CHANGES IN BODY COMPOSITION OF COLLEGE FOOTBALL PLAYERS DURING FOUR VARYING TRAINING PROGRAMS

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B.S., KANSAS STATE UNIVERSITY, 1971

A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Health, Physical Education, and Recreation

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1973

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Chapter 1

INTRODUCTION

The study of man's body composition has become the topic of much recent research. In the past it was thought by many that high body weight was a sign of good health, especially in children. But recent studies have indicated that many physical problems associated with body fat are causes of diseases. This, and the cosmetic value of leanness, has made the problem one of great importance to the American public. Overabundance of body fat is now one of the major causes of degenerate diseases of the heart. Degenerative heart disease overshadows all other causes of death in this country.[1]

Body fat is a problem for major college football players as well as the general public. With the great amount of emphasis that is now being placed on major college football programs, it is attracting many physically exceptional individuals and requiring them to go through many different and demanding types of training programs. When involved in these types of training programs, it is very important to limit and restrict or sometimes change the body composition or per cent of body fat of the individual. The individuals involved in these programs are quite often of massive muscular structure and weight with a low amount of body fat. It is not uncommon for university varsity lines to average more than 225 pounds per man. The demanding programs that are conducted during the year are to prepare individuals for the game itself which requires superbly conditioned athletes who can endure the bruising bodily contact of blocking and tackling, and also be very agile and swift a foot.[2] The effectiveness of an individual in performing these required tasks can be hampered to a great degree by an excess of body fat. This study attempts to examine the changes and variations, if any, in body weight, fat, and bodily composition that occur in major college football players during four varying types of training periods.

Statement of Purpose

The purpose of this study was to determine whether there were significant changes or variations in body weight, fat, and bodily composition resulting from four varying training periods. Secondary intentions of the study were to show the relationships between the eight variables tested and also the relationships between the results of the programs and individuals examined in this study, great insight can be gained and thereby used in organizing more efficient training programs for athletes.

Footnotes

[1]Kraus and Raab, pp. 3-5.

[2]Thompson, C. W. "Changes in Body Fat, Estimated from Skinfold Measurements of Varsity College Football Players During a Season, Research Quarterly, Vol. 30, No. 1, p. 88-93, 1958.

Chapter 2

REVIEW OF LITERATURE

History of Background

In this study it was necessary to review material that would present some of the information and studies that have been conducted and researched in the area of determining body composition or body fat.

Historically, the first quantitative measurements of skinfold thickness with a caliper was made by a Frenchman by the name of Richer as early as 1890.[3] He was also the first to use pinching of a skin fold with the fingers as a caliper to survey "nutritional status" of an individual.[4] Richer in the same year of 1890 described what was probably the first calipers used for the measurement of skinfold thickness in man.[5]

From this early beginning many individuals used and experimented with numerous types, sizes, and shapes of calipers for work done in the area of body composition and the measurement of body fat.

However, most of the very early work done in this area was done with anthropometric measures such as height and weight. These early measures resulted in the height and weight charts such as the one developed by the Metropolitan Life Insurance Company.[6] These charts were soon challenged by Behnke and others.[7] The inadequacy of the charts was readily brought out, and as early as 1942 they were said to be invalid measurements of leanness and fatness amoung man. Behnke and others established that the common practice of assessing the degree of obesity or body composition of an individual with a high total body weight having a high percentage of lean body mass or a better development of bone or muscle, both heavier than adipose tissue, would be considered overweight by the height and weight charts. Vice versa, an individual with a low total body weight and high percentage of fat would be considered underweight by height and weight charts.[8]

Through Behnke's study and others it was then concluded that skinfold measurements with the use of a caliper are much more accurate in predicting the percentage of body fat or body composition.[7]

Two individuals that were of great importance in the study and research of the calculation and measurement of body fat and body composition were Brozek and Keys. As early as 1920 they were instrumental in the standardization, development, and design of accurate constant pressure calipers. In 1951 Brozek and Keys were the first to demonstrate the use of skin fold measures for estimating body density and percent of body fat.[9] They were also the originators of the formulas for the equations to calculate the per cent of body fat and body density or specific gravity from skinfold measurements.[10] They layed the ground work for numerous attempts and accomplishments that have been made in the refinement of technique for the determination of body composition or body fatness and leanness.[11]

The primary instrument involved in skinfold measurement is the caliper. Brozek, Keys and other individuals were responsible for important studies involving the improvement in design and accuracy of the caliper. In the measurement of skinfolds by a caliper, one of the most important aspects is the pressure at the points of the caliper. This pressure on the caliper face, varied over the whole possible range from essentially no pressure to the maximum compression tolerable without pain.[12]

Several early studies by Sandler[13] and others revealed that by varying the amount of pressure per unit surface of the contact plates of a caliper on a skinfold, the thickness of the double skin-plus-fat thickness can be varied. This indicated the need for a caliper that measured with a constant pressure from reading to reading and over the range of skinfold thicknesses studied. After exhaustive exploration of various caliper designs and trial of models embodying different principles, Key and Brozek designed a simple caliper which could easily be set to any desired pressure from 5 to 20 gm/mm^2 and which exerted constant pressure at all openings.[12]

As early as 1929 Franzen also developed a constant-tension caliper that facilitated the systematic study of subcutaneous fat in man. The value of skinfold measurements as an index of body fat has been amply demonstrated since that time. Caliper measurements of skinfold thickness has become the standard anthropometric procedure with triceps and subscapular sites regarded as the best.[14]

In a later study of design and accuracy, Edward, Hammond, Healy, Whitehouse, and Tanner[15] established that a change in pressure within the range of the caliper has a marked effect on the observed thickness of the fold so that provision of a caliper producing constant, or nearly constant pressure at all jaw openings becomes a point of first importance. The precise pressure used depends upon several considerations, one being the discomfort produced by the caliper squeezing the fold. This study also established that the face area of skinfold calipers should be 6 x 15 mm, should not vary by more than 2.0 g/mm^2; that the pressure should be between the limits of 9-15 g/mm^2 with a recommended standard value of 10 g/mm^2; that the scale of the instrument should be read at least to 0.5 mm and preferably to 0.1 mm. Through this study a new caliper was developed and tested that proved to be satisfactory in all areas previously mentioned.[15]

Through continuous study and research the caliper became a very accurate and precise instrument. In 1954, Best[5] developed and put into use a skinfold caliper which was easily manipulated with one hand, and with it maintaining a constant tension on the plates. The caliper also had parallel faces regardless of skinfold size. Readings were made readily and accurately, and the standard deviation of a single measurement was found to be 0.0743 cm.[5]

Because the vast improvement of the skinfold caliper and a need for a simplified manner in which the assessments of body fat and body composition in humans are made, the skinfold caliper became the most applicable method of measuring body fat for clinical, general evaluation, research purpose, and routine health and physical education tests.[16] Its inexpensive measurements are quickly and easily made, and it affords a very reasonable estimate of the total body fat.[17]

General Review of Studies

Body fat has long been recognized as one of the major variables associated with body composition. It can be altered by changes in nutrition, disease, and exercise.[11] The body fat or subcutaneous adipose tissue constitutes a large fraction of the total fat deposit in man. According to Wilmer, the weight of skin plus subcutaneous tissue constitutes 17 per cent of body weight in the adult man. Of this, skin alone accounts for 6 per cent, the subcutaneous tissue for 11 per cent.[18]

Numerous tests and studies have been done since about 1950 involving the accuracy and the reliability of the skinfold caliper technique. These tests and studies have been administered to various types of humans from children to obese women. In an early study done by Piscopo[19] on pre-adolescent boys, it was stated that skinfold caliper techniques provide a reliable means of estimating subcutaneous body fat. Skinfold measurement is being considered, with increasing frequency, a criterion of fatness. In Piscopo's study on changes in body fat estimated from skinfold measurements, the application of this technique was demonstrated by physical education research workers. Through the information produced from this study it was concluded that skinfold data in conjunction with accurate and quantitative height, weight, and girth measurements can aid in appraising the physical status of the individual.

Through the results of several studies conducted by Hechter, von Doblin, and Wilmore in 1954 it was shown that body density or specific gravity and per cent of body fat can be predicted from a few simple skinfold measurements with a comparatively high degree of accuracy.[16]

A study by Thompson, Buskich, and Goldman in 1956 showed that intercorrelations between skinfold measures at various sites on the body are high (0.7-0.95). Thus, if body fat is to be predicted from multiple skinfolds, one soon reaches a point of diminishing returns. Three or four well selected and properly weighted sites give optimal prediction although subcutaneous fat is known to vary considerably between sites. The abdomen, chest, and upper arm seem to have the best prediction value and can readily be measured on the average male. The site on the upper arm has the unique advantage of accessibility and acceptability for both male and female.[20]

Edwards[21] conducted studies in 1956 showing that the total fat fold thickness based on 53 sites increased as body weight increased. Also in a study by Brozek and Keys it was found that specific gravity decreased (and the estimated fat content increased) with increasing relative weight in both young and middle aged men.[21]

In 1958, Baker established evidence that skinfolds represent a good estimate of skin plus subcutaneous fat thickness. The coefficient of correlation was 0.952 between the skinfold caliper readings over the arm and thigh, and measurements of skin plus fat thickness from roentgenograms.[22]

Also as early as the 1950's the reliability of skinfold measurements were examined in terms of correlations between repeated measurements of 65 to 70 adults by Tanner and Wiener.[23] The measurements were made by Franzen-type calipers, and repeated by the same examiner within a 3-minute interval. The coefficients of consistency determined under those conditions were 0.955 and 0.982.

A study by Newan and White in 1958 calculated the fat percentage from the three skinfold measurements, using equations obtained from Brozek and Keys.[24]

In a more recent study done by A. W. Sloan in 1967 the results of ultrasonic measurement and skinfold measurements for the estimation of body fat were compared. It was found that skinfold measurements are simple to perform and reasonably reproducible. In Sloans' investigation it was also found that the ultrasonoscope gave no greater accuracy of prediction than the simple, cheaper, and less cumbersome skinfold calipers.[25]

Review of Studies Involving Physically Trained or Active Individuals

It wasn't until the 1950's that a great deal of research was done in the area of the effects of physical training or activity on body composition or body fat. One of the first studies of body composition involving active individuals was conducted by Welham and Behnke, who found that professional football players had a larger "lean body mass" than average Navy men although the mean specific gravity values were not significantly different. Another study by Wilham and Behnke of college athletes and other students showed that wrestlers and cross country runners have higher body densities and less fat than "average" college students.[26]

A study was done in 1955 on body composition of paratroopers before and after training. The average loss in body weight was only 0.6 Kg., and a small but significant increase occurred in body density as measured by underwater weighing. Body fat had decreased significantly.[27]

In 1956 Cureton conducted a study involving United States Olympic Swimming teams, this work covered the relationship of fatness, estimated by skinfold, to performance of strenuous physical exercise. It was found that large fat measurements were negatively correlated with performance.[28]

A study in 1956 by Brozek compared two groups of middle aged men, "active" and "inactive". The two groups had long standing differences in habitual physical activity. The "active" men were less fat and more muscular, as estimated from differences in skinfold measurements. The large fat-free weight of the "active" group indicated a minimal loss of muscular tissues. This finding is in contrast to the usual aging trend.[29]

In another study conducted in the late 1950's, the development of ten "mesomorphic" young men who were under the guidance of a professional weight lifter for four months was observed by Tanner. The results of this study demonstrated a significant increase of approximately 2 cm. in upper arm circumference, with essentially no change in the skinfold measurements over the front and back of the upper arm.[30]

In 1958 a study by Thompson, Buskirh, and Goldman examined the changes in body composition associated with conditioning and training. They found that body fat, particularly subcutaneous fatness, was altered by a season of strenuous training in both varsity college basketball and hockey players. Body weight loss was not significant but skinfold measurements of abdomen, chest, and upper arm all decreased significantly. Body density estimated from skinfold measurements increased, thus indicating a loss of body fat which has a lower [illegible]ity than muscle. Also, body fat estimates from skinfold measurements were less at the end of the season in both basketball and hockey players.[31]

In another very similar study also by Thompson in 1958, the use of skinfold measurements was demonstrated as being a practical way to study changes in body composition, especially body fat. Skinfold measurements, abdomen, chest, and arm were made on varsity football players at the beginning and end of a season. Using this information changes in body composition that occurred during conditioning and training were studied. Body weight did not change significantly, but significant losses occurred from the three skinfold sites. Body density as estimated from skinfold data increased with training and conditioning. Presumably this increase was due to loss of body fat and increase in muscle mass and other bodily components.[2]

A more recent study in 1968 was conducted by pre-season and post-season skinfold tests of women athletes. In this study by Lundgren it was shown that there was a significant reduction in fat measures at the three sites but that there was no significant changes in body weight, although it was interesting to note that there was a tendency for individual group members to gain weight. This seems to indicate that, as was found in men, body fat can be altered during a season of varsity play, although body weight does not necessarily change.[32]

In another study just completed in 1970 by Costill, Bowers and Kammer, it was estimated through skinfold measurements and equations that highly trained marathon runners possess about 7.5% body fat or 5% less fat than normally active college men. The marathoners examined in this investigation appeared to have less body fat than any athletic group previously measured. Costill also conducted a study of 75 collegiate football players which resulted in a mean body density of 1.064 and a mean body fat of 15.4.[33]

Footnotes

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Chapter 3

METHODS AND PROCEDURES

This chapter of the study examines the methods and the procedures used in administering the tests reliably. Also described in this section are the activities or programs and varying periods of time involved in the different training programs that the subjects participated in. The entire study covers four different training programs that started in mid-August and finished at the end of April or totally covered approximately 8½ months.

Procedures

As has been noted earlier, the skinfold calipers and measuring technique has been tested and improved until at the present time it is a standard and reliable method of measurement. Among the factors that have been considered in determining the choice of skinfolds sites to be measured, Edwards mentioned the ease with which a fold of skin may be lifted, and accuracy with which a site can be located in different subjects. This affects the consistency of repeated measurements, a criterion used by Edwards for reducing the original number of sites.[21]

The number of site measures was cut to a minimum of three; the chest, tricep or arm, and abdomen. These three appear to be the most useful for many purposes, particularly surveys. Since intercorrelation between skinfolds measured at various sites are high (0.7-0.95), the three selected sites are all that is necessary for good predictive value.

An important point in reference to standardization of skinfold measurement was brought out by Keys and Brozek. They stated that the skin should be lifted so that a proper fold (a complete double layer is formed). When skin is very thin, this is readily accomplished with a "bite" covering less than 3 cm. When the subcutaneous layer is thick, 7 or more cm., an accurate skinfold measurement is more difficult. This occurs most frequently in the abdominal skinfold.[9]

The Lange skinfold caliper was used in this study. When the measurements were made in these tests the caliper had a recommended pressure of approximately 10 gm/mm^2 between the jaw faces in order to secure reliable measurements. The measured skinfold thickness is highly dependent on caliper pressure until at least 10 gm/mm^2 is reached.[15]

The tests were administered to the 30 athletes by a trained technician whose reliability was tested through the Spearmen rank correlation coefficient and proven to be adequate.

The accepted standard of reliability or significance for the Spearman rank correlation coefficient using a N of ten is rho of .65 at the .05 level of significance. In the case of this study, ten sample subjects were selected and tested on all three skinfold measurements. After a period of ten minutes the same testing procedure was repeated on the same ten subjects. The results of these two skinfold tests were then plotted on Consolazio's Nomogram for the determination of the per cent of body fat for each of the ten subjects in both tests. These two test results were then used in a Spearman rank correlation coefficient to determine the rho.

The rank correlation coefficient or rho for these tests was .80. A rho of .80 exceeds the value of .65 needed for significances at the .05 level of significances and indicates adequate reliability.

The skinfold measurement sites were:

1). Abdomen--approximately 5 cm. to the right of the umbilicus.

2). Chest--about 5 cm. from the right nipple on a line toward the uppermost point of the axillary fold (skinfold parallel to this line).

3). Upper arm--over the right triceps, halfway between the olecranon acromial processes. (Skinfold parallel to the long axis of the arm).

In making a measurement, the skinfold was lifted with the thumb and index finger and held while the caliper was applied approximately 1-1.5 cm. away. Care was taken not to exceed the standard pressure before the measurement was made in order to reduce the early changes in thickness thought to occur with fluid shift. The measurements were taken with the individual in a relaxed state.

The three skinfold measurements of the 30 athletes were then plotted on Consolzaio's Nomogram for the determination of body fat and specific gravity for young men. Each skin fold was lifted and measured three times. The results recorded are the average of the three measurements. Body weight and height was measured on a standard physician's scale. In the strength test olympic weights were used in performing four basic lifts; dead lift, bench press, clean and jerk, and squat. These lifts were tested after a 8 week training program so the technique of all 30 athletes was approximately equal.

The six skinfold and weight measurements were taken after all four training periods. While the height test was taken during the first series of tests only and the strength test was only administered during the fourth series of tests. This was done because no significant difference or change in height or strength was believed to occur during these training periods.

Subjects

The subjects consisted of a group of thirty major college football players who had all lettered in the 1972 season at K. S. U. This group of 30 athletes was made up of 15 backfield men and 15 linemen. The entire group's mean age was 20 years, height was 73.6 inches and weight was 207 lb. The 15 linemen were considerably larger with a mean height of 74.5 inches and a mean weight of 224 pounds. The back's mean height was 72.8 inches and their mean weight was 191 pounds. All of these measurements for the mean scores listed above were taken at the beginning of the study on Nov. 20.

Some of the discrepancies that are involved in most studies of this nature were eliminated because of the great similarities between the individuals involved. For example, they were all exceptional athletes or very similar in physical characteristics and ability, they were all males and of the same age, and also were all exposed to the same activities.

Description of the Training Programs

The first group of tests were administered on Nov. 2, 1972 following a season of eleven football games. The eleven game season began as early as August 20, 1972 and continued until the last game on Nov. 18, 1972. The first two weeks of practice consisted of two-a-day practices which continued from Aug. 20, 1972, to Sept. 14, 1972. From the 4th of September, until the end of the season on Nov. 18, 1972 the athletes practiced once a day for approximately 2 hours. On game days the athlete's activity varied, however, those involved in this study were all lettermen and as a result they all received a considerable amount of physical activity on game days also.

The second group of tests were administered on Jan. 15, 1973 following a vacation of approximately 55 days from Nov. 20, 1972 to Jan. 15, 1973. During this time the athletes were under no controlled or supervised workout program. The individuals were on vacation from school and the football program for most of this time. The physical activity received at this time was completely self-motivated. However, the athletes were advised to stay in good physical condition over the vacation because workouts would resume in the form of off-season program on Jan. 15, 1973.

The third group of tests were administered on March 7, 1973 following the off-season program which is devised to improve the athlete's physical ability to perform as a football player. It consists of 5 one-hour workout sessions each week. These daily sessions cover four different areas or types of physical activity. The activities consist of weight lifting and running three days a week, usually Monday, Wednesday, and Friday. This is to improve the athletes speed and strength. On Tuesdays and Thursdays the workouts consist of agility and conditioning drills which are to increase the athlete's stamina and quickness. This off-season program lasted for approximately 8 weeks or 40 workouts from Jan. 15, 1973, to March 7, 1973.

The last group of tests were administered on April 29, 1973 following Spring football practice sessions. Spring football started on March 7, 1973 and consisted of 20, usually 2½ hour practice sessions. These 20 practice sessions were distributed as evenly as possible from March 7, 1973 to April 29, 1973. Usually there were 3 practice sessions a week if no conflicting situations occurred. At that rate the spring sessions usually lasted approximately 7 weeks. The practices were similar to those during the regular season except usually about 30 min. longer.

Footnotes

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Chapter 4

RESULTS AND DISCUSSION

Six of the eight variables were tested after each of the four training periods. The results of these four tests were compared through an analysis of variance. This was to see if any significant changes or difference occurred in the six variables during the four different training periods. When the mean abdominal skinfolds were compared for each of the four tests a significant F was noted (F-25.598).

Through a Duncan Multiple Range Test it was indicated where or between which of the four tests a significant change occurred. This is shown in the following table:

Abdominal Skinfold

Duncan Multiple Range Test

1st Test (Post-regular season)	4th Test (Post-spring training)	3rd Test (Post-off-season)	2nd Test (Post-vacation)
18.367	18.500	20.100	22.700

There was a significant difference indicated between all four tests except test no. 1 and test no. 4. The largest variation occurred between test no. 1 and test no. 2. Athletes had largest abdominal skinfolds after a layoff and the smallest skinfolds after the season and after spring practice.

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The second group of tests that were examined were those of the triceps skinfold. These four test were also compared through an analysis of variance to see if any significant changes did occur during the four tests. The F (19.651) was significant at the .05 level.

The Duncan Multiple Range Test, showing where or between which of the four tests a significant change occurred, was administered and the results are on the following table:

Tricep Skinfold

Duncan Multiple Range Test

1st Test (Post-regular season)	4th Test (Post-spring training)	3rd Test (Post-off-season)	2nd Test (Post-vacation)
11.20	11.50	12.70	13.867

A significant difference occurred between all four tests except tests 1 and 4. The greatest significant difference occurred between test 1 and 2. Again skinfolds were smallest after the season and after spring practice.

The third group of test results that were examined were those of the chest skinfold. These four tests were also compared through an analysis of variance to see if significant changes occurred during the four tests. The F (11.122) was significant at the .05 level.

Through a Duncan Multiple Range test, it was shown to what extent and where significant changes occurred in the four test results. The results of the Duncan test are listed in the table below:

Chest Skinfold

Duncan Multiple Range Test

1st test (Post-regular season)	4th test (Post-spring training)	3rd test (Post-off-season)	2nd test (Post-vacation)
10.47	10.47	11.40	12.10

A significant change or difference occurred between all tests except test 1 and test 4. They were shown to be significantly the same. Again, the largest change or significant difference occurred between the 1st and 2nd tests. Athletes had largest skinfolds after the holiday layoff.

The fourth group of test results that were examined were those of the percent of body fat. These four tests were also compared through an analysis of variance to see if a significant change occurred during the four tests. The F (25.198) was significant at the .05 level.

Through a Duncan Multiple Range Test showing to what extent and where significant changes occurred in the four test results the following conclusions were drawn and listed in the table below:

Percent of Total Body Fat

Duncan Multiple Range Test

1st test (Post-regular season)	4th test (Post-spring training)	3rd test (Post-off-season)	2nd test (Post-vacation)
9.68	9.92	10.97	12.05

A significant change or difference occurred between all tests except test no. 1 and test no. 4 which were shown to be significantly the same. Again, the largest chance or significant difference occurred between the 1st and 2nd test.

The fifth group of test results that were examined were those of the total body weight. These four tests were also compared through analysis of variance to see if a significant change occurred during the four tests. The F (12.190) was significant at the .05 level.

Through a Duncan Multiple Range test, showing to what extent and where significant changes occurred in the four test results, the following conclusions were shown and listed in the table below:

Total Body Weight

Duncan Multiple Range Test

1st test (Post-regular season)	4th test (Post-spring training)	3rd test (Post-off-season)	2nd test (Post-vacation)
207.23	207.57	210.17	212.70

A significant change or difference occurred between all tests except test no. 1 and no. 4, which were shown to be significantly equal. Again, the largest change occurred between the 1st and 2nd test.

The specific gravity or density tests were the sixth and last group of tests that were taken after all four training periods. In examining these four density tests it was found that a complete analysis of variance could not be formulated. But, since specific gravity is calculated directly from the three skinfold tests, the significant changes are probably very similar to that of the skinfold tests and the percent of body fat tests.

The mean scores also indicate a similar pattern or variation shown in the table below:

Specific Gravity Mean Scores

1st test (Post-regular season)	4th test (Post-spring training)	3rd test (Post-off-season)	2nd test (Post-vacation)
1.079	1.074	1.076	1.079

An increase in body density, such as in tests 1, 3 and 4, indicates a change in bodily components. As body fat decreases and muscle fibers and other bodily components increase, the density or specific gravity increases. In this example it was caused by an increase in the amount of training. Conversely, a decrease in training or no training at all, such as in test no. 2, will cause an increase in body fat and a decrease in body density, as body fat has lower specific gravity than body water.

In all four test results of the 6 variables, there existed a similar pattern of variation. In all six variables only tests no. 1 and test no. 4 showed no significant difference or change. Between all other tests there was a significant and similar variation established. As a result there is a very high correlation between the 6 variables in relation to the 4 training periods. The results show decreases in all 6 variables when training is intensified and increases when training was relaxed or stopped. This indicates that when intense training is in process, the athletes undergo a change in body composition toward less body fat and weight, and greater lean body weight or body density.

These results are very similar to many studies done in the area of body composition changes. In several studies by Keys, it was found that through vigorous physical activity of any type, body weight and composition changes will result. These changes involve decreases in body fat, increases in muscle mass, decreases in skinfold fat measurements, and increases in body density.[35]

In other similar studies conducted by Thompson, Buskich, Goldman, and others it was concluded that body fat, particularly subcutaneous fatness, can be altered by strenuous training. Concomitant with this change in fatness, body density usually increases even if no loss in weight occurs. Since body cells and body water are more dense than body fat, body density could increase without an increase in muscle. Presumably muscle mass, in certain regions at least, can be increased by training, which lends credence to the usual interpretation of alternations of large muscle groups associated with strenuous training.[17]

In comparing the four test results of the skinfold measurements it was found that redistribution of weight had occurred. The most pronounced skinfold changes occurred in the largest skinfold, the abdominal fold. The skinfolds largest degree of change occurred during test no. 1 and no. 2. The abdominal skinfold mean change during these tests was approximately 4.2 mm. which is much greater than tricep 2.6 mm. or chest 1.6 mm. This indicates that a much greater variation in subcutaneous fat occurred in the abdominal area and that the larger the skinfold the greater the variations when involved in physical activity.

These results were very similar to the results of a study done by Thompson of paratroopers before and after training. In this study it was also found that the largest skinfold change appeared in the abdominal skinfold.[27]

A correlation matrix for the eight variables or tests that were administered in the first series of tests follows. These tests were taken after the regular 11 game season or training period. All of the eight tests or variables were administered in all four series of testing periods except the height and strength tests. The height test was administered during test no. 1 or the post-regular season test only. The strength test was administered during test no. 4, or the post-spring training series and this was also the only time it was administered. These two variables are marked with an asterisk to acknowledge this deviation. The correlations of the eight variables for the 1st series are presented on the following table:

Correlation Coefficients for Test No. 1 (Post-regular season)

		1(AS)	2(TS)	3(CS)	4(SG)	5(PF)	6(H)	7(S)	8(BW)
1. Abdominal Skinfold	(AS)	1.00	0.774	0.878	-0.908	.913	.221	.407	.790
2. Tricep Skinfold	(TS)		1.00	.853	-0.940	.949	.237	.234	.624
3. Chest Skinfold	(CS)			1.00	-0.947	.957	.240	.279	.695
4. Specific Gravity	(SG)				1.00	-0.989	-0.240	-0.286	-0.715
5. Percent Fat	(PF)					1.00	.232	.281	.395
6. Height*	(H)						1.00	-0.201	.395
7. Strength*	(S)							1.00	.601
8. Body Weight	(BW)								1.00

* Height test was taken only in the 1st test
* Strength test was taken only in the 4th test

The correlation of the eight variables shown in the table above indicate some significant results. One important aspect that is shown is the correlation of .712 between estimated percent of body fat and total body weight.

This correlation of only .712 illustrates the fact that the individuals have a very large total body weight without an excessive percent of fat. This characteristic is very frequent and necessary in major college football players.

Another important aspect is that strength's highest correlation of .601 was with total body weight and yet strength had very low correlations with percent of body fat or any of the skinfold tests. These correlations seem to indicate that the individuals tested were of great body weight and strength, yet had very low percent of fat. Again this is a very significant and important characteristic of the individuals involved.

The correlation of .957 between the chest skinfold and the percent of body fat is higher than any of the skinfold measurements and the percent of body fat. This indicates that chest skinfold is the most reliable or best indicator of percent of body fat. This result is against most accepted theories including the one cited earlier. In studies done by Seltzer, Mayer and others it was shown that the triceps skinfold was the best or most reliable indicator of obesity or percent of body fat.[20]

The correlation of .790 between total body weight and abdominal skinfold is the highest correlation between body weight and any of the other variables. This indicates that the larger or heavier individuals have the largest abdominal skinfolds. This being the area of the greatest variation and accumulation of subcutaneous fat, it is a very logical correlation.

Other very high and logical correlations listed in the table on the previous page are the high correlations between the three skinfold measurements, specific gravity, and percent of body fat. These high correlations between .774 and .989 are logical because the five variables involved are directly related and because the three skinfold measurements are used in equating specific gravity or body density and percent of body fat.

The following table presents a correlation matrix for the eight variables or tests that were administered in the second series of tests. They were taken after a vacation of approximately 55 days from November 20, 1972 to January 15, 1973. The correlation of the second series of tests is presented in the following table:

Correlation Coeficients for Tests No. II (Post Vacation)

	1(AS)	2(TS)	3(CS)	4(SG)	5(PF)	6(H)	7(S)	8(BW)
1. Abdominal Skinfold (AS)	1.00	.764	.880	-0.905	.927	.197	.412	.817
2. Tricep Skinfold (TS)		1.00	.795	-0.917	.924	.236	.320	.699
3. Chest Skinfold (CS)			1.00	-0.925	.952	.249	.256	.720
4. Specific Gravity (SG)				1.00	-0.980	-0.229	-0.333	-0.766
5. Percent Fat (PF)					1.00	.246	.344	.784
6. Height* (H)						1.00	-0.201	.421
7. Strength* (S)							1.00	.556
8. Body Weight (BW)								1.00

* Height tests were taken only in the test no. 1
* Strength tests were taken only in the test no. 4

The correlation of the eight variables shown in the table did not indicate any large change or deviations. An increase in the mean body weight made the most significant changes in the correlation. All correlations involving total body weight increased except body weight correlation with strength which decreased. This indicates that during this period of time there was an increase in subcutaneous fat in all areas examined which caused an adverse effect on correlations involving strength. This is a result or a characteristic not advantageous to a major college athlete and one that has been proven to have a negative effect on performance.[28]

The following correlation matrix is for the eight variables or tests that were administered in the third series of tests. These tests were taken after an off-season training program. The correlations of the third series of tests are presented in the following table:

Correlation Coeficients for Tests No. III
(Post Off-Season Training)

	1(AS)	2(TS)	3(CS)	4(SG)	5(PF)	6(H)	7(S)	8(BW)
1. Abdominal Skinfold (AS)	1.00	.758	.879	-0.899	.900	.180	.462	.825
2. Tricep Skinfold (TS)		1.00	.880	-0.937	.950	.215	.256	.685
3. Chest Skinfold (CS)			1.00	-0.963	.974	.244	.271	.736
4. Specific Gravity (SG)				1.00	-0.988	-0.221	-0.333	-0.774
5. Percent Fat (PF)					1.00	.222	.321	.769
6. Height* (H)						1.00	-0.201	.445
7. Strength* (S)							1.00	.567
8. Body Weight (BW)								1.00

* Height tests were taken only in the test no. 1
* Strength tests were taken only in the test no. 4

These correllations again showed no significant deviation or change except that caused by a training program. These changes were primarily a reduction of the mean body weight and also a reduction in the measurements of subcutaneous fat in all areas. This reduction of weight had a positive effect on the strength and body density variables which indicated an improved physical condition. This is, of course, a logical and advantageous result of a training program.

The following correlation matrix is for the eight variables or tests that were administered in the fourth and last series of tests. They were taken after the spring-training sessions. The correlations of the fourth series of tests are presented on the following table:

Correlation Coeficients for Tests No. IV
(Post-Spring Training)

	1(AS)	2(TS)	3(CS)	4(SG)	5(PF)	6(H)	7(S)	8(BW)
1. Abdominal Skinfold (AS)	1.00	.831	.866	-0.902	.916	.268	.356	.831
2. Tricep Skinfold (TS)		1.00	.942	-0.952	.975	.229	.267	.740
3. Chest Skinfold (CS)			1.00	-0.956	.978	.286	.234	.755
4. Specific Gravity (SG)				1.00	-0.977	-0.263	-0.276	-0.783
5. Percent Fat (PF)					1.00	.269	.289	.795
6. Height* (H)						1.00	-0.201	.465
7. Strength* (S)							1.00	.523
8. Body Weight (BW)								1.00

* Height tests were taken only in test no. 1
* Strength tests were taken only in test no. 4

These correlations also showed no significant deviations or change except that caused by a more strenuous training program. The results of this is shown in greater reductions in mean body weight, percent fat, and skinfold measurements. This reduced condition has a positive effect on the individuals body density and strength. As a result, the individuals physical characteristics will show a positive reaction in performance as an athlete.

All four correlations or tests show the same significant results that were mentioned earlier after test no. 1. The only changes from test to test were produced from the varying degrees of training the athletes received. This training didn't really cause any significant or unexpected deviations between tests. The changes that did occur were a low mean body weight and excellent condition during test No. I, a heavier and poorer condition resulting from less training during test No. II, an improved condition again during test No. III because of increased training, and an excellent condition and low mean body weight during test No. IV again because of increased training. The condition during this fourth test was very similar to that registered during test No. I.

Footnotes

[35]Keys, A. and J. Brozek, Body Fat in Adult Man. Physiological Reviews, 33:245 (1953).

[17]Thompson, C. W., E. R. Buskirk, R. F. Goldman. 1956 Changes in body fat, estimated from skinfold measurements of college basketball and hockey players during a season. Res. Quart. 27:418-430 .

[27]Pascale, L. R. et al. "Changes in Body Composition of Soldiers During Paratroop Training." Medical Nutrition Laboratory Report #156; March 1955.

[20]Brozek, J. and A. Keys. Evaluation of Leanness--Fatness in Man: Norms and Inter-relationships. British J. Nutrition, 5:194 (1951).

[28]Cureton, T. K. Physical Fitness of Champion Athletes. Urbana: The University of Illinois Press, 1956.

Chapter 5

SUMMARY & CONCLUSIONS

The purpose of this study was (1) to determine whether there were significant changes or variations in body weight, body fat, and body composition resulting from four varying training programs, (2) to show the relationship among the results of the eight variables examined in each test, and (3) to show the relationship between the results of all four series of tests.

Thirty university varsity football players were studied. These athletes were tested in eight areas all relating closely with body composition. Areas tested were three skinfold measurements, body density, percent of body fat, body weight, height, and total body strength. The Lange skinfold caliper was used to determine the skinfold measurement, body density, and percent of body fat. The total of four basic lifts, using Olympic weights, was used to determine total body strength. The Standard Physician's scale was used to determine body weight and height. Six of the eight tests were administered after each of the four training periods. The height and strength tests were administered during only one series of tests.

Test results were programmed and calculated through the use of a computer. An Analysis of Variance was computed between the four series of tests and a Pearson Correlations was taken to find the correlation between all eight variables tested. Analysis of the results reveal significant variation in mean score between the four series of tests and several significant correlations between the eight variables.

From the data obtained and presented in this study, one could conclude that through four varying training programs body composition or body weight, body fat, and body density changes significantly in direct relationship to the intensity of the training program involved. The training programs that produced the highest level of conditioning according to the effect on the variables tested were the programs proceeding tests No. 1 and 4. So we can assume they were the most intense and most effective of the four programs involved. We can also conclude that through training programs athletes change or improve their body composition by decreasing percent of body fat and increasing muscle mass.

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APPENDIX I

Abdominal Skinfold
(Caliper Measurements)

Subjects	Test No. I	Test No. II	Test No. III	Test No. IV
(Linemen)				
01	19	23	22	22
02	27	33	29	27
03	16	18	19	16
04	22	25	21	15
05	19	24	22	20
06	27	30	24	22
07	28	39	32	30
08	29	37	34	31
09	33	48	45	43
10	18	20	19	19
11	28	36	31	31
12	41	45	42	40
13	24	30	25	22
14	18	19	21	17
15	13	15	14	11
(Backs)				
16	15	17	17	15
17	15	22	22	12
18	11	12	12	08
19	07	07	07	07
20	09	14	14	09
21	15	17	17	10
22	10	12	12	09
23	12	22	22	15
24	16	19	19	18
25	11	11	11	09
26	07	07	07	08
27	11	12	12	08
28	16	22	22	14
29	18	23	23	23
30	20	22	22	20

APPENDIX II

Triceps Skinfold
(Caliper Measurements)

Subjects	Test No. I	Test No. II	Test No. III	Test No. IV
(Linemen)				
01	10	12	12	10
02	11	12	12	12
03	20	25	26	20
04	12	14	12	11
05	15	20	17	13
06	18	21	17	13
07	16	26	19	17
08	12	18	17	15
09	21	25	28	27
10	10	14	11	11
11	13	15	14	13
12	20	22	10	19
13	14	19	16	15
14	09	11	13	11
15	09	12	12	09
(Backs)				
16	08	12	08	08
17	10	11	10	09
18	08	09	08	08
19	04	06	06	06
20	04	05	07	07
21	08	11	10	08
22	09	10	09	08
23	09	14	11	10
24	08	11	11	10
25	07	06	06	08
26	06	05	06	05
27	12	13	13	10
28	09	10	08	08
29	09	12	10	11
30	14	15	12	13

APPENDIX III

Chest Skinfold
(Caliper Measurements)

Subjects	Test No. I	Test No. II	Test No. III	Test No. IV
(Linemen)				
01	08	09	10	10
02	12	13	12	11
03	12	13	15	15
04	10	11	09	06
05	10	11	12	11
06	16	18	16	13
07	14	17	16	15
08	15	20	19	16
09	22	30	33	28
10	09	11	10	10
11	13	14	14	11
12	38	20	20	18
13	15	19	17	16
14	11	11	12	10
15	08	11	09	08
(Backs)				
16	09	09	09	09
17	07	09	09	08
18	08	08	08	07
19	06	07	06	07
20	07	09	05	05
21	06	08	06	06
22	07	07	07	07
23	09	12	11	10
24	09	10	10	10
25	09	09	06	06
26	05	05	05	06
27	10	10	08	07
28	08	10	09	08
29	09	10	08	10
30	12	12	11	10

APPENDIX IV

Specific Gravity

Subjects	Test No. I	Test No. II	Test No. III	Test No. IV
(Linemen)				
01	1.081	1.079	1.078	1.079
02	1.076	1.072	1.074	1.075
03	1.071	1.065	1.063	1.068
04	1.078	1.074	1.078	1.083
05	1.076	1.070	1.072	1.076
06	1.066	1.062	1.068	1.074
07	1.070	1.055	1.064	1.067
08	1.072	1.061	1.063	1.068
09	1.058	1.044	1.040	1.045
10	1.082	1.076	1.079	1.079
11	1.073	1.068	1.070	1.073
12	1.059	1.055	1.057	1.061
13	1.072	1.062	1.068	1.071
14	1.081	1.079	1.075	1.080
15	1.084	1.079	1.081	1.085
(Backs)				
16	1.084	1.080	1.084	1.084
17	1.084	1.079	1.080	1.085
18	1.086	1.085	1.086	1.087
19	1.091	1.089	1.090	1.089
20	1.091	1.089	1.089	1.090
21	1.086	1.081	1.085	1.088
22	1.086	1.085	1.086	1.087
23	1.084	1.074	1.079	1.080
24	1.084	1.079	1.079	1.081
25	1.086	1.087	1.090	1.088
26	1.091	1.092	1.090	1.091
27	1.081	1.080	1.082	1.086
28	1.083	1.079	1.085	1.085
29	1.082	1.077	1.081	1.077
30	1.075	1.073	1.079	1.077

APPENDIX V

Percent of Body Fat

Subject	Test No. I	Test No. II	Test No. III	Test No. IV
(Linemen)				
01	09.0	10.0	10.0	09.5
02	11.0	13.0	12.0	11.0
03	13.5	16.9	18.0	15.0
04	10.0	12.0	10.0	08.0
05	11.0	14.0	13.0	11.0
06	16.0	18.0	15.0	12.0
07	14.0	21.0	17.0	15.0
08	13.0	19.0	17.0	15.0
09	20.0	27.0	29.0	26.0
10	08.0	11.0	10.0	10.0
11	12.5	15.0	14.0	12.0
12	19.5	22.0	20.0	19.0
13	13.0	18.0	15.0	14.0
14	09.0	10.0	11.0	09.0
15	07.0	10.0	09.0	07.0
(Backs)				
16	07.0	09.0	07.5	07.0
17	07.5	10.0	09.0	07.0
18	06.5	07.0	06.5	06.0
19	04.0	05.0	04.5	05.0
20	04.0	06.0	05.0	05.0
21	06.5	08.5	07.0	06.0
22	06.5	07.0	06.5	06.0
23	07.5	12.0	10.0	09.0
24	07.5	09.5	10.0	09.0
25	06.5	06.0	05.0	09.0
26	04.0	03.5	04.0	05.5
27	09.0	09.5	08.0	04.0
28	08.0	10.0	07.0	06.5
29	08.0	10.5	09.0	07.0
30	11.5	12.0	10.0	10.0

APPENDIX VI

Body Weight

Subjects	Test No. I	Test No. II	Test No. III	Test No. IV
(Linemen)				
01	220	225	220	220
02	230	240	234	233
03	208	220	219	215
04	225	234	225	218
05	220	223	225	224
06	209	208	207	199
07	239	246	239	236
08	226	235	230	230
09	240	265	259	258
10	223	235	230	223
11	235	243	237	236
12	240	247	245	237
13	228	238	236	237
14	215	210	208	206
15	195	202	200	195
(Backs)				
16	204	215	211	204
17	186	195	189	185
18	194	198	194	190
19	173	172	180	175
20	204	205	206	204
21	178	181	175	174
22	202	208	205	202
23	189	196	192	190
24	196	185	195	195
25	166	165	157	161
26	203	198	203	200
27	194	195	187	186
28	191	202	200	199
29	195	200	210	209
30	190	195	187	191

APPENDIX VII

Total Body Strength

Subject	Test No. IV
(Linemen)	
01	1060
02	1210
03	1200
04	1320
05	1330
06	1210
07	1540
08	1310
09	1190
10	1420
11	1490
12	1380
13	1320
14	1360
15	1110
(Backs)	
16	1280
17	1490
18	1410
19	1080
20	1410
21	0990
22	1190
23	0970
24	1260
25	0940
26	1060
27	1010
28	1050
29	1130
30	1030

APPENDIX VIII

Height

Subject	Test No. I
01	74
02	77
03	73
04	74
05	77
06	72
07	73
08	75
09	75
10	76
11	72
12	75
13	77
14	72
15	75
(Backs)	
16	73
17	69
18	71
19	75
20	71
21	71
22	74
23	74
24	70
25	72
26	76
27	75
28	74
29	74
30	74

APPENDIX IX

Spearman's Rank Order Correlation Coefficient

Per Cent of Body Fat

Players	x	y	R_x	R_y	d	d^2
A.	10	10	3	3	0	0
B.	12	12	6	4.5	1.5	2.25
C.	12	13	6	7	-1.	1.
D.	9	9	2	2	0	0
E.	12	14	6	9	-3.	9
F.	7	8	1	1	0	0
G.	12	13	6	7	-1.	1
H.	12	13	6	7	-1.	0
I.	18	18	10	10	0	0
J.	13	12	9	4.5	4.5	20.25
						34.50

$$\text{rho} = 1 - \frac{6\ d^2}{N(N^2-1)} \qquad = 1 - .20$$

$$= 1 - \frac{6(34.5)}{10\ (99)} \qquad \text{rho} = 1 = .80$$

$$= 1 - \frac{207}{990}$$

CHANGES IN BODY COMPOSITION OF COLLEGE FOOTBALL PLAYERS DURING FOUR VARYING TRAINING PROGRAMS

by

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B.S., KANSAS STATE UNIVERSITY, 1971

AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Health, Physical Education, and Recreation

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1973

This study was conducted to determine whether there were significant changes or variations in body weight, fat, and bodily composition resulting from four varying training periods. Secondary intentions of the study were to show the relationships between the eight variables tested and also the relationships between the results of all four series of tests.

Thirty university varsity football players were used in this study. These athletes were tested in eight areas all relating closely with body composition. Areas tested were three skinfold measurements, body density, percent of body fat, body weight, height, and total body strength. The Lange skinfold caliper was used to determine the skinfold measurements, body density, and percent of body fat. The total of four basic lifts, using Olympic weights, was used to determine total body strength. The standard physician's scale was used to determine body weight and height. Six of the eight tests were administered after each of the four training periods. The height and strength tests were administered during only one series of tests.

Test results were programmed and calculated through the use of a computer. An analysis of variance was computed between the four series of tests and a Pearson correlation was calculated to find the correlation between all eight variables tested.

Analysis of the results of the data revealed significant variation in mean score between the four series of tests and several significant correlations between the eight variables. Consequently, one could conclude that through four varying training programs body composition or body weight, body fat, and body density changes significantly in direct relationship to the intensity of the training program involved. The training programs that produced the highest level of conditioning according to the effect on the variables tested were the programs preceeding tests No. I (Post-regular season) and No. IV (Post-Spring Training). The lowest level of conditioning was produced during the second training period which was shown in test No. II (Post-vacation). An improved level of condition was shown after the third training period which was indicated in test No. III (Post-off-season). So we can assume that test No. I and No. IV were the most intense and most effective of the four programs involved. We can also conclude that through training programs athletes change or improve their body composition by decreasing the percent of body fat and increasing body density, muscle mass, and other bodily components which has a positive effect on their performance as varsity college athletes.

The information received from this study can benefit or be of value in evaluating and improving the training programs involved in the study. Also, by studying the effects and relationships between the results of the programs and individuals examined in this study, great insight can be gained and thereby used in organizing more efficient training programs that would be more appropriate and individualized for participating athletes.