taking vital capacity was reduced by having the subjects perform stretching exercises and practice inhalations before their trials. Since the direct measurement of residual volume was not conducted in this study, it is not possible to assess the effects of this factor upon the validity of the findings.
Strength Battery

The results of the pre, middle, and post test scores for one minute push-ups and one minute sit-ups reflected significant increases in both measures. These two strength measures were chosen from fitness batteries presented by Clark (3) and Karpovich (6). The selected strength exercises were specific components of the body conditioning program, and were performed with increasing intensity during each class session. Therefore, an increase in these measures might be expected.

Grip strength has been shown to correlate .66 with total body strength of non-athletes (57), and is a satisfactory measure for group descriptive and comparative purposes (3). During the conditioning program the subjects did not appear to overload grip strength in any specific manner, which may account for the failure of this measure to reach significance (5).

Cardio-Vascular Fitness Test

Results of the pre, middle, and post test scores for the one minute step test showed no significant changes in the fitness measures of resting heart rate, immediate post work heart rate, and thirty, sixty, and ninety second recovery heart rates. Although running activities were a part of the conditioning program, it appears that the training stimulus was not intense enough to induce changes in the cardio-vascular fitness levels of the subjects.
Significant changes in one minute cardio-vascular fitness measures have been shown to occur in basketball players after undergoing just six weeks of conditioning (51). Similarly, significant changes in cardio-vascular fitness measures occurred in college women who underwent three different training programs on the bicycle ergometer during a six week time period (81). Karvonen has concluded from his investigations concerning the physiological principle of threshold stimulus for training that resting heart rate plus sixty per cent of the difference between resting and maximum heart rate is necessary to improve exercise tolerance and cardio-vascular efficiency. It appears that the participants in the program studied did not reach this workload intensity during the cardio-vascular fitness training.

**Conclusion**

The hypothesis of this investigation was designed to ask the following experimental question: Does participation in a body conditioning program induce desirable changes in body composition, strength, and cardio-vascular fitness? The following general conclusions appear to be justified:

1. Body conditioning, as experienced in a one semester program, does significantly change body composition as shown by decreases in per cent body fat and total body fat, and increases in total body density and lean body mass.

2. Although body conditioning does appear to improve muscular strength, no significant improvement in cardio-vascular fitness was
Recommendations for Future Research

The effect of body conditioning on body composition, strength, and cardio-vascular fitness requires further investigation. The findings of this study suggest the following implications for future research:

1. An attempt should be made to clinically control the caloric intake of subjects during a body conditioning program. This investigation should probably occur in a regulated community, such as a women's penal colony, where diet could be readily controlled.

2. Future research should investigate the average caloric expenditure during each body conditioning class. Similarly, subjects might be randomly monitored to assess specific cardio-vascular workloads to determine if a sufficient training stimulus to improve cardio-vascular fitness is achieved.

3. An attempt should be made in future studies to compare direct measures of residual volume with indirect measures before and after a conditioning program.
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Books


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58. Rathbun, E. N. and Pace, N. "Studies on body composition I: The determination of total body fat by means of the body's specific gravity." Journal of Biological Chemistry.


Unpublished Papers


APPENDIX A

DATA CARD FOR BODY COMPOSITION, STRENGTH, AND CARDIO-VASCULAR FITNESS
DATA CARD FOR BODY COMPOSITION, STRENGTH, AND CARDIO-VASCULAR FITNESS

Name_________________________ Age____ Phone_______ Ht____ Wt____

Address_________________________ Class hr._____

STEP TEST

Resting ___ ____ Work ___ 30 sec. ____ 60 sec. ____ 90 sec. ____

STRENGTH

Grip ______ ______ ______ Sit-ups ____ Push-ups ____

BODY COMPOSITION

Tare wt. ______ H2O temp. ______ V.C. _______ _______ ______

Underwater weighings

__________________________

__________________________
APPENDIX B

RAW DATA FOR VALIDITY TEST OF STUDENT HEART RATE MONITORS
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APPENDIX C

DESCRIPTIVE DATA FOR BODY COMPOSITION, STRENGTH, AND CARDIO-VASCULAR FITNESS
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DESCRIPTIVE DATA FOR PRE, MIDDLE, AND POST TEST
BODY COMPOSITION MEASURES

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DESCRIPTIVE DATA FOR PRE, MIDDLE, AND POST TEST STRENGTH MEASURES

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