1983

Physical Characteristics, Body Composition and Somatotype of Selected NCAA Division II Collegiate Baseball Players

Ronnie Carda

PHYSICAL CHARACTERISTICS, BODY COMPOSITION AND SOMATOTYPE OF SELECTED NCAA DIVISION II COLLEGIATE BASEBALL PLAYERS

Ronnie Carda

A Thesis
Presented to South Dakota State University
in partial fulfillment of the
requirements for the degree of
Master of Science
in
College of Arts and Science
1983

PHYSICAL CHARACTERISTICS, BODY

COMPOSITION AND SOMATOTYPE OF SELECTED NCAA

DIVISION II COLLEGIATE BASEBALL PLAYERS

This thesis is approved as a creditable and independent investigation by a candidate for the degree, aster of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Dr. Marilyn A. Looney
Thesis Advisor — Date

Dr. Jack Ewing
Graduate Coordinator, HPER — Date

Dr. Harry L. Forsyth
Head, HPER Department — Date

PHYSICAL CHARACTERISTICS, BODY

COMPOSITION AND SOMATOTYPE OF SELECTED NCAA

DIVISION II COLLEGIATE BASEBALL PLAYERS

Abstract

RONNIE D. CARDA

The purpose of this investigation was to determine the body composition and body type of 132 NCAA Division II baseball players. In addition, physical characteristics and body composition of subgroups were determined to see if the subgroups had distinct profiles. Body composition was assessed from measures of three skinfolds (chest, abdomen, and thigh) and age, by using the body density equation of Jackson and Pollock (British Journal of Nutrition 40:501, 1978) and Siri's percent body fat equation (McArdle, Katch, & Katch. Exercise Physiology: Energy, Nutrition, and Human Performance 1981, 373). Somatotyping was assessed by use of the Heath-Carter Anthropometric Method. Descriptive statistics were applied to the data and one-way analyses of variance were conducted on selected variables to test the differences among subgroups. Tukey's test was conducted to test a posteriori comparisons. Pitchers were found to be taller (M=183.48) thaninfielders (M=180.14) and outfielders (M=178.69). First basemen (M=185.19), third basemen (M=177.79) and shortstops (M=181.91) were found to be taller than second basemen (M=175.30). Second basemen (M=70.96) were found to possess less weight than first basemen (M=84.42) and catchers (M=80.73) and to possess less lean body weight (M=61.71) than first basemen (M=73.61), third basemen (M=63.07), catchers

(M=69.58) andshortstops (M=68.03). It was concluded that pitchers and first basemen were taller and weighed more than players of the other positions, and second basemen were shorter, weighed less and possessed less lean body weight than players of the other positions. There were no differences in percent body fat among the players of the various positions $F(2,129)=3.35$, $p>.05$; $F(4,55)=8.82$, $p>.05$; and, as a group, the players of the NCAA Division II had similar profiles in body composition when compared to major league baseball players. Pitchers' mean somatoplot differed significantly from the mean somatoplot of outfielders as the pitchers displayed more endomorphy and less mesomorphy than did the outfielders.

TABLE OF CONTENTS

LIST OF TABLES

Table

page

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

The physical demands of the game of baseball have been found to have a significant relationship to the physical characteristics of the individuals who play the game competitively. It has been found that baseball players typically play at 11 to 12 percent below their normal weight-for-somatotype (Sheldon, 1970:). This shows that baseball players, as a group, differ from the general public in weight-for-somatotype, however, differences which may be present among the players within the sport are not revealed.

It has been common practice to generalize across all positions when describing the physical characteristics of baseball players rather than to describe their physical characteristics on a defensive position basis. Carter (1970), for example, described baseball players' typical somatotype by using a mean body type which was determined from players of all positions. He did so even though it was recognized that differences did exist between defensive positions.

General descriptions of baseball player's body composition have been more common than descriptions of their body composition on a defensive position basis. Since several other sports have had body composition descriptions by position (Wilmore & Haskell, 1972; Parr, Wilmore, Hoover, Bechman, & Kerlan, 1978; Tanner, 1964), it would be appropriate for the same to be done for the game of baseball.

The defensive positions of baseball vary in physical demands, as they do in most other sports. Shortstops and second basemen need to be able to move their feet and hands quickly to execute a double play; outfielders need to be fast afoot to run down the long fly balls; pitchers need to possess "live arms" to get key strikeouts; and catchers need to be "stocky" to withstand contact which results when blocking the plate from base runners and wild pitches. To make the plays required at specific positions, different types of physical characteristics may be required. Any generalized body build and physical characteristic descriptions of baseball players may be misleading since there may be several body types commonly seen among baseball players.

There may also be other reasons that a generalized description is insufficient. The level of performance may make it difficult to identify a "typical" body build. Professional players may possess different body types than collegiate players, and collegiate players at various levels of competition may differ. These differences may even occur when considering individuals playing the same defensive position. There may also be the possibility that such things as more play on artificial surfaces, more games, more travel, and more emphasis on speed, quickness, strength and agility have differing influences on physical characteristics of the players at the professional level.

Another reason that a generalized description of baseball players' body build is insufficient may be that body build descriptions are no longer as accurate as when they were originally determined. In the past ten to fifteen years there may have occurred a gradual change in the mean physical characteristics for baseball players, possibly due to the increased emphasis on year-round strength and conditioning programs.

Other sports have been recognized to have differences in the physical characteristics of their players by position. Football, for example, has been recognized to have four or five different body types (Wilmore and Haskell, 1972; Wickkiser and Kelly, 1975), while physical characteristics of basketball players have been described by three recognized body types, one for each of the three positions (Parr et al., 1978; Clarke, Wrenn & Vaccaro, 1979). Baseball, however, appears to have had only a few extensive studies in the areas of body composition and somatotype (Coleman, 1981; 1982a; 1982b; Imlay, 1966).

One wonders, then, if a single body build description is sufficient for all baseball players. It certainly would be more accurate to describe them by position and by level of performance. The possibility exists that four or five body build descriptions are necessary to more accurately describe the physical characteristics of baseball players.

Statement of the Problem

The purpose of this study was to determine the body composition and body type of NCAA Division II baseball players. Physical characteristics and body composition for various subgroups of players were determined to see if the subgroups had distinct profiles. The three subgroup categories investigated were: (a) pitchers, infielders and outfielders; (b) catchers, first and third basemen, and second basemen and shortstops; and (c) catchers, first basemen, second basemen, third basemen and shortstops. The chest, abdomen and thigh skinfolds were used to determine body composition, while Heath-Carter somatotyping was used to determine body type.

Significance of the Study

One is frequently told by baseball announcers that a certain position currently has players taller and/or leaner than the players who have played that position in the past. Description statements of defensive ballplayers are quite common, and they assume that physical differences do exist for several positions; shortstops are often described as being tall and lean, catchers as being muscular and bulky, first basemen as being tall, pitchers as being taller and fatter than other positions, and outfielders as being slender. However, these statements are made with little or no scientific support since there have been few studies conducted comparing physical characteristics of past and present baseball players. Another shortcoming of such statements is that most are made in reference to major league ballplayers. It is logical to ask if these same statements can be made when discussing collegiate baseball players.

More than a simple determination of physical characteristics by the use of a height-weight nomogram is necessary. Nomograms have been found to be inaccurate and potentially dangerous to follow because they do not allow for individual differences in muscle and bone mass.

One example of how a height-weight chart can be misused involved Ron Cey, a veteran major league third baseman. The Los Angeles Dodgers' organization had Cey's weight measured, compared it to a height-weight nomogram, and determined he was overweight. They suggested Cey lose 25 pounds. However, Cey was not convinced that the nomogram was accurate, so he decided to get a second opinion. His body composition was determined using the hydrostatic weighing technique. The findings of this measurement showed he was approximately 5% body fat (Wilmore, 1982). If Cey had lost the weight the Dodgers had requested, a hazardous, career ending situation could have occurred.

The rationale for this study was threefold: (a) there appeared to be a need to describe baseball players' physical characteristics by subgroups, rather than by using only a general description of the "typical" baseball player; (b) there was a need to update past studies in this area, because physical characteristics of baseball players may have changed due to an increased emphasis on strength and conditioning programs, speed, quickness and agility; and (c) there was a need to determine body composition by using valid and reliable methods, rather than by using a height-weight nomogram.

Hypotheses

The following hypotheses were investigated:

1. There is no significant difference among the subgroups of pitchers, infielders and outfielders for the following dependent variables: age, height, weight, chest, abdomen and thigh skinfolds, sum of skinfolds, body density, body fat percent, body fat weight, lean body weight and somatotype.

2. There is no significant difference among the subgroups of catchers, first basemen, second basemen, third basemen and shortstops for the following dependent variables: age, height, weight, sum of skinfolds, body density, body fat percent, body fat weight, lean body weight and somatotype.

Scope

This study determined the body composition and somatotype of the traveling squads of seven out of nine North Central Conference (NCC) baseball teams during the 1983 season (See Appendix A). One-hundred thirty-two baseball players, from the seven teams, participated in the study. The researcher traveled to the various universities over a four week period to collect the data. The data collected were age, skinfolds (chest, abdomen, thigh, triceps, subscapular, suprailiac and calf), anthropometric widths (humerus and femur), anthropometric girths (biceps and calf), as well as weight and height. The subjects were measured with the following equipment: Harpenden skinfold caliper, cloth measuring tape with a Gulick handle, Harpenden anthropometer, a weight scale and a stadiometer.

Limitations

The following limitations have been acknowledged by the investigator:

1. Due to the limited number of subjects in some subgroups, the extent of any generalizations are limited.

2. Within the subgroups, several players played more than one position. These players, however, were placed in only one subgroup for analysis purposes based on their coach's prediction of the player's most frequently played position. This may not have been their best position.

3. The accuracy of the weight determinations were limited as the scales differed from school to school and were not always calibrated instruments. An attempt to estimate this error was made by testing the scales, before anyone was measured, with a set of standard kilogram weights. When necessary, measurements were adjusted.

4. All subjects were not measured under the same conditions. Some of the players were measured before practice, some during practice and others were measured after practice. This was done due to the tight scheduling and limited time the researcher had at several of the universities.

5. Heath and Carter (Carter, 1980), in their somatotyping procedures, measure girths and widths on both sides of the body and use the larger of the figures in calculating a somatotype. In the present study measurements were taken only from the right side of the body.

Definition of Terms

The following terms have been defined for this study:

Anthropometric Measures

Anthropometric measures are measures of the human body to determine size and proportion of various body parts, such as girths, diameters, and circumferences.

Body Composition

Body composition is the physical makeup of an individual's body and can be described in a two-component system. This system consists of the body fat and the lean body mass percentages of an individual.

Body Density

Body density is computed as mass per unit volume. For this study, body density was determined using Jackson and Pollock's (1978) generalized equation utilizing the sum of three skinfolds (chest, abdomen and thigh).

Ectomorphy

Ectomorphy is the third component of somatotyping. It is a measure of an individual's amount of linearity or slenderness (Willgoose, 1961).

Endomorphy

Endomorphy is the first component of somatotyping. It is a measure of an individual's amount of "fatness" (Fox and Mathews, 1981).

Fat Free Body (FFB)

Fat free body is a measurement of musculo-skeletal size in relation to height to characterize body physique (Slaughter & Lohman, 1980).

Hydrostatic Weighing

The process of immersing an individual in water to determine the amount of density that an individual possesses (Fox & Mathews, 1981).

Lean Body Mass

Lean body mass is the body weight minus the weight of the body fat (Fox and Mathews, 1981). Lean body mass consists of muscle, bone and organ tissues.

Mesomorphy

Mesomorphy is the second component of somatotyping. It is a measure of an individual's amount of bulk, derived from bone, muscle and connective tissue (Sheldon, 1970).

Phenotype

Phenotype is a measurement of body type, similar to somatotype at a particular stage in an individual's life that is not to be interpreted on an age scale basis.

Skinfold Measures

Skinfold measures are estimations of the amount of body fat an individual has at particular landmarks. When used to predict body fat percent they have a standard error of estimation of plus or minus 3.3% to 3.5% (Lohman, 1981; Coleman, 1981).

Somatotype

Somatotype is the body type or physical classification of the human body (Fox and Mathews, 1981). Somatotyping describes an individual's body structure in three components by the use of a numbering system usually ranging from one to seven. The larger the number for a component, the more the individual displays that component. Somatotyping describes the physical characteristics of individuals by classifying them as endomorphic, mesomorphic or ectomorphic or combinations thereof.

Sum of Skinfolds

The sum of skinfolds, used to determine body density, is the total of three skinfolds. The skinfold sites that were used were the chest, abdomen and thigh.

CHAPTER 2

REVIEW OF LITERATURE

The study conducted measured physical characteristics and determined somatotypes of NCAA Division II college baseball players. In addition, the subjects' body compositions were computed after the body density had been calculated for each player. The study described characteristics of these subjects, both as a group, and in the various subgroups which were determined according to position played. The following areas will be discussed in this chapter:

1. Methods of determining body composition.
2. Body composition studies conducted on athletes.
3. Body composition studies conducted on baseball players.
4. Methods of determining somatotypes.
5. Somatotype studies conducted on athletes.
6. Summary of related literature.

Methods of Determining Body Composition

Studies in the area of determining body composition and/or body density have been numerous, with their purpose to either make descriptive statements about physical characteristics or devise new or improved methods of determining composition and density. Many of these studies have come to be standards or guidelines for recent studies in regard to methodology and scientific analysis. It must be pointed out that there is not just one method available to the researcher, but several possible accepted procedures.

There is, however, one method which is no longer viewed as an acceptable process for estimating body composition. This is the practice of using height-weight nomograms. They are no longer thought to be accurate or reliable, as differences in body composition could occur due to such things as more muscle development and/or bone development (Sloan, 1967).

In most methods, body density must be calculated before body composition can be determined. Body density can be determined using several methods of indirect assessment. Indirect assessments are the only feasable methods of determining body fat, as direct assessment would require an autopsy.

Possibly the most accurate, but not always the most convenient method of determining body density is by use of the underwater weighing procedure. This method uses Archimede's Principle which states that an object immersed in a fluid loses an amount of weight equivalent to the weight of the fluid which is displaced (Fox & Mathews, 1981). Archimede's Principle can be used in determination of body density by two ways, water displacement and weight underwater (McArdle, Katch & Katch, 1981). These processes both determine body volume.

The process of determining body volume can be done by measuring the amount of water displaced when a subject is submerged or can be done by measuring the weight of the subject in air and dividing that weight by the loss of weight in water (weight in air minus weight in water). In both methods an allowance must be made for the residual volume of air remaining in the lungs, the accurate measurement of which is difficult and expensive.

Even though the processes of hydrostatic weighing are deemed to be the most accurate in determining body density, they are only predictions. When final computations are made, they can be stated only as estimates with a plus or minus 2.5% standard error of estimation (Coleman, 1981). Underwater measurements are not as easily employed as some other methods. Two common reasons for not using this method are that the apparatus for hydrostatic weighing is not easily portable and many subjects are not comfortable during the process of being measured by this method.

One of the most convenient methods of determining body density is to use anthropometric measurements. Wilmore and Behnke (1968), in a study conducted on fifty-four college males, attempted to determine which anthropometric equations are most accurate in determining body density and lean body weight. Anthropometric values were then placed into standard body density and body fat equations either individually or in groups of sums of six or eight diameters, with specific diameters for certain equations being used. Lean body weight and percent body fat were calculated using the equations of Rathbun and Pace, Siri, and Brozek, Grande, Anderson and Keys (Wilmore & Behnke, 1968). High correlation values were found among these equations. The findings of the study revealed that lean body weight can be predicted with accuracy utilizing body diameters, as correlation values ranged from 0.879 to

0.924 with underwater weighing. They also revealed that there was little difference as to which anthropometric equations were used, or which combination of body diameters were used. Four diameters (biacromial, bitrochanteric, wrist and ankle) were suggested, as well as the following equation:

$$LBW = D^2 \times H$$

where LBW is lean body weight, D^2 is the square of the average of the four diameters, and H is height.

In a later study, by Wilmore and Behnke (1967), a combination of anthropometric measurements, including skinfolds, diameters and circumferences, were used to determine body density. There were 133 college males involved in the study. Measurements were determined at 54 sites, including seven skinfolds, 20 diameters and 25 circumferences. Various previously determined equations were used to predict fat free and lean body weight, density and specific gravity. After conducting analyses of various regression equations, it was indicated that both body density and lean body weight could be predicted accurately from a limited number of anthropometric measurements. It was also determined that there was little difference when using skinfolds, diameters and circumferences, or a combination of these to predict percent body density, although it was found that the use of skinfolds alone had a slightly lower multiple correlation coefficient.

The use of skinfold measurements is quite popular, as they are relatively simple to perform and reasonably reproduceable (Sloan, 1967). Their accuracy in predicting body density can closely approximate the results of underwater weighing as was found by Sloan (1967) in a study of 50 males ranging in age from 18 to 26 years. By using hydrostatic weighing, a 10.8% mean body fat estimate was calculated while a 10.7% mean body fat estimate was calculated using skinfold measurements. Individually, seven different skinfolds (thigh, abdomen, iliac, chest, scapula, arm and buttock) were correlated with body density which was determined by hydrostatic weighing. The thigh (r=0.800) and the abdomen (r=0.765) had the highest correlations with body density of the seven skinfolds.

As with anthropometric girths and diameters, there are several anatomical landmarks from where skinfold measurements can be taken to determine body density (Wilmore & Behnke, 1974). Of these, three to ten skinfolds are often used to predict body density. However, Lohman (1981) has shown that equations using three or more skinfolds have no greater advantage over the use of equations using two skinfolds. Utilizing a rather large sample size of 400 young males as subjects, it was also revealed that any of a number of combinations of two or three skinfolds could accurately predict body density.

The theoretical relationship of skinfolds to body fatness is that a large portion of fat deposits are located subcutaneously, and that skinfold thicknesses are accurate measurements of subcutaneous fat at any given location (Lohman, 1981). There is, however, allowance for error of estimation due to biological and technical errors. This allowance is estimated to be between plus or minus 3.3% and 3.5% (Lohman, 1981; Coleman, 1981).

Various regression equations for determining body density have been established for use with skinfold measurements. Pascale, Grossman, Sloane & Frankel (1956) studied eighty-eight soldiers and derived an equation using the chest, at the mid-axillary line at the level of the xiphoid process; chest, in the juxta-nipple position; and dorsum of the arm, midpoint between the tip of the acromion and tip of the olecranon. This equation was found to have a correlation coefficient of R = 0.85.

Sloan, (1967) in his study of fifty males, derived a regression equation using the thigh and subscapular skinfolds. This equation was found to have the highest multiple correlation of two skinfolds to body density (R = 0.845). Accuracy of prediction was not significantly increased when all seven skinfold measurements were used (R = 0.861). Lohman (1981), in a further study of Sloan's equation, cross validated the equation and showed that it could be used for athletic and non-athletic young men.

Several other equations have been developed but most are population-specific and are not highly predictive of body composition across age groups and body types (Lohman, 1981:182). However, there have been at least two general approaches, to estimate body composition across various populations. One of these was proposed by Durnin and Womersley (1974) who studied sedentary males and females from ages 16 to 72 years. From their study they developed a table of body fat predictions using four skinfolds and included age as a variable because as age increases there is a higher proportion of body fat to be located internally, and a decrease in percent of fat free mass. The approach of

Durnin and Womersley, though, has not been applied to athletes (Lohman, 1981).

A second approach, developed by Jackson and Pollock (1978) for men, and another by Jackson, Pollock and Ward (1980) for women, has allowed not only for age differences, but also for variances in body density, body type and exercise habits. In their study of 403 men, Jackson and Pollock (1978) developed the following generalized equation for determining body density:

$$\text{Density} = 1.10938 - (0.0008267)(X2) + (0.0000016)(X2)^2 - (0.0002574)(X3)$$

where X2 represents the sum of three skinfolds (chest, abdomen and thigh), and X3 represents age of the subject. They found this equation to have a multiple correlation with hydrostatic weighing of 0.917.

As with the case of body density, there are several equations which convert body density to percent body fat. Brozek, Grande, Anderson and Keys (1963) revised an equation developed by Keys and Brozek (1953) for estimation of percent body fat. The new formula they established has had frequent use since being developed (Forsyth, 1970). Rathbun and Pace (1945) and Siri (McArdle, Katch & Katch, 1981) have developed formulas for estimating body fat percentages which have had frequent use as well. Siri's equation was derived from the two component model of the body consisting of fat and lean tissues, with fat having a density of 0.90 g/ml and lean tissue having a density of approximately 1.10 g/ml (McArdle, Katch & Katch, 1981).

It was found by Wilmore and Behnke (1968) that there is good agreement among all three equations in relation to their means, standard deviations and ranges for percentage of fat, as their intercorrelations ranged between 0.995 and 1.000. The basic differences between the formulas are generally less than 1%, within a range of body fat of 4% to 30% (McArdle, Katch & Katch, 1981).

A more recently developed method of describing the athletic population is the use of an index measurement of musculo-skeletal size in relation to height to characterize body physique. This method, established by Slaughter and Lohman (1980), determines how athletes of various sports deviate from a regression line that represents a non-athletic population made up of 289 men.

The regression line equation for men is as follows:

$$Y' = .719\ HT - 63.9$$

where Y' represents predicted fat-free body and HT is height. The equation was shown to be valid across sports and has a standard error of estimation of 6.3 kg.

Body Composition Studies Conducted On Athletes

There have been various studies conducted on athletes to determine their body composition. Behnke and Royce (1966) were the first to quantify body size, shape and composition of athletes. In their study they used weight, height and circumferences to determine lean body weight of weight lifters, basketball players, distance runners and professional football players. There were three subjects in each group (except the football group where 25 subjects were used), and comparisons between the groups were made. Lean body weight was calculated for all groups using specific gravity determined by hydrostatic weighing, by estimates of body potassium (K^{40}) and by anthropometric measurements. Behnke and Royce found the weight lifters to have a mean body fat value of 12.8% using the K^{40} method and 15.4% using hydrostatic weighing. Mean values for body fat of the basketball players and distance runners was 12.2% and 7.9%, respectively, using anthropoometric measurements while football players were found to have a mean body fat value of 10% using hydrostatic weighting.

One of the main purposes for studying physical characteristics of athletes is to determine a typical body composition description for specific sports. This has been done for almost all sports with football and basketball being the most frequently studied sports. In several studies the approach has been to not only study a sport, but to also describe physical characteristics by position, or at least by subgroups where demands and physical requirements are similar. In football studies this has been common practice. For example, Behnke and Wilmore (1974) report that as early as 1940-41, Behnke and Welham studied professional football players and divided them into two subgroups, backs (n=13) and linemen (n=12). Mean values for body fat for each group were calculated as 7.1% and 14.0%, respectively. As a group, their mean body fat value was calculated to be 10.4%.

In a comparison study to determine how personnel have changed in physical characteristics, Wilmore and Haskell (1972) studied 44 professional football players playing during the years of 1969 to 1971. Their body density was determined by hydrostatic weighing, and relative fat was calculated using Siri's equation. The players were divided into the subgroups of defensive backs, offensive backs and receivers, linebackers, offensive linemen (including tight ends) and defensive linemen. The mean values for body fat were: defensive backs (n=4), 7.7%; offensive backs and receivers (n=10), 8.3%; linebackers (n=6), 18.5%; offensive linemen (n=12), 15.5%; and defensive linemen (n=12), 18.7%. It was concluded that the players of this study were considerably taller, heavier, fatter and possessed more lean body weight than those studied by Behnke and Welham (Wilmore & Haskell, 1972).

Wilmore, Parr, Haskell, Costill, Milburn and Kerlan (1976) conducted a later study using 185 professional players from 14 teams. The same subgroups were used as had been employed by Wilmore and Haskell (1972) with the addition of a subgroup for quarterbacks and kickers. The mean values for body fat were established for the subgroups with the following results: defensive backs (n=26), 9.6%; offensive backs and receivers (n=40), 9.4%; linebackers (n=28), 14.0%; offensive linemen and tight ends (n=38), 15.6%; and defensive linemen (n=32), 18.2%. As a group, a mean body fat percent was calculated to be 13.4%.

Professionals have not been the only group of football players to be measured. McArdle Katch and Katch (1981) cite several studies conducted on collegiate football players. For example, Girandola studied 88 members of an NCAA Division I collegiate football team and found a mean body fat value of 11.4%. By subgroups his findings of mean body fat were: defensive backs (n=15), 9.6%; offensive backs and receivers (n=18), 9.9%; linebackers (n=17), 13.2%; offensive linemen and tight ends (n=25), 15.3%; defensive linemen (n=13), 14.7%; and quarterbacks and kickers (n=16), 14.4%.

In a study conducted by Burke (1980), another Division I college team was measured using skinfold measures. Fifty-three subjects were measured and found to have a mean body fat value of 18.3%. The study separated backs and linemen and found the backs (n=20) to have a mean value of 13.0% and the linemen (n=33) to have a mean value of 21.8%.

Kollias, Buskirk, Howley, and Loomis (1972) conducted a study to determine the body composition of high school football players. Using skinfold estimates, twenty-seven high school football players were determined to have a mean body fat value of 15.4%. Subgroups were established for backs and ends (n=15) and for the linemen and linebackers (n=12). Their mean body fat values were 13.7% and 17.6%, respectively.

Wickkiser and Kelly (1974) conducted a study of an NCAA Division II college football team. Using hydrostatic weighing, sixty-five subjects were measured and found to have a mean body fat value of 15.0%. Using the same groupings as Wilmore and Haskell (1972), the following mean values were calculated for each of the groups: defensive backs (n=15), 11.5%; offensive backs and receivers (n=15), 12.4%; linebackers (n=7), 13.4%; offensive linemen and tight ends (n=13), 19.1%; and defensive linemen (n=15), 18.5%. When these studies are compared, it is revealed that professional football players, especially those of the study conducted by Wilmore et al. (1976), differed in physique from those of the Division II level. However, a comparison also shows that little difference exists between those same professionals and Division I players. It would therefore appear that at the highest levels of collegiate competition the body composition of college players varies little from professional players.

In a study conducted by Slaughter and Lohman (1980), it was revealed that the football players studied by Wilmore and Haskell (1972) possessed considerably more musculo-skeletal mass (FFB) in each subgrouping when compared to a mean FFB for non-athletic subjects. Using the same procedure, they found the subjects studied by Wickkiser and Kelly (1974) to have significantly more musculo-skeletal mass (FFB) than the non-athletes, but not as much as the professional football players studied by Wilmore and Haskell (1972).

In a study conducted by Parr et al. (1978), professional basketball players (n=34) were measured to determine their body composition. This was done by utilizing the underwater weighing technique for determining body density, and the Siri formula for estimating percent body fat. The players were then separated into the three groups of guards, forwards and centers. Parr found the mean value for body fat of the centers (n=4) to be 7.1%, for the forwards (n=15) 9.0%, and for the guards (n=15) 10.6%. In measuring seven skinfolds and summing them together for each player, it was found that forwards have the highest total skinfold value with guards' skinfold values quite similar but slightly lower, and centers' skinfolds significantly lower.

In a study conducted by Clarke et al. (1979), collegiate basketball players at the Division I level were measured for determination of body size characteristics. Thirteen subjects were studied and divided into subgroups according to body size. The subgroup analysis revealed few differences in body composition, but there were differences in somatotypes. When Clarke et al. compared the findings of their study to those of Parr et al. (1978), they concluded that differences in body composition at the two levels of performance existed, but the differences were insignificant.

Slaughter and Lohman (1980), using their FFB regression line method, determined that basketball players do not differ significantly from non-athletes in musculo-skeletal mass. This conclusion, however, was made on a limited number of Division II players. More and different levels of players need to be studied.

Body Composition Studies Conducted on Baseball Players

Studies examining the body composition of baseball players have also been conducted, although they are not as frequent or generally as extensive as football or basketball studies. Studies have been conducted with professional baseball players both at the minor and major league levels.

Coleman (1982a) studied professional baseball players for seven years. In at least two of the studies conducted by Coleman (1981;1982b), comparisons by subgroups have been made. These subgroups have been established according to defensive positions with similar demands and physical requirements. Using three skinfold estimates, the body density equation of Jackson and Pollock (1978) and the percent body fat equation developed by Siri, Coleman concluded that the mean value for body fat for 137 baseball players was 12.6%. By subgroups it was concluded that mean values for pitchers (n=56), infielders (including catchers) (n=50) and outfielders (n=31) were 14.7%, 12.0% and 9.9%, respectively. After dividing the players into subgroups, Coleman determined mean body fat values for each infield position. Catchers (n=12) were found to have 13.5% body fat; first basemen (n=11), 10.9%; second basemen (n=13), 11.5%; third basemen (n=8), 12.9%; and shortstops (n=12), 9.2%.

In a later study conducted by Coleman (1982b), twenty-two major league baseball players were measured and found to have a mean body fat value of 11.0%. Mean body fat values found for the subgroups of pitchers (n=8), infielders (n=8) and outfielders (n=6) were 13.6%, 11.9% and 9.7%, respectively.

In a study conducted by Golding (1966) to determine physical fitness levels of baseball players at both the professional and collegiate levels, it was revealed that skinfold measurements of professional players were greater than those of collegiate ballplayers and those of the general population. Grouping professional and collegiate players together, skinfold fat was found to be the highest in outfielders with pitchers being next highest and infielders being the lowest. No calculations of percent body fat were reported. However, it did reveal the relatively large skinfold values that professional baseball players possessed at that time.

Other studies have also been conducted on professional baseball players, however, the results in most cases have not been made public (Coleman, 1982a). The purpose of these studies appears to have been primarily for the information of the players and their team's management in regards to body composition and condition of the athletes. These studies help determine if weight should be gained, lost or maintained.

Baseball players at the collegiate level have also been studied. However, the general practice has been to include them as part of a larger study of college athletes. Therefore, it is rare to find studies that have gone into depth on the study of collegiate baseball players on a position-by-position basis. Novak, Hyatt, and Alexander (1968), in a study which included collegiate baseball players (n=10), found that the players as a group had a mean body fat value of 14.18%. Various skinfold and skeletal diameters were measured to determine body composition. Potassium levels, total body water, creatinine amounts, body solids, fat and fat free solids were all estimated for the baseball players as well as the other athletes. It was shown that there was a great range of body weight in the ballplayers, from 65.2 kg for one of the infielders to 96.68 kg for one of the pitchers. Not only were wide ranges of weight found, but there were also varying degrees of fatness.

Forsyth (1970) studied 17 collegiate baseball players as part of a larger study on collegiate athletes of various sports. Several skeletal diameters and skinfold measurements were taken as well as hydrostatic weighing performed. Six different combinations of the raw data obtained from all the subjects (n=50) were used to compute regression equations. However, the findings of the study were presented for the total athletic population studied and are not shown for specific groups of athletes.

Slaughter and Lohman (1980) were able to compute FFB deviations from the regression line of non-athletes for baseball players (n=17). The baseball players were found to have more musculo-skeletal mass than non-athletes.

Between the years 1974 to 1976, Sinning (1982) measured 18 collegiate baseball players for body composition. Again, the baseball players are only a portion of a larger study on athletes, and this study has not been published.

Coleman (1981) compared the body composition mean of the baseball players he studied to several other types of athletes. Other studies, such as the one conducted by Behnke and Royce (1966), not only describe athletes by sport, but also make comparisons of physical characteristics between the sports. Behnke and Royce compared weightlifters, basketball players, distance runners and football players and found considerable differences between the groups. Fox and Mathews (1981) have developed a chart comparing body compositions which are typical of athletes in various sports, although no position descriptions were established.

Methods of Determining Somatotypes

As with determination of body density and body composition, there have been several studies conducted to determine somatotypes. In this area there are three methods which are most frequently used. These are the Sheldon Method, the Heath-Carter Method and the Parnell Method (Sheldon, 1970; Carter, 1980; Parnell, 1958).

Sheldon (1970) was instrumental in developing the current method of classifying the physique of an individual. He established standards for various physiques and made comparisons to these standards when a subject was photographed in differing planes. From these photographs, measurements are taken and are related to tables which determine the subject's somatotype. He has established standards for all possible body types, and the standards are age-scaled to fit the individual throughout his lifetime.

Sheldon has also related various physiques to specific physical and behavioral traits. With his temperament scale Sheldon has found relationships between somatotype and various social and psychological characteristics. Relationships of body structure to interests, activities and aspirations which tend to develop have also been established by Sheldon (Willgoose, 1961). Sheldon has also developed a psychiatric classification in which three types of delinquency are devised on the basis of structure.

Parnell (1958) suggested that physical anthropometry be used along with somatotype photographs to make somatotype ratings more objective. He selected three sets of measurements: (a) bone diameters,

(b) muscle girths and (c) skinfolds. Parnell's M.4 deviation chart, based on studies of more than 2,000 male and 700 female college students, 800 school children and some small samples, emphasizes phenotyping, a measurement of body type at a particular time in an individual's life that is not to be interpreted on an age scale basis.

Heath and Carter (1966) have developed their somatotype system based on modification of the Sheldon and Parnell methods. The procedure can use both anthropometric measurements and photoscopic assessments. The method, established by Heath, has opened the rating scale at both ends, has eliminated extrapolation for age and has established a linear relationship between somatotype ratings and height/weight ratios. This has allowed for the consideration of the possibility that several phenotypes or somatotypes are possible for each individual. In Heath and Carter's method, various skinfolds, muscle girths and bone diameters very similar to those measured by the Parnell method are measured.

Haronian and Sugerman (1965) conducted a study to determine if differences existed between the Sheldon and Parnell methods of describing physique. Their findings on 102 male college-aged students revealed that differences do exist. Scores were deemed not to be interchangeable between the two systems. On the scale of one to seven, Parnell's method showed 1/4 point less for endomorphy, nearly a full point less for mesomorphy, and almost 1/4 point more in ectomorphy than did Sheldon's method. Intercorrelations between the three pairs of scores were .35 for endomorphy, .44 for mesomorphy and .74 for ectomorphy.

Heath and Carter (1966) conducted a study to determine if differences existed between their method and that of Parnell. Their findings on 120 college students, 59 males and 61 females, revealed that Heath's means are significantly lower than Parnell's means for the first component for males, higher in the second component for females, and lower for both males and females in the third component. On an athletic group of young men Heath's ratings were approximately 1/4 unit lower on the third component. Adjustments between the two methods can be made by subtracting one quarter point for the first component and one half point for the third component if the Parnell method has been used.

Somatotypes have been used to relate body build to various health aspects. Studies have shown that heavily muscular men have a greater tendency toward artery and coronary diseases than do ectomorphic individuals (Willgoose, 1961). Coaches and physical educators use somatotyping as a method of relating body type to success in various sports (Fox and Mathews, 1981).

Somatotype Studies Conducted on Athletes

Somatotypes have been used in describing "typical" athletes of a certain sport or certain positions of a sport. These have been done on several types of athletes, both male and female (Fox and Mathews, 1981). Behnke and Royce (1966) studied body size and shape of several types of athletes in the mid 1960's. Using a somatogram upon which they plotted eleven various anthropometric girth measurements and determined deviation from the middle of the graph, they studied weightlifters, basketball players, distance runners and professional football players. The study, however, was severely limited in sample size, as only three subjects were used for each sport, (except football in which 25 subjects were used). Behnke and Royce concluded that weightlifters displayed an excess of muscle development and leanness and significant deviation from the average values of the reference man. In basketball players little muscularity was detected other than in the shoulder and calf muscles. Other than these sites, little variation between the basketball players and reference man existed with regards to body structure. Distance runners' typical physical characteristics were determined to be that they were lean and small in body size with little arm girth. The football players were found to be bigger than the reference man and had exceptional amounts of lean body mass.

In a study conducted by Clarke et al. (1979), thirteen varsity basketball players of a Division I college were somatotyped using the Heath-Carter anthropometric method. The mean somatotype rating was found to be 2.03-4.35-3.65. The study also divided the subjects into subgroups by the positions of guard, forward and center. Means were calculated for each as being 1.80-3.90-3.60, 2.10-4.70-3.40 and 2.33-4.50-4.17, respectively.

Carter (1970) reported that Lewis studied 100 New Zealand basketball players using the Parnell M.4 Deviation method. He concluded that their mean phenotype was 3.5-4.5-3.5. When transformed to the Heath-Carter rating method, these mean values were 3.0-5.0-2.5.

Other basketball players consisting of two different collegiate teams and eight Russian players have been studied (Carter, 1970). Described as a group, they were found to have a mean somatotype rating of 2.5-5.0-3.5 with some variations of mesomorphy and ectomorphy among players. Willgoose (1961) reports that Chaulkley, in his study, found basketball players to display tendencies of possessing more ectomorphy than athletes of other sports.

Sheldon (1970) has stated that many professional football players are 2-6-2, 2-6-3 or 4-6-2. He also suggested that there are many seven ratings in mesomorphy, and linemen could be 3-7-1, 4-7-1 or 5-6-1.

Carter (1968) reported that Heath studied 66 college football players from various institutions. She determined mean somatotype ratings using her modification of Sheldon's system. The mean somatotype values calculated were 3.64-5.48-2.12.

In a later study Carter (1968) determined the somatotype of 35 collegiate football players for the purpose of describing the mean somatotype of an outstanding college football team. He divided the members of the team into various subgroups according to positions played. Using Parnell's M.4 Deviation technique, linemen and linebackers were found to have a rating of 5.08-5.70-1.75 with offensive linemen at a mean rating of 5.05-5.70-1.85 and defensive linemen and linebackers having a value of 5.13-5.75-1.68. The 17 backs somatotyped were found to have a mean rating of 4.29-5.44-2.38 with offensive backs, including split ends, found to possess a mean rating of 4.46-5.46-2.25, and defensive backs having a mean rating of 3.90-5.50-2.70. When all 35 subjects were grouped together, Carter found their mean somatotype rating to be 4.70-5.52-2.06.

Carter (1970) also studied 20 members of another collegiate football team and found their mean somatotype rating to be 3.2-6.2-1.6. From his studies, Carter has concluded that there is a predominance of endo-mesomorphs of extremely large size in football.

Fox and Mathews (1981) reported that distance runners have been studied by Carter who described the mean somatotype for Olympic marathon runners as being 1.4-4.3-3.5. Tanner (1964) has also studied distance runners and found that their somatotypes displayed more strength in ectomorphy as the distance run in competition lengthened. He concluded that the mean rating for the 34 distance runners studied was 1.5-4.6-3.6.

Carter (1970) has studied collegiate and high school distance running champions using the Parnell M.4 Deviation method and Heath criteria. The findings for the 17 collegiate runners and the eight high school runners were mean somatotype values of 1.8-3.9-4.0 and 2.2-4.2-3.9, respectively, using the Heath criteria.

Carter (1970) reported that the track and field members have been included in studies in which distance runners have been rated. Cureton (1951) for one, grouped 24 of these athletes together and, by using the Sheldon somatotype method, he found the mean rating to be 2.5-5.5-4.5. Rerated by Carter (1970) using the Heath criteria, nineteen of these athletes were found to have a mean somatotype of

2.5-5.2-3.1. Willgoose (1961) reports that track athletes studied by Chaulkley were typically more ectomorphic than other athletes.

Weightlifters have been somatotyped by various methods. Carter (1970) has taken some of these weightlifter's measurements and rerated them using the Heath criteria. Grouping studies together, he has determined a mean somatotype rating for weightlifters to be 3.0-7.0-1.0. Carter (1970) reported that 34 Russian wrestlers were studied and found to have a mean rating of 3.5-6.4-1.3, while 31 other wrestlers were found to have a mean rating of 2.1-6.2-1.6. Willgoose (1961) reported that Chaulkley's study showed that wrestlers possessed a high degree of mesomorphy.

Baseball studies in the area of somatotyping are very limited. Sheldon (1970) has suggested that most baseball players' physiques would be somatotyped as 2-6-2, 2-6-3, 3-6-2 or 4-6-2. However, this is not scientifically documented.

Carter (1982) has also stated that there appears to be only one extensive study conducted on baseball players, that being the study of Imlay (1966) on collegiate baseball players from the San Diego area. Imlay pointed out that most somatotype ratings which have been given to baseball players have been done on opinion rather than on specific studies. Using Parnell's M.4 Deviation method, Imlay studied 151 college baseball players from the San Diego area and ten baseball players from the University of Iowa. As a group, Imlay found the San Diego area baseball players to have a mean somatotype rating of 3.8-5.2-2.2. Imlay (1966) also studied the San Diego area baseball players by offensive and defensive positions. One reason for doing this was the fact that observation by many had indicated a trend of players' physiques to vary according to position. The findings of his defensive position-by-position comparisons revealed that significant differences in physique did exist. The following are the defensive position mean phenotype ratings: pitchers, 3.98-4.81-2.88; catchers, 4.38-5.15-2.03; first and third basemen, 3.98-5.24-2.41; second basemen and shortstops, 3.33-4.79-3.10; and outfielders, 3.50-5.26-2.80. As can be seen, a wide range of phenotypes were found for the various positions.

Summary of Related Literature

There are various methods that a researcher can use to determine body density and body fat percent. For body density determination, hydrostatic weighing has been established as the standard to which other methods have been compared. The use of the anthropometric measurements of skeletal girths and diameters have been correlated with body density determined by hydrostatic weighing, as have been various skinfold measurements.

For determination of percent body fat from body density several methods have been established. These methods have been found to have similar correlations with each other, and there appears to be little difference among the formulas.

Physical characteristics of specific sports have been described using body density and percent body fat equations. Studies of football players have been done to describe their physical characteristics both as a group and in various subgroups as determined by positions played. Performance levels and positions played have been shown to be related to their physical characteristics. Studies conducted on basketball players have also revealed a relationship between physical characteristics and level of performance, and physical characteristics and position played. Studies conducted on baseball players appear to be extensive only at the professional level. Relationships between physical characteristics and positions played at the major league level of performance have been found (Coleman, 1981).

Collegiate baseball players have been studied as well, but generally were only a portion of a larger study on college athletes. When separated from the other athletes and placed into subgroups determined by positions played, a relationship between physical characteristics and subgroups developed. However, sample sizes were too small to draw any accurate conclusions.

Various methods of somatotype rating have been developed. The three most frequently used are the Sheldon, Parnell and Heath-Carter methods. Sheldon's method determines somatotype by photoscopic procedures, Parnell's method uses anthropometric measurements to determine somatotype in a more objective manner and the Heath-Carter method can use both photoscopic and anthropometric measures. Parnell's method is time related in that his ratings are only valid for an individual at that particular age grouping whereas the Heath-Carter method is age-scaled and once determined is good for the individual's lifespan. Studies to determine the relationships of these methods have been conducted and have shown that there are significant differences between the methods and that their rating systems are not interchangeable.

Somatotype ratings have been conducted on several types of athletes to determine mean somatotype ratings for particular sports. Some studies have described the mean ratings not only for a particular sport, but also for subgroups determined by position played. In basketball for example, guards were found to be less endomorphic and mesomorphic than forwards and centers while forwards were found to be more mesomorphic and less ectomorphic than the other two groups, and centers were found to be more endomorphic and ectomorphic than guards and forwards. Basketball players, distance runners and track athletes have been found to display more ectomorphy than other athletes. Football players and wrestlers have been found to display more mesomorphy than other athletes. There appears to be only one extensive study conducted on baseball players. In this study the mean somatotype rating was found to be 3.8-5.0-2.7 with a wide range of recognized phenotypes. By position, catchers were found to be more endomorphic and less ectomorphic than pitchers, first and third basemen, second basemen and shortstops, and outfielders. Second basemen and shortstops were found to have the least amount of endomorphy and mesomorphy, and the most ectomorphy of any of the defensive subgroups while outfielders displayed the most amount of mesomorphy of the defensive subgroups.

CHAPTER 3

METHODS AND PROCEDURES

The purpose of this study was to describe the body composition and somatotypes of NCAA Division II baseball players. In addition, the baseball players were divided into subgroups by position. Physical characteristics and body composition for subgroups were determined to see if subgroups have distinct body composition and somatotype profiles. The methods and procedures have been organized accordingly:

1. Subjects
2. Techniques for determining body composition.
3. Techniques for determining somatotype.
4. Data collection.
5. Statistical analysis.

Subjects

One hundred thirty-two baseball players of seven NCAA Division II baseball teams were measured. All subjects were members of their respective 1983 North Central Conference baseball team's traveling squad. (See Appendix A.) Each subject who volunteered to participate played a defensive position and signed an informed consent form before any of the measurements were taken. (See Appendix B.)

Technique for Determining Body Composition

The sum of three skinfolds was used to estimate body composition. The skinfolds used were the chest, abdomen and thigh. These skinfolds were required for the body density equation developed by Jackson and Pollock (1978). Skinfolds were measured with a Harpenden Skinfold Caliper which exerts a constant pressure of 10 g/mm^2 at the skinfold sight. Lohman and Pollock (1981) have noted that use of this caliper is worldwide, and its reliability and validity is well documented. Each skinfold was measured three times on a rotating basis with order of measurement being chest, abdomen and thigh. The average of the three measurements at each site was used for analyses. All measurements were taken from the right side of the body.

To determine proper location of the landmark, the procedures were consistent with procedures described by Behnke and Wilmore (1974). The chest skinfold was measured over the lateral border of the pectoralis major just medial to the axilla, on a fold running diagonally between the shoulder and the opposite hip. The abdominal skinfold was measured by horizontal folds adjacent to the umbilicus. The thigh skinfold was measured by a vertical fold on the anterior aspect of the thigh midway between the inguinal fold and the top of the patella. When measurements were necessary to find the mid-point between two locations, a cloth tape for measuring and a felt pen for marking were used.

Sinning (1975) has stated the procedure to be used in obtaining a skinfold measurement as follows:

> Pick up the subject's skinfold between your index finger and thumb. Be sure that you have two layers of skin and the underlying fat. Allow the skinfold to follow its natural stress lines as you lift. If you doubt that you have a true fold, have the subject contract the muscle underneath it; you will be able to retain your grasp on the skin, if it is a true skinfold. Make all measurements of skinfolds on the right side of the body.
>
> Apply the caliper about 1 cm from the fingers. It should be applied where the two surfaces of the fold are parallel. Do not apply the caliper where the fold is rounded near the top, or where it is broader at its base.

The caliper was held in the right hand and, when properly applied, the measurements were read and then recorded.

The generalized equation utilizing the sum of three skinfolds developed by Jackson and Pollock (1978) for predicting body density was used. This equation is as follows:

$$\text{Density} = 1.10938 - (0.0008267)(X2) + (0.0000016)(X2)^2 - (0.0002574)(X3)$$

where X2 is the sum of three skinfolds, and X3 is the subject's age. The reason for using this equation to determine body density was that Coleman (1981;1982b), in his study of major league baseball players, used this equation and Coleman's procedures were replicated in order to compare body composition of collegiate and major league baseball players.

After body density was determined, percent body fat was calculated using Siri's equation. The equation is as follows:

$$\%\ \text{fat} = 100(4.950/\text{density} - 4.500)$$

(McArdle, Katch & Katch, 1981). The rationale for using Siri's equation was that both Coleman (1981;1982b), in his studies of baseball players, and Jackson and Pollock (1978), in their study to develop generalized equations, used this equation. Therefore, it was necessary to use this equation in order to replicate Coleman's procedures on collegiate baseball players.

After percent body fat was determined, body composition of the subject was determined. The determination of body composition in this study was based on the two component system of fat weight and lean body weight. Therefore, the remaining value following subtraction of fat weight from total body weight was considered to be lean body mass.

Technique for Determining Somatotype

Four skinfolds (triceps, subscapular, suprailiac and calf) plus height, widths of the humerus and femur, girths of the biceps and calf and body weight were measured in order to determine somatotype. The skinfolds, widths and girths were measured three times each on a rotating basis, and the average of the three measurements were used for analyses. All measurements were taken on the right side of the body and followed the methods described by Behnke and Wilmore (1974) and Sinning (1975). The triceps skinfold was located midway between the acromion and olecranon processes on the posterior aspect of the arm, the arm held vertically, with the fold running parallel to the length of the arm. The subscapular skinfold was located immediately below the inferior angle of the scapula with the fold running parallel to the axillary border. The suprailiac skinfold was located at the vertical fold on the crest of the ilium at the midaxillary line. The calf skinfold was the vertical fold on the posterior calf at the level of the maximal circumference. All measurements were taken with the subject in a standing position.

Widths of the humerus and femur were measured with a Harpenden Anthropometer. The humerus width was the distance between the condyles of the humerus with the elbow flexed and hand supinated. The femur width was the distance between the outermost projections of the tibial condyles with the knee flexed to 90°.

Girths of the biceps and calf were measured with a Gulick tape to insure consistent measurement. The biceps girth was measured with the subject's arm hanging in a relaxed position slightly away from the side of the body. The location measured was the mid-point between the inferior border of the acromion process and the top of the olecranon process. The calf girth was taken with the leg hanging freely and with the location being the point of maximal girth.

Height of the subjects was measured with a standard stadiometer which was transported to each institution by the researcher. Weight was measured on a scale made available by each institution. These were not necessarily calibrated instruments and an attempt to estimate the error was made by testing the scales prior to any measurements with a set of standard kilogram weights. When necessary measures were adjusted.

Heath and Carter's Somatotype Rating Form was used. (See Appendix C.) Only the anthropometric somatotype was conducted as the researcher had neither the experience nor the equipment to conduct a photoscopic somatotype. The reason for using the Heath and Carter method was that it had been improved several times and had been compared to other methods to determine reliability and validity of its measurements (Heath and Carter, 1966). It is probably the most up-to-date method of somatotype rating. Validity of the Heath and Carter method had been tested by several researchers (Slaughter and Lohman, 1976, 1977; Slaughter, Lohman and Boileau, 1977; Wilmore, 1970) and had been found to be more accurate than Sheldon's method.

Computation of the First Component

For computation of the first component the formula established by Carter (1980) for endomorphy was used. The formula is as follows:

$$\text{Endomorphy} = -0.7182 + 0.1451\ (X) - 0.00068\ (X)^2 + 0.0000014\ (X)^3$$

where X is the sum of the triceps, subscapular and suprailiac skinfolds.

Computation of the Second Component

For computation of the second component the formula established by Carter (1980) for mesomorphy was used. The formula is as follows:

$$\text{Mesomorphy} = 0.858\ (\text{humerus width}) + 0.601\ (\text{femur width}) + 0.188\ (\text{corrected arm girth}) + 0.161\ (\text{corrected calf girth}) - (\text{height})(\ (0.131) + 4.50$$

To get the corrected arm girth figure the triceps skinfold was divided by 10 to convert it to centimeters, and then subtracted from the biceps girth. To get the corrected calf girth the calf skinfold was divided by 10 and then subtracted from the calf girth.

Computation of the Third Component

The third component was computed by using the formula established by Carter (1980) for ectomorphy. The formula is as follows:

$$\text{Ectomorphy} = \text{HWR} \times 0.732 - 28.58$$

If HWR < 40.75 but > 38.25, then:

$$\text{Ectomorphy} = \text{HWR} \times 0.463 - 17.63$$

If HWR < 38.25 then a rating of 0.1 was to be assigned where HWR represents height measured in centimeters divided by the cubed root of weight measured in kilograms.

Once all three components were determined, the subjects were able to be classified according to the strongest two components they displayed. The strongest component is their classification with the second strongest component being an adjective to be used with the classification.

Data Collection

The researcher practiced the techniques of measuring skinfolds and anthropometric girths and widths on an estimated 50 subjects prior to gathering the data on the baseball players of this study. Lohman and Pollock (1981) have stated that a tester can become quite skilled in measuring skinfolds with relatively little training or practice. They reported that an inexperienced tester should have measured 50 to 100 subjects, after they have been properly trained, to attain adequate proficiency.

After contacting each coach by telephone, a letter explaining the coaches role and purpose of the study was sent to each of the coaches. (See Appendix D.) When a date was agreeable to the coach and the researcher the researcher visited that institute. The researcher visited the campuses of seven of the nine North Central Conference schools over a four week period during the 1983 spring semester. A schedule was set up with the players which not only established a meeting time, but also explained where to meet, how long the measuring session would last and what should be worn. The players were also instructed not to do anything different in regards to their eating and exercise habits.

Before the subjects were measured, each was given an informed consent form explaining the purpose of the study and the subject's role in participating. Most of the subjects were measured prior to practice sessions, however, due to scheduling problems, some subjects were measured during or after practice.

The same procedure was used for all subjects with the order of measurement being as follows: subject's age, measured in years to the nearest month; anthropometric girths, measured in centimeters to the nearest tenth; skinfolds, measured in millimeters to the nearest tenth; anthropometric widths, measured in centimeters to the nearest tenth; weight, measured in pounds to the nearest ounce and then converted to kilograms and recorded to the nearest tenth; and height, measured in centimeters to the nearest tenth.

The anthropometric girths were measured in the following order: biceps and calf. The seven skinfold landmarks were measured in the order of subscapular, triceps, chest, suprailiac, abdomen, thigh and calf and the anthropometric widths were measured in the order of humerus and femur.

A recording sheet was used to record all the data. Volunteers, selected from the subject ranks, were used when available for recording the data on the sheet. They were informed to be precise in their recording of data which was relayed to them by the researcher. When three measurements at each stage of the measurement session were completed, the researcher studied the record sheet to determine if various measurements needed to be repeated. Anthropometric girth measurements were repeated if differences between any of three measurements exceeded one centimeter. Repeated measures were taken until three measurements were within one centimeter. Measurements of skinfolds were repeated if they did not meet the requirements of Sinning (1975) which were: (a) all measurements of a skinfold site were within 5% accuracy or (b) all measurements of skinfolds over 20 millimeters had one millimeter or less difference between the measurements. Repeated measures were taken until three skinfolds met these criteria. Anthropometric width measurements were repeated if differences of three measurements exceeded one centimeter. Repeated measures were taken until three measurements were within one centimeter.

Analysis of the Data

Descriptive statistics were applied to the data, for the purpose of describing the physical characteristics of baseball players. Means, standard deviations, and maximum and minimum scores for age, height, weight, seven skinfolds (chest, abdomen, thigh, triceps, subscapular, suprailiac and calf), humerus and femur widths, biceps and calf girths, body density, body fat percent, body fat weight, lean body weight, and sum of skinfolds were computed for the group and for each subgroup classification.

The subgroups used were pitchers; infielders, which included catchers, first, second, and third basemen and shortstops; and outfielders, which included right, left and center fielders. These subgroups were the same ones employed by Coleman (1981;1982) in his studies on baseball players. Other subgroups included: catchers; first and third basemen; and second basemen and shortstops. The final categorization into subgroups were by each infield position.

Once all descriptive statistics were computed, a series of analyses of variance tests was conducted for specific subgroup comparisons. The Statistical Package for the Social Sciences (SPSS) at South Dakota State University was used to analyze all data (Nie, Hull, Jenkins, Steinbrenner & Bent, 1975). SPSS subprogram ANOVA (option 9) was used in the analyses of variance. The dependent variables for the subgroups of pitchers, infielders and outfielders were: age, height, chest, abdomen and thigh skinfolds, sum of skinfolds, body density, body fat percent, body weight, lean body weight and somatotype. For the subgroups of catchers, first basemen, second basemen, third basemen and shortstops, the dependent variables were: age, height, sum of skinfolds, body density, body fat percent, weight and lean body weight.

Using the measurements of four skinfolds (suprailiac, triceps, subscapular, and calf), biceps and calf girths, humerus and femur widths, body weight, and height the subject's somatotype ratings were determined. Also, the subgroups mean somatoplots were placed on somatocharts. These somatoplots were determined by using the computational steps suggested by Carter (1980). Each individual's three component rating had to be converted to X-Y coordinates in order to be plotted on the Heath-Carter Somatochart by using the formula:

$$X = III - I$$

$$Y = 2II - (III + I)$$

where X and Y are the coordinates and I, II and III represent the first, second and third components, respectively. The grand mean somatotype was then calculated by using the following formula:

$$M = (S1 + S2 + ...+ Sk)k$$

where M is the mean somatotype expressed as a three digit rating. S1, S2 and Sk represent the mean endomorphy component for each subgroup and k is the number of subgroups. This process was repeated for each of the components, endomorphy, mesomorphy and ectomorphy, as they are determined independently of each other.

For determining differences in somatoplots among subgroups a series of analyses of variance were also conducted. Before calculating F-ratios by following standard procedures, sum of squares had to be calculated using formulas that are different from the standard formulas.

A somatotype dispersion distance was calculated to determine how far on the somatochart one somatoplot was from another. This was done by using the following formula:

$$SDD = (3\ (X1 - X2)^2 + (Y1 - Y2)^2)^{.5}$$

where SDD represents the somatotype dispersion distance and X1 and Y1, and X2 and Y2 are coordinates of any two somatoplots.

The sum of squares within samples was then computed. The formula for obtaining the sum of squares within was as follows:

$$SSw = \sum_{j=1}^{k} \sum_{i=1}^{n} (SDD_i^2)$$

where SSw is the sum of squares within samples, k is the number of groups, and n is the number of subjects in the sample.

To compute the sum of squares between groups, the harmonic mean first had to be calculated. The formula used for this computation was:

$$\tilde{n} = k/(1/n1 + 1/n2 + \ldots + 1/nk)$$

where n represents the harmonic mean, k is the number of samples and n1, n2 and nk are the number of subjects comprising each sample. Once the harmonic mean was computed the sum of squares between groups was calculated using the following formula:

$$SSb = \tilde{n} \sum_{j=1}^{k} (SDDM)^2$$

where SSb is the sum of squares between groups, n represents the harmonic mean, k is the number of groups and SDDM is the distance between each sample mean somatoplot and the grand mean somatoplot.

To conduct the analyses of variance to determine if there were significant sample dispersion distances, sum of squares between and sum of squares within were divided by their respective degrees of freedom of k - 1 and n - k to get mean square between and mean square within. Once these values were derived, the F-ratio was calculated.

A computer program was written and documented to perform analysis of variance of somatotype data. (See Appendix E.) The probability level of $p<.05$ was used as the significance level for all analyses. Tukey's test was used to test a posteriori comparisons.

Finally, fat free body (FFB) of the subjects was predicted by using the fat free body equation of Slaughter and Lohman (1980) which is:

$$Y' = .719\ HT - 63.9$$

where Y' represents the predicted fat free body and HT is the height of the individual. The difference between actual FFB and predicted FFB was calculated for each subject. Deviation from the regression line established by Slaughter and Lohman (1980) on 289 non-athletes was then calculated. This was done by dividing the difference between actual FFB and predicted FFB by 6.3 which was one standard error of estimation for Slaughter and Lohman's (1980) regression line.

CHAPTER 4

RESULTS AND DISCUSSION

The purpose of this investigation was to determine the body composition and body type of NCAA Division II baseball players and body composition and body type of subgroups defined by positions played. Physical characteristics, body composition and body types for subgroups were determined to see if subgroups had distinct profiles. North Central Conference baseball players from seven teams (n=132) were measured and divided into the following subgroups: (a) pitchers (n=43); (b) infielders (catchers, first, second and third basemen and shortstops) (n=60); (c) outfielders (n=29); (d) catchers (n=15); (e) first-third basemen (n=25); (f) second basemen-shortstops (n=20); (g) first basemen (n=13); (h) second basemen (n=10); (i) third basemen (n=12); and (j) shortstops (n=10).

The variables that were measured to determine physical characteristics, body composition and body types were: skinfolds of the chest, abdomen, thigh, subscapula, suprailiac, calf and triceps; girths of the biceps and calf; widths of the humerus and femur; and height, weight and age. Test-retest reliability was established for all variables except age, height and weight, after four teams had been measured. Nineteen baseball players from South Dakota State University were measured and remeasured on consecutive days in order to estimate test-retest intraclass reliability coefficients. The results are shown in Table 1. The mean square within subjects was used as the error term in the computation of the intraclass reliability coefficient. Intraclass values ranged from .951 to .986 for skinfolds with the exception of chest skinfold which was .785. Intraclass values for the biceps and calf girths, and humerus and femur widths were .991, .974, .987, and .966, respectively. A significant difference was found between measurements of Day 1 and Day 2 for each of the following variables: chest, abdomen, subscapular, suprailiac and triceps skinfolds and biceps girth. Where differences were small, the statistical significance that was present may have been due to the low standard errors of the difference between means.

As well as the measured variables, there were several variables which were derived. These included body density, body fat percent, body fat weight, lean body weight, sum of skinfolds and somatotype rating, which was made up of endomorphy, mesomorphy and ectomorphy components. All variables had the descriptive statistics of mean, standard deviation and mininimum and maximum scores computed. Also, a series of one-way analyses of variance was used to analyze the differences among pitchers, infielders and outfielders for each variable. When players were grouped as catchers, first basemen, second basemen, third basemen and shortstops another series of analyses of variance was conducted where the selected dependent variables were age, height, weight, body density, body fat percent, body fat weight, lean body weight, sum of skinfolds and somatotype rating. Tukey's test was used to test a posteriori comparisons. The alpha level was established at .05 for all analyses.

TABLE 1

Test-Retest Intraclass Reliability Coefficients (n=19)

Variable	Mean Day 1	Day 2	R
Skinfolds (mm)			
Chest	10.75*	9.76	.785
Abdomen	23.95*	22.41	.976
Thigh	16.15	15.65	.980
Subscapular	14.19*	13.43	.964
Suprailiac	23.56*	22.67	.986
Calf	8.78	8.55	.974
Triceps	15.95*	14.63	.951
Girths (cm)			
Biceps	34.51*	34.36	.991
Calf	38.48	38.79	.970
Widths (cm)			
Humerus	7.27	7.23	.987
Femur	9.90	9.99	.966

Note. Mean square within subjects was used as the error term in the computation of the the intraclass reliability coefficient.
* Significant difference between Day 1 and Day 2, $p<.05$.

The subgroups of baseball players were also plotted along a regression line developed by Slaughter and Lohman (1980) to determine how many standard errors of estimation they were away from the regression line which represented the fat free body (FFB) of 289 sedentary men.

Analysis of the data and summary of the results are presented in four sections: (a) body composition, including the variables age, height, chest skinfold, abdominal skinfold, thigh skinfold, body density, body fat percent, total body weight, body fat weight and lean body weight; (b) somatotype, including the variables height, weight, subscapular skinfold, triceps skinfold, calf skinfolds, biceps girth, calf girth, humerus width and femur width; (c) fat free body regression line analysis, including the variable of lean body weight; and (d) discussion of the results.

Body Composition

The descriptive statistics for the variables of age, height, three skinfolds (chest, abdomen and thigh), sum of skinfolds, body density, body fat percent, total body weight, body fat weight and lean body weight are presented in Table 2 for all players (n=132). The baseball players as a group had a mean age of 21.10 years (SD=1.41), a mean height of 180.91 cm (SD=6.16) and a mean weight of 79.11 kg (SD=7.54). As a group the baseball players had a mean body density value of 1.070 g/ml (SD=0.008) and a mean body fat value of 12.49% (SD=3.39). For body fat weight and lean body weight the group had mean values of 9.98 kg (SD=3.25) and 69.13 kg (SD=6.04), respectively.

Subgroup descriptive statistics are presented in three sections: (1) pitchers, infielders and outfielders; (2) catchers, first-third basemen and second basemen-shortstops; and (3) catchers, first basemen, second basemen, third basemen and shortstops. Analyses of variance are also reported for the subgroups of pitchers, infielders and outfielders and for catchers, first basemen, second basemen, third basemen and shortstops.

TABLE 2

Physical Characteristics and Body Composition
of Selected NCAA Division II Baseball Players (n=132)

Variable	M	SD	Min.	Max.
Age (yr)	21.10	1.41	18.41	25.17
Height (cm)	180.91	6.16	166.40	197.50
Skinfolds (mm)				
Chest	10.21	3.25	5.37	22.07
Abdomen	21.30	6.49	8.37	37.27
Thigh	13.26	4.56	5.43	25.70
Sum	44.77	11.57	23.60	73.63
Body Density (g/ml)	1.070	0.008	1.051	1.085
Body Fat Percent	12.49	3.39	6.15	20.82
Weight (kg)				
Total Body	79.11	7.54	58.76	100.28
Body Fat	9.98	3.25	4.16	20.54
Lean Body	69.13	6.04	52.26	81.70

Pitchers, Infielders and Outfielders

The descriptive statistics for the variables of age, height, three skinfolds (chest, abdomen and thigh), sum of skinfolds, body density, body fat percent, total body weight, body fat weight and lean body weight were computed for the subgroups of pitchers, infielders and outfielders. The results are presented in Table 3.

The outfielders were found to have the largest mean age value at 21.42 years (SD=1.25), while pitchers had the smallest mean age value at 20.85 years (SD=1.40). Pitchers were found to be the tallest with a mean height of 183.48 cm (SD=6.34) and outfielders were the shortest

TABLE 3

Physical Characteristics and Body Composition
of Pitchers, Infielders and Outfielders

	Pitchers (n=43)				Infielders (n=60)				Outfielders (n=29)			
Variable	M	SD	Min.	Max.	M	SD	Min.	Max.	M	SD	Min.	Max.
Age (yr)	20.85	1.40	18.60	23.42	21.13	1.48	18.41	25.17	21.42	1.25	19.12	24.08
Height (cm)	183.48*	6.34	170.50	197.50	180.14*	6.11	166.40	191.40	178.69*	4.67	169.90	186.80
Skinfolds (mm)												
Chest	9.73	2.48	6.00	15.67	10.90	4.01	5.37	22.07	9.47	2.08	6.70	13.47
Abdomen	21.48	7.02	8.37	36.07	21.86	6.78	9.03	37.27	19.89	4.81	12.17	28.40
Thigh	13.70	5.06	5.43	25.70	13.28	4.58	6.30	23.00	12.58	3.70	7.50	21.97
Sum	44.90	11.99	23.60	73.03	46.05	12.51	24.97	73.63	41.94	8.32	28.13	61.50
Body Density (g/ml)	1.070	0.008	1.052	1.085	1.070	0.008	1.051	1.085	1.072	0.006	1.060	1.082
Body Fat Percent	12.50	3.52	6.15	20.49	12.86	3.66	6.38	20.82	11.72	2.49	7.45	17.13
Weight (kg)												
Total Body	80.11	7.83	65.89	100.28	78.81	7.88	58.76	92.55	78.24	6.39	66.38	90.18
Body Fat	10.13	3.52	4.16	20.54	10.23	3.40	4.73	18.49	9.24	2.42	4.99	15.45
Lean Body	69.98	6.05	58.62	81.70	68.58	6.48	52.26	80.79	69.00	5.02	60.81	77.51

* Differences significant at $p \leq .05$.

with a mean height of 178.69 cm (SD=4.67). For the chest, abdomen and sum of skinfolds, infielders had the largest mean values at 10.90 mm (SD=4.01), 21.86 mm (SD=6.78) and 46.05 mm (SD=12.51), respectively, while pitchers had the largest thigh skinfold value at 13.70 mm (SD=5.06). The smallest mean values for each of those skinfolds and sum of skinfolds were those of the outfielders with values for the chest, abdomen, thigh and sum of skinfolds being 9.47 mm (SD=2.08), 19.89 mm (SD=4.81), 12.58 mm (SD=3.70) and 41.94 mm (SD=8.32),respectively.

The infielders and pitchers both had a mean body density of 1.070 g/ml (SD=0.008) while outfielders had a slightly higher body density mean value of 1.072 g/ml (SD=0.006). Outfielders had the smallest mean values for body fat percent, total body weight and body fat weight with values of 11.72% (SD=2.49), 78.24 kg (SD=6.39) and 9.24 kg (SD=2.42). Infielders had the largest mean values for body fat percent and body fat weight with values of 12.86% (SD=3.66) and 10.23 kg (SD=3.40), respectively, while pitchers had the largest total body weight with a mean value of 80.11 kg (SD=7.83). Infielders had the least amount of lean body weight with a mean value of 68.58 kg (SD=6.48) while pitchers had the greatest amount of lean body weight with a mean value of 69.98 kg (SD=6.05).

Results of the series of one-way analyses of variance are shown in Table 3. There was a significant difference among the subgroups for height; $F(2,129)=6.62$, $p<.05$. Utilizing Tukey's a posteriori test, the differences in height were found to be between pitchers (M=183.48 cm) and infielders (M=180.14 cm) and pitchers

(M=183.48 cm) and outfielders (M=178.69 cm) with the pitchers being significantly taller than the other two groups. The difference between the height of infielders and outfielders was not significant. The results of the a posteriori comparisons are shown in Table 4.

TABLE 4

Mean Heights of Pitchers, Infielders and Outfielders

Pitchers (n=43)	Infielders (n=60)	Outfielders (n=29)
183.48	180.14	178.69

Note. Underscore represents no significant difference. A difference of 2.01 was required for significance for $p<.05$ utilizing Tukey's a posteriori test.

Due to unequal group sizes and variances, the analyses of variance were conservative tests. Therefore, power of the statistical tests was diminished which may be the reason for nonsignificant findings for the other variables. However,the percent of variance attributed to groups was very small for some of the variables that follow: age, 2.16%; height, 9.30%; weight, .94%; body density, 0.00%; body fat percent, 1.68%; body fat weight, 1.50%; and lean body weight, 1.04%.

Catchers, First-Third Basemen and Second Basemen-Shortstops

The descriptive statistics for the dependent variables of age, three skinfolds (chest, abdomen and thigh), sum of skinfolds, body density, body fat percent, total body weight and lean body weight for the subgroups of catchers, first-third basemen and second basemen-shortstops are presented in Table 5.

The first-third basemen group were found to have the largest mean age value at 21.21 years (SD=1.27) while the second basemen-shortstops group were found to have the smallest mean age value at 20.99 years (SD=1.70). The second basemen-shortstop group had the lowest mean value for each of the skinfolds and for the sum of skinfolds with mean values of 10.49 mm (SD=3.80) for the chest, 21.35 mm (SD=5.73) for the abdomen, 13.00 mm (SD=4.54) for the thigh and 44.74 mm (SD=10.74) for the sum of skinfolds. Catchers had the largest mean values for each of the skinfold variables. These values were 11.28 mm (SD=3.20) for the chest, 23.25 mm (SD=7.19) for the abdomen, 14.29 mm (SD=5.15) for the thigh and 48.82 mm (SD=12.80) for the sum of skinfolds.

For body density the subgroup of catchers had the lowest mean value of the three groups (1.068 g/ml, SD=0.009) while the other two groups each had the same mean value for body density of 1.070 g/ml (SD for first-third basemen =0.009 and SD for second basemen-shortstops =0.007). The second basemen-shortstops subgroup had the lowest mean values for body fat percent, total body weight and body fat weight with mean values being 12.48% (SD=3.18), 74.21 kg (SD=7.30) and 9.35 kg

TABLE 5

Physical Characteristics and Body Composition of Catchers, First-Third Basemen and Second Basemen-Shortstops

	Catchers (n=15)				First-Third Basemen (n=25)				Second Basemen-Shortstops (n=20)			
Variable	M	SD	Min.	Max.	M	SD	Min.	Max.	M	SD	Min.	Max.
Age (yr)	21.17	1.58	18.75	23.00	21.21	1.27	18.41	23.00	20.99	1.70	18.58	25.17
Height (cm)	179.71	5.27	169.80	186.10	181.64	5.87	168.50	190.80	178.61	6.81	166.40	191.40
Skinfolds (mm)												
Chest	11.28	3.20	6.67	15.57	11.01	4.68	5.37	22.07	10.49	3.80	6.53	19.00
Abdomen	23.25	7.19	9.03	37.27	21.52	7.43	11.10	33.73	21.35	5.73	12.00	35.77
Thigh	14.29	5.15	7.07	23.00	12.90	4.36	7.63	21.77	13.00	4.54	6.30	21.50
Sum	48.82	12.80	24.97	67.33	45.42	13.82	26.70	71.47	44.74	10.74	25.13	73.63
Body Density (g/ml)	1.068	0.009	1.055	1.084	1.070	0.009	1.053	1.083	1.070	0.007	1.051	1.085
Body Fat Percent	13.67	3.79	6.66	19.05	12.67	4.00	7.05	19.98	12.48	3.18	6.38	20.82
Weight (kg)												
Total Body	80.73	6.63	67.11	90.99	81.35	7.64	66.21	92.55	74.21	7.30	58.76	87.00
Body Fat	11.15	3.44	4.73	15.76	10.40	3.73	5.09	18.49	9.35	2.85	5.07	16.37
Lean Body	69.58	5.15	59.77	78.64	70.95	6.44	59.27	80.79	64.87	6.00	52.26	75.76

(SD=2.85), respectively. Catchers had the largest mean values for body fat percent and body fat weight with values of 13.67% (SD=3.79) and 11.15 kg (SD=3.44), respectively, while first-third basemen subgroup had the largest total body weight mean value at 81.35 kg (SD=7.64). The subgroup of second basemen-shortstops had the lowest mean value for lean body weight at 64.87 kg (SD=7.30) while the first-third basemen group had the largest mean value at 70.95 kg (SD=6.44). No analysis of variance was conducted for these subgroups as these players were later placed into single position subgroups for analyses.

Catchers, First, Second, and Third Basemen, and Shortstops

For the subgroups of catchers, first basemen, second basemen, third basemen and shortstops the dependent variables of age, height, three skinfolds (chest, abdomen and thigh), sum of skinfolds, body density, body fat percent, total body weight, body fat weight and lean body weight were statistically described. The results are presented in Table 6. For age, the first basemen and second basemen had the largest mean value of 21.75 years (SD for the first basemen = 1.03 and SD for the second basemen = 1.86) while shortstops were the youngest with a mean age of 20.24 years (SD=1.18). Shortstops had the smallest mean value for the chest, abdomen and sum of skinfolds with values of 9.71 mm (SD=2.91), 20.37 mm (SD=4.29) and 43.71 mm (SD=8.70), respectively, and first basemen had the smallest thigh skinfold value, that being 11.99 mm (SD=4.42). The largest mean values for all of the skinfolds for these subgroups were the values of the catchers. These values were 11.28 mm

TABLE 6

Physical Characteristics and Body Composition of
Catchers, First, Second, and Third Basemen, and Shortstops

Variable	Catchers (n=15)				First Basemen (n=13)				Second Basemen (n=10)				Third Basemen (n=12)				Shortstops (n=10)			
	M	SD	Min.	Max.	M	SD	Min.	Max.	M	SD	Min.	Max.	M	SD	Min.	Max.	M	SD	Min.	Max.
Age (yr)	21.17	1.58	18.75	23.00	21.75	1.03	19.14	22.87	21.75	1.86	19.42	25.17	20.63	1.30	18.41	23.00	20.24	1.18	18.58	21.83
Height (cm)	179.71	5.27	169.80	186.10	185.19*	4.14	176.20	190.80	175.30*	5.30	166.40	184.20	177.79*	5.06	168.50	186.20	181.91*	6.74	170.90	191.40
Skinfolds (mm)																				
Chest	11.28	3.20	6.67	15.57	11.18	4.74	6.67	20.97	11.26	4.54	6.53	19.00	10.82	4.81	5.37	22.07	9.71	2.91	6.63	16.10
Abdomen	23.25	7.19	9.03	37.27	21.97	5.96	14.13	31.57	22.13	7.01	12.73	35.77	21.02	9.01	11.10	33.73	20.37	4.29	12.00	26.30
Thigh	14.29	5.15	7.07	23.00	11.99	4.42	7.63	21.43	12.38	4.50	6.30	20.40	13.89	4.25	9.00	21.77	13.63	4.73	6.50	21.50
Sum	48.82	12.80	24.97	67.33	45.14	12.09	30.93	71.47	45.77	12.87	31.27	73.63	45.73	16.03	26.70	66.73	43.71	8.70	25.13	52.37
Body Density (g/ml)	1.068	0.009	1.055	1.084	1.070	0.008	1.053	1.080	1.070	0.009	1.051	1.080	1.070	0.011	1.056	1.083	1.071	0.006	1.065	1.085
Body Fat Percent	13.67	3.79	6.66	19.05	12.67	3.50	8.44	19.98	12.85	3.74	8.30	20.82	12.67	4.64	7.05	18.58	12.11	2.65	6.38	14.85
Weight (kg)																				
Total Body	80.73*	6.63	67.11	90.99	84.42*	6.88	66.21	92.55	70.96*	6.62	58.76	78.60	78.02	7.24	69.14	90.39	77.47	6.71	65.21	87.00
Body Fat	11.15	3.44	4.73	15.76	10.81	3.58	6.95	18.49	9.26	3.32	5.07	16.37	9.95	3.99	5.09	16.79	9.44	2.46	5.17	12.55
Lean Body	69.58	5.15	59.77	78.64	73.61	5.19	59.27	80.79	61.71*	4.71	52.26	68.13	68.07	6.61	59.73	80.33	68.03	5.61	59.03	75.76

* Differences significant at $p < .05$.

(SD=3.20) for the chest, 23.25 mm (SD=7.19) for the abdomen, 14.29 mm (SD=5.15) for the thigh and 48.82 mm (SD=12.80) for the sum of skinfolds.

Catchers had the lowest mean value for body density with a value of 1.068 g/ml (SD=0.009) while shortstops had the largest mean value for body density at 1.071 g/ml (SD=0.006). Shortstops had the lowest mean value for body fat at 12.11% (SD=2.65) while catchers had the largest mean value for body fat with a value of 13.67% (SD=3.79). Second basemen had the smallest mean values for total body weight and body fat weight with values of 70.96 kg (SD=6.62) and 9.26 kg (SD=3.32), respectively, while first basemen were heaviest with a mean value for total body weight of 84.42 kg (SD=6.88) and catchers possessed the most body fat weight with a mean value of 11.15 kg (SD=3.44). For lean body weight, second basemen at 61.71 kg (SD=4.71) had the smallest value while first basemen had the largest value at 73.61 kg (SD=5.19).

A series of one-way analyses of variance was conducted for these subgroups, and significant differences were found for the variables height $F(4,55)=5.95$; total body weight $F(4,55)=5.94$; and lean body weight $F(4,55)=6.82$ at $p<.05$. Tukey's a posteriori test was conducted to determine where the significant differences were located and these results are presented in Table 7.

The post hoc comparisons for the variable height revealed that first basemen (M=185.19 cm) were significantly taller than second basemen (M=175.30 cm) and third basemen (M=177.79 cm) while shortstops (M=181.91 cm) were significantly taller than second basemen. For

TABLE 7

Mean Heights, Weights, and Lean Body Weights (LBW) of Catchers, First Basemen, Second Basemen, Third Basemen and Shortstops

	Second Basemen (n=10)	Third Basemen (n=12)	Catchers (n=15)	Shortstops (n=10)	First Basemen (n=13)
Height (cm)	175.30	177.79	179.71	181.91	185.19

	Second Basemen (n=10)	Shortstops (n=10)	Third Basemen (n=12)	Catchers (n=15)	First Basemen (n=13)
Weight (kg)	70.96	77.47	78.02	80.73	84.42

	Second Basemen (n=10)	Shortstops (n=10)	Third Basemen (n=12)	Catchers (n=15)	First Basemen (n=13)
LBW (kg)	61.71	68.03	68.07	69.58	73.61

Note. Underscore represents no significant difference. Differences of 5.86 for height, 7.55 for weight and 6.08 for lean body weight (LBW) were required for significance for $p<.05$ utilizing Tukey's a posteriori test.

weight, the test revealed that catchers (M=80.73 kg) and first basemen (M=84.42 kg) were significantly heavier than second basemen (M=70.96 kg). The test for lean body weight revealed that second basemen (M=61.71 kg) were significantly lighter than catchers (M=69.58 kg), first basemen (M=73.61 kg), third basemen (M=68.07 kg) and shortstops (M=68.03 kg). There were no other significant differences revealed among these position subgroups.

As sample sizes were small for these subgroups, the power of the test must be taken into consideration when interpreting nonsignificant findings. The percent of variance attributed to the group for the nonsignificant variables are as follows: 15.3% for age, 0.00% for body density, 2.08% for body fat percent, 4.95% for body fat weight and 1.98% for sum of skinfolds.

Somatotype

The descriptive statistics for the dependent variables of height, weight, four skinfolds (subscapular, triceps, suprailiac and calf), biceps and calf girths, humerus and femur widths and the somatotype ratings of endomorphy, mesomorphy and ectomorphy are presented in Table 8 for all players. As the height and weight variables have already been discussed in previous tables, no further discussion of these is needed. As a group, the players had mean values of 12.46 mm for the subscapular skinfold (SD=3.76), 12.62 mm for the triceps skinfold (SD=4.26), 21.53 mm for the suprailiac skinfold (SD=7.12) and 7.67 mm for the calf skinfold (SD=2.90). For the biceps and calf girths the players had mean values of 33.77 cm (SD=1.91) and 38.13 cm (SD=2.11), respectively. The humerus and femur width mean values for the total group of players were 7.23 cm (SD=0.36) and 9.82 cm (SD=0.45), respectively. The mean values for the somatoype components of endomporphy, mesomorphy and ectomorphy were 4.62 (SD=1.21), 5.04 (SD=0.86) and 2.33 (SD=0.84), respectively.

TABLE 8

Physical Characteristics and Somatotypes of Selected NCAA Division II Baseball Players (n=132)

Variable	M	SD	Min.	Max.
Height (cm)	180.11	6.17	166.40	197.50
Weight (kg)	79.11	0.66	58.76	100.28
Skinfolds (mm)				
Subscapular	12.46	3.76	6.97	22.43
Triceps	12.62	4.26	6.23	25.07
Suprailiac	21.53	7.12	8.93	42.60
Calf	7.67	2.90	3.53	16.43
Girths (cm)				
Biceps	33.77	1.91	28.60	38.33
Calf	38.13	2.11	32.37	44.87
Widths (cm)				
Humerus	7.23	0.36	6.46	8.44
Femur	9.82	0.45	8.82	10.83
Endomorphy	4.62	1.21	2.59	7.66
Mesomorphy	5.04	0.86	2.88	7.24
Ectomorphy	2.33	0.84	0.53	4.67

Pitchers, Infielders and Outfielders

The results of the descriptive statistics are shown in Table 9 for the subgroups of pitchers, infielders and outfielders. Among the three subgroups of pitchers, infielders and outfielders, outfielders had the smallest mean value for each of the four skinfolds with mean values of 11.85 mm (SD=2.97) for the subscapular, 11.21 mm (SD=2.47) for the triceps, 19.69 mm (SD=5.14) for the suprailiac and 7.12 mm (SD=2.69) for the calf. Pitchers had the largest mean value for the subscapular, triceps and calf skinfolds with mean values of 12.69 mm (SD=4.02), 13.18 mm (SD=4.94) and 8.04 mm (SD=3.14), respectively, while infielders had the largest mean value for the suprailiac skinfold at 22.34 mm (SD=7.92).

The smallest mean value for biceps girth was that of the pitchers at 33.55 cm (SD=1.93) while the smallest calf girth was that of the infielders at 38.05 cm (SD=2.14). Outfielders had the largest mean values for both the biceps and calf girths with values of 34.09 cm (SD=1.58) and 38.32 cm (SD=1.88), respectively. Outfielders had the smallest mean value for both the humerus and femur widths with values of 7.15 cm (SD=0.34) and 9.74 cm (SD=0.44), respectively, while pitchers had the largest mean value for each width at 7.31 cm (SD=0.38) for the humerus and 9.86 cm (SD=0.40) for the calf.

For the somatotype ratings, outfielders displayed the smallest mean value for endomorphy and ectomorphy with values of 4.31 (SD=0.88) and 2.06 (SD=0.80), respectively, while pitchers had the smallest mean value for mesomorphy at 4.73 (SD=0.88) Infielders had the largest mean

TABLE 9

Physical Characteristics and Somatotypes of Pitchers, Infielders and Outfielders

	Pitchers (n=43)				Infielders (n=60)				Outfielders (n=29)			
Variable	M	SD	Min.	Max.	M	SD	Min.	Max.	M	SD	Min.	Max.
Height (cm)	183.48	6.34	170.50	197.50	180.14	6.11	166.40	191.40	178.69	4.67	169.90	186.80
Weight (kg)	80.11	7.83	65.89	100.28	78.81	7.88	58.76	92.55	78.24	6.39	66.38	90.18
Skinfolds (mm)												
Subscapular	12.69	4.02	7.80	22.07	12.58	3.92	6.97	22.43	11.85	2.97	7.47	21.17
Triceps	13.18	4.94	6.83	25.07	12.90	4.32	6.23	23.90	11.21	2.47	7.17	17.37
Suprailiac	21.63	7.01	8.93	37.80	22.34	7.92	10.83	42.60	19.69	5.14	10.03	31.00
Calf	8.04	3.14	3.53	16.43	7.68	2.82	3.63	16.03	7.12	2.69	4.53	16.17
Girths (cm)												
Biceps	33.55	1.93	30.97	37.80	33.77	2.05	28.60	38.33	34.09	1.58	30.33	36.93
Calf	38.13	2.25	32.57	44.87	38.05	2.14	32.37	42.57	38.32	1.88	34.13	41.53
Widths (cm)												
Humerus	7.31	0.38	6.54	8.44	7.22	0.36	6.46	7.88	7.15	0.34	6.54	7.97
Femur	9.86	0.40	9.09	10.82	9.84	0.49	8.84	10.83	9.74	0.44	8.82	10.80
Endomorphy	4.69	1.29	2.59	7.18	4.72	1.28	2.66	7.66	4.31	0.88	2.69	6.55
Mesomorphy	4.73	0.88	2.97	7.09	5.12	0.84	3.62	7.24	5.33	0.76	2.88	6.92
Ectomorphy	2.63	0.88	0.76	3.96	2.24	0.78	0.66	3.82	2.06	0.80	0.53	4.67

value for endomorphy at 4.72 (SD=1.28) while outfielders had the largest mean value for mesomorphy at 5.33 (SD=0.76) and pitchers had the largest mean value for ectomorphy at 2.63 (SD=0.88).

No analyses of variance were conducted for physical characteristics or individual somatotype components. However, as a standard somatotype rating, reported in the three components of endomorphy, mesomorphy and ectomorphy, the somatotypes were analyzed for these subgroups. Before this could be done, several computations first had to be executed. Each individual's three component rating had to be converted to X-Y coordinates in order to plot each rating on the Heath-Carter Somatochart (1980:5-36). Somatoplot dispersion distances had to be derived before sums of squares could be calculated in order to determine F-ratios. The formulas required were described in Chapter 3.

The somatoplots of each group are shown in Figure 1. The analysis of variance which was conducted revealed that a significant difference did exist between somatoplots $F(2,129),=3.63$, $p<.05$. A Tukey a posteriori test was then conducted with the results shown in Table 10. The difference between somatoplots was found to be between pitchers and outfielders, with pitchers displaying significantly more endomorphy and less mesomorphy than the outfielders. No other significant differences were revealed.

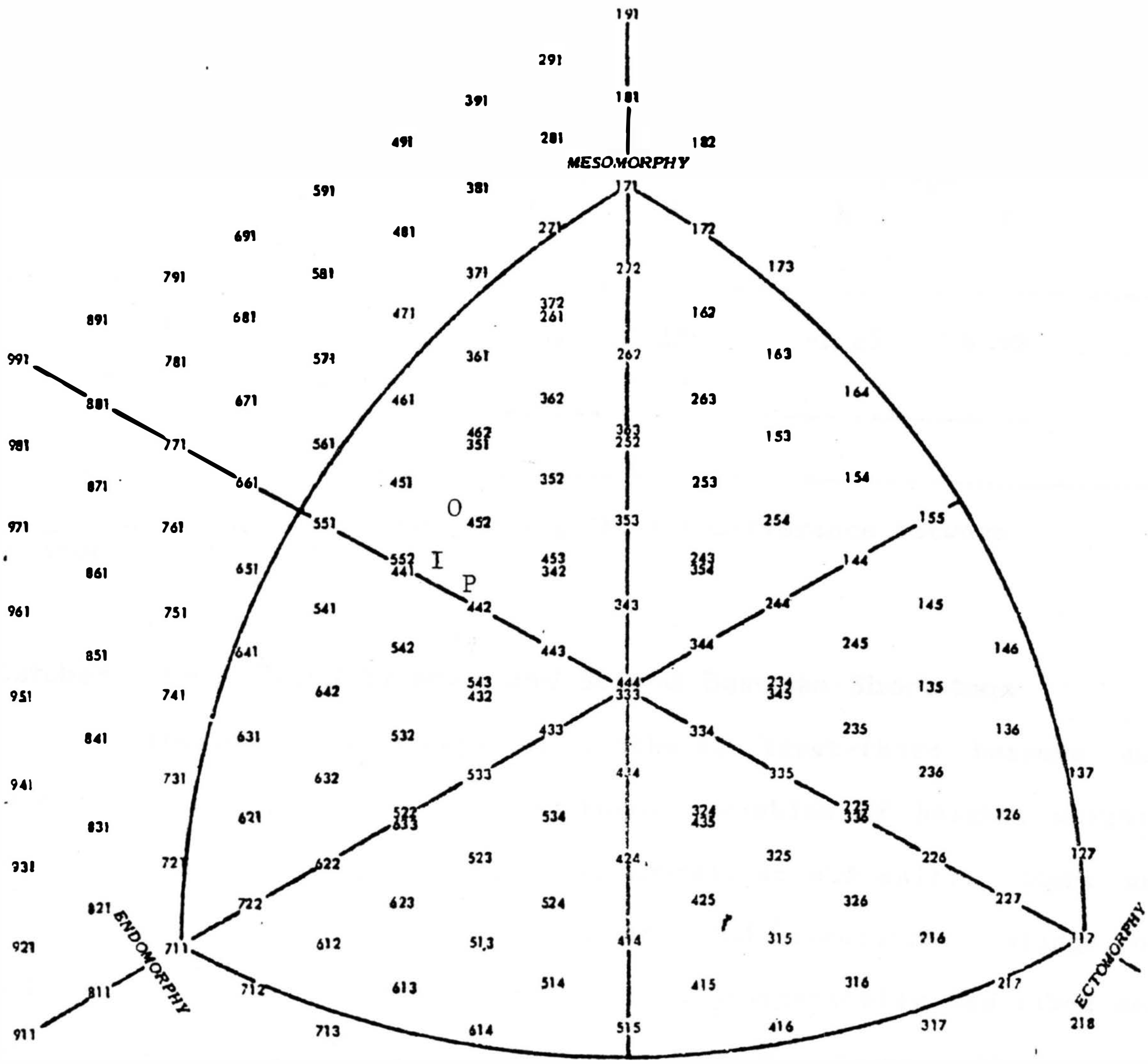

FIGURE 1

Somatoplots of Pitchers, Infielders and Outfielders

P=Pitchers I=Infielders O=Outfielders

TABLE 10

X, Y Coordinates of Mean Somatotypes of Pitchers, Infielders and Outfielders

Pitchers (n=43)		Infielders (n=60)		Outfielders (n=29)	
X	Y	X	Y	X	Y
-2.06	2.13	-2.47	3.28	-2.25	4.30

Note. Underscore represents no significant difference between somatoplots at $p<.05$.

Catchers, First-Third Basemen and Second Basemen-Shortstops

Among the subgroups of catchers, first-third basemen and second basemen-shortstops, the dependent variables of height, weight, four skinfolds (subscapular, triceps, suprailiac and calf), biceps and calf girths, humerus and femur widths and somatotype ratings of endomorphy, mesomorphy and ectomorphy were statistically described and are presented in Table 11. Among these groups, the second basemen-shortstops had the smallest mean value for each of the four skinfolds with means of 11.79 mm (SD=3.25) for the subscapular, 12.41 mm (SD=4.02) for the triceps, 20.58 mm (SD=6.59) for the suprailiac and 6.95 mm (SD=2.32) for the calf. Catchers had the largest mean values for the subscapular skinfold at 14.05 mm (SD=4.30), triceps skinfold at

TABLE 11

Physical Characteristics and Somatotypes of Catchers, First-Third Basemen and Second Basemen-Shortstops

Variable	Catchers (n=15)				First-Third Basemen (n=25)				Second Basemen-Shortstops (n=20)			
	M	SD	Min.	Max.	M	SD	Min.	Max.	M	SD	Min.	Max.
Height (cm)	179.71	5.27	169.80	186.10	181.64	5.87	168.50	190.80	178.61	6.81	166.40	191.40
Weight (kg)	80.73	6.63	67.11	90.99	81.35	7.64	66.21	92.55	74.21	7.30	58.76	87.00
Skinfolds (mm)												
Subscapular	14.05	4.30	8.13	22.23	12.33	4.09	6.97	19.97	11.79	3.25	7.97	22.43
Triceps	13.36	4.52	6.43	20.47	13.02	4.57	7.40	23.90	12.41	4.02	6.23	21.53
Suprailiac	23.44	6.59	13.10	38.03	23.10	9.53	10.83	41.80	20.58	6.59	11.40	42.60
Calf	7.84	2.90	4.37	13.80	8.16	3.11	4.23	16.03	6.95	2.32	3.63	12.60
Girths (cm)												
Biceps	34.13	2.05	31.70	38.30	34.32	1.97	30.27	38.33	32.82	1.90	28.60	37.10
Calf	38.68	2.36	34.03	42.27	38.41	2.01	32.60	42.57	37.12	1.89	32.37	39.40
Widths (cm)												
Humerus	7.17	0.36	6.46	7.67	7.37	0.33	6.68	7.88	7.07	0.32	6.47	7.52
Femur	9.95	0.51	9.10	10.83	10.02	0.43	9.14	10.82	9.53	0.41	8.84	10.20
Endomorphy	5.00	1.22	2.81	7.30	4.75	1.44	2.66	7.25	4.47	1.11	2.74	7.66
Mesomorphy	5.35	1.09	3.66	7.24	5.32	0.72	3.62	6.41	4.70	0.61	4.04	5.97
Ectomorphy	1.93	0.88	0.75	3.36	2.17	0.77	0.66	3.40	2.57	0.63	1.40	3.82

13.36 mm (SD=4.52) and suprailiac skinfold at 23.44 mm (SD=6.59) while the group of first-third basemen had the largest mean value for the calf skinfold at 8.16 mm (SD=3.11).

The second basemen-shortstop group also had the smallest mean values for the biceps and calf girths with means of 32.82 cm (SD=1.90) and 37.12 cm (SD=1.89), respectively. The group of first-third basemen had the largest biceps girth mean value with a mean of 34.32 cm (SD=1.97) while the catchers had the largest mean value for the calf girth at 38.68 cm (SD=2.36). The smallest mean values for the humerus and femur widths were again those of the second basemen-shortstops. These means were 7.07 cm (SD=0.32) and 9.53 cm (SD=0.41), respectively. The largest mean values for both widths were those of the first-third basemen group. These means were 7.37 cm (SD=0.33) and 10.02 cm (SD=0.43), respectively.

For the somatotype components,the subgroup of second basemen-shortstops had the smallest mean value for endomorphy and mesomorphy with means of 4.47 (SD=1.11) and 4.70 (SD=0.61), respectively, while catchers had the smallest mean value for ectomorphy at 1.93 (SD=0.88). Catchers had the largest mean value for both endomorphy and mesomorphy with means of 5.00 (SD=1.22) and 5.35 (SD=1.09), respectively, while the second basemen-shortstop group had the largest mean value for ectomorphy at 2.57 (SD=0.63). No analyses of variance were conducted for these subgroups.

Catchers, First, Second, and Third Basemen, and Shortstops

Among the subgroups of catchers, first basemen, second basemen, third basemen and shortstops, the dependent variables of height, weight, four skinfolds (subscapular, triceps, suprailiac and calf), biceps and calf girths, humerus and femur widths and the somatotype components endomorphy, mesomorphy and ectomorphy were statistically described. The results of these statistical descriptions are shown in Table 12.

Among these subgroups, the shortstops had the smallest mean values for the subscapular, suprailiac and calf skinfolds with means of 10.94 mm (SD=1.87), 19.57 mm (SD=4.27) and 6.94 mm (SD=2.22), respectively. First basemen had the smallest mean value for the triceps skinfold at 11.81 mm (SD=3.55). Catchers had the largest mean value for the subscapular skinfold at 14.05 mm (SD=4.30) while third basemen had the largest mean values for the triceps and calf skinfolds with means of 14.32 mm (SD=5.30) and 8.45 mm (SD=3.02), respectively, and first basemen had the largest mean value for the suprailiac skinfold at 23.56 mm (SD=9.10).

The second basemen had the smallest mean values for both the biceps and calf girths with means of 32.20 cm (SD=1.97) for the biceps and 36.94 cm (SD=2.30) for the calf. The largest mean values for both girths were those of the first basemen. These means were 34.64 cm (SD=2.01) for the biceps and 38.82 cm (SD=2.55) for the calf.

The second basemen had the smallest mean values for both the humerus and femur widths with means of 7.02 cm (SD=0.38) and 9.50 cm

TABLE 12

Physical Characteristics and Somatotypes of
Catchers, First, Second, and Third Basemen, and Shortstops

Variable	Catchers (n=15)				First Basemen (n=13)				Second Basemen (n=10)				Third Basemen (n=12)				Shortstops (n=10)			
	M	SD	Min.	Max.	M	SD	Min.	Max.	M	SD	Min.	Max.	M	SD	Min.	Max.	M	SD	Min.	Max.
Height (cm)	179.71	5.27	169.80	186.10	185.19	4.14	176.20	190.80	175.30	5.30	166.40	184.20	177.79	5.06	168.50	186.20	181.91	6.74	170.90	190.40
Weight (kg)	80.73	6.63	67.11	90.99	84.42	6.88	66.21	92.55	70.96	6.62	58.76	78.60	78.02	7.24	69.14	90.39	77.47	6.71	65.21	87.00
Skinfolds (mm)																				
Subscapular	14.05	4.30	8.13	22.23	12.20	3.64	8.03	18.90	12.64	4.15	8.77	22.43	12.48	4.70	6.97	19.97	10.94	1.87	7.97	13.57
Triceps	13.36	4.52	6.43	20.47	11.81	3.55	7.40	18.67	12.67	4.66	6.23	21.53	14.32	5.30	8.17	23.90	12.14	3.51	6.63	16.43
Suprailiac	23.44	6.59	13.10	38.03	23.56	9.10	10.83	41.80	21.59	8.43	11.40	42.60	22.60	10.35	11.03	40.37	19.57	4.27	12.50	26.70
Calf	7.84	2.90	4.37	13.80	7.89	3.28	5.10	15.40	6.96	2.53	3.63	12.60	8.45	3.02	4.23	16.03	6.94	2.22	4.07	9.67
Girths (cm)																				
Biceps	34.13	2.05	31.70	38.30	34.64	2.01	30.93	38.33	32.20	1.97	28.60	34.80	33.97	1.93	30.27	37.53	33.44	1.69	30.93	37.10
Calf	38.68	2.36	34.03	42.27	38.82	2.55	32.60	42.57	36.94	2.30	32.37	39.40	37.96	1.16	35.33	39.43	37.30	1.49	35.50	39.33
Widths (cm)																				
Humerus	7.17	0.36	6.46	7.67	7.43	0.28	6.92	7.88	7.02	0.38	6.47	7.52	7.31	0.37	6.68	7.83	7.13	0.26	6.66	7.46
Femur	9.95	0.51	9.10	10.83	10.11	0.44	9.14	10.79	9.50	0.37	8.88	10.02	9.93	0.42	9.47	10.82	9.55	0.46	8.84	10.20
Endomorphy	5.00	1.22	2.81	7.30	4.71	1.26	2.85	6.74	4.63	1.33	2.96	7.66	4.80	1.68	2.66	7.25	4.31	0.86	2.74	5.39
Mesomorphy	5.35	1.09	3.66	7.24	5.10	0.79	3.62	6.40	4.92	0.73	4.09	5.97	5.55	0.60	4.62	6.41	4.48	0.38	4.04	5.21
Ectomorphy	1.93	0.88	0.75	3.36	2.37	0.68	1.04	3.34	2.46	0.67	1.40	3.39	1.96	0.83	0.66	3.40	2.68	0.59	1.96	3.82

(SD=0.37), respectively. First basemen had the largest mean values for both widths with means of 7.43 cm (SD=0.28) and 10.11 cm (SD=0.44), respectively.

For the somatotype components of endomorphy, mesomorphy and ectomorphy, shortstops had the smallest mean values for endomorphy and mesomorphy with means of 4.31 (SD=0.86) and 4.48 (SD=0.38), respectively. Catchers had the smallest mean value for ectomorphy at 1.93 (SD=0.88). The largest mean value for endomorphy was that of the catchers at 5.00 (SD=1.22), while third basemen had the largest mean value for mesomorphy at 5.55 (SD=0.60) and shortstops had the largest mean value for ectomorphy at 2.68 (SD=0.59).

The one-way analysis of variance that was conducted analyzed the standard three component somatotype rating of endomorphy, mesomorphy and ectomorphy. The plots of somatotype ratings are presented in Figure 2. The results of the one-way analysis of variance revealed no significant differences among somatoplots of these subgroups; $F(4,55)=1.47$, $p>.05$. However, due to small and unequal sample sizes and unequal sample variances, the statistical test was conservative. In other words, power of the statistical test was diminished which may be the reason for the non-significant finding. The variance attributed to groups was 9.64%.

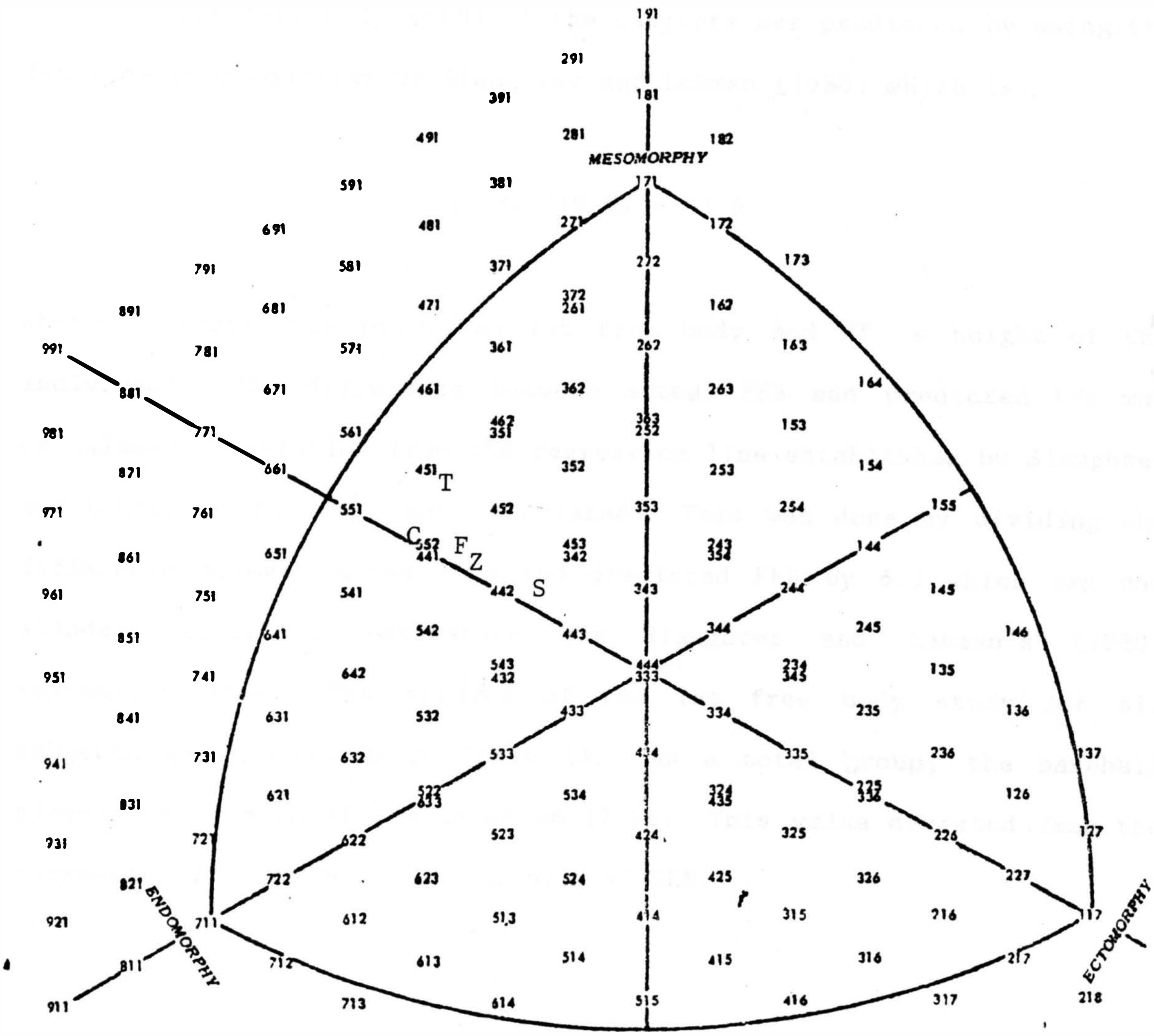

FIGURE 2

Somatoplots of Catchers, First, Second, and Third Basemen, and Shortstops

C=Catchers F=First Basemen Z=Second Basemen

T=Third Basemen S=Shortstops

Fat Free Body Regression Line Analysis

Fat free body (FFB) of the subjects was predicted by using the fat free body equation of Slaughter and Lohman (1980) which is:

$$Y' = .719\ HT - 63.9$$

where Y' represents predicted fat free body and HT is height of the individual. The difference between actual FFB and predicted FFB was calculated. Deviation from the regression line established by Slaughter and Lohman (1980) was then calculated. This was done by dividing the difference between actual FFB and predicted FFB by 6.3 which was one standard error of estimation for Slaughter and Lohman's (1980) regression line. The results of the fat free body study for all subjects are presented in Table 13. As a total group, the baseball players had a mean FFB value of 66.17 kg. This value deviated from the regression line of non-athletes by 0.47 SEE.

TABLE 13

Deviations from the Non-Athletic Regression Line of FFB in NCAA Division II Baseball Players

Present Study	n	M Ht (cm)	M FFB 9kg)	No. of SEE's
All Players	132	180.91	66.17	0.47
Pitchers	43	183.43	68.02	0.31
Infielders	60	180.14	65.62	0.47
Catchers	15	179.71	65.31	0.68
First Basemen	13	185.19	69.25	0.69
Second Basemen	10	175.30	62.14	0.07
Third Basemen	12	177.79	63.93	0.66
Shortstops	10	181.91	66.89	0.18
Outfielders	29	178.69	64.58	0.70
Sinning, 1978	17	182.20	72.00	0.80

Note. Sinning's data was analyzed by Slaughter and Lohman (1980).

Pitchers, Infielders and Outfielders

The results of the fat free body calculation and deviations from the regression line among the subgroups of pitchers, infielders and outfielders are presented in Table 13. The pitchers were found to have the largest mean value for fat free body with a mean of 68.02 kg while outfielders had the smallest mean value at 64.58 kg. The outfielders deviated most from the regression line with the mean number of SEE being 0.70 while pitchers were closest to the non-athletes regression line with a mean value of 0.31.

Catchers, First, Second, and Third Basemen, and Shortstops

The results of the fat free body determinations and deviation calculations among the subgroups of catchers, first basemen, second basemen, third basemen and shortstops are presented in Table 13. For these subgroups, first basemen were found to have the largest amount of fat free body with a mean value of 69.25 kg. They also deviated the most from the regression line as they had the largest mean number of SEE, 0.69. Second basemen had the least amount of fat free body with a mean value of 62.14 kg. They also had the smallest mean number of SEE from the regression line with a mean of 0.07.

Discussion of the Results

Body Composition

The mean body fat value for all the baseball players players of this study (n=132) was found to be 12.49%. This appears to be very similar to the finding of Coleman (1981) when he found major league baseball players to have a mean body fat value of 12.6%. Therefore, the results of this study appear to support the finding of Coleman (1981) and that there is little difference between NCAA Division II baseball players and major league baseball players.

For the subgroups of pitchers, infielders and outfielders, this study revealed that pitchers (n=43) had a mean body fat value of 12.5%, infielders had a mean body fat value of 12.86% and outfielders had a mean body fat value of 11.72%. Coleman (1981) found major league pitchers (n=56) to have a mean body fat value of 14.7%, infielders (n=50) to have a mean body fat value of 12.0% and outfielders (n=31) to have a mean body fat value of 9.9%. The body fat percents for the infielders and outfielders of the present study and Coleman's study appear to be quite similar as well. Although there is more variation between the infielders and outfielders studied by Coleman (1981) and the infielders and outfielders of the present study, their mean body fat values are within 2% of each other. For both subgroupings the major league players of Coleman's study had less body fat percent than did the NCAA Division II players. This may be due to the different levels of performance at which the players of the present study and Coleman's study play, differences in emphasis of year round conditioning programs and possibly a difference in physical demands which are required of them. Pitchers of this study had less body fat percent than did the pitchers studied by Coleman (1981). This may have been due to the fact that the pitchers of this study, in many cases, played other positions as well as pitch, and the pitchers of Coleman's study played no other position.

For the subgroups of catchers (n=15), first basemen (n=13), second basemen (n=10), third basemen (n=12) and shortstops (n=10) the mean values for body fat were 13.67%, 12.67%, 12.85%, 12.67% and 12.11%, respectively. Coleman (1981) found the catchers (n=12) of his study to have a mean body fat value of 13.5%, first basemen (n=11) had a mean body fat value of 10.9%, second basemen (n=13) had a mean body fat value of 11.5%, third basemen (n=8) had a mean body fat value of 12.9% and shortstops (n=12) had a mean body fat value of 9.2%. The results of the two studies appear to show that the catchers, first basemen, second basemen and third basemen are quite similar in body fat percent as variation between respective groups is less than 2%. The only position where there appears to be differences in body fat percent is shortstop. Shortstops of this study possessed almost 3% more body fat percent than did the major league shortstops of Coleman's (1981) study. This may be due to several things, such as artificial surfaces, which may require more quickness and less body fat to meet the demands of a faster playing surface, more games played, and possibly more specific and extensive demands of the position played at the major league level of performance.

There appears to be few differences in body fat percent among baseball players at the NCAA Division II level of performance when studied by position. There would appear to be a difference in body fat percent between catchers and outfielders, and catchers and second basemen as catchers appear to possess more body fat percent. This possibly is due to the demands of the respective positions. However, all other positions appear to be quite similar as there is less than 2% difference in body fat percent between any two positions. The reasons for the similarities may be several, such as position demands at the NCAA Division II level of performance are not specialized to any great degree, players at this level may be capable of playing several positions and play where they are most needed, and the sample size of the study may not have been large enough to be representative of the various groups.

Height, Weight, Fat Weight, and Lean Body Weight

There appears to be more differences present in height, weight fat weight and lean body weight of baseball players by subgroup. Pitchers were found to be taller than both infielders and outfielders and appear to be taller and usually heavier than most other subgroups, excluding first basemen, although catchers appear to weigh slightly more than pitchers. First basemen were found to be taller than second and third basemen and appear to be taller than the other subgroups, the exception being that pitchers appear to be similar in height. Shortstops were also found to be taller than second basemen. First basemen and catchers were heavier than second basemen and second basemen possessed less lean lean body weight than did the subgroups of catchers, first basemen, second basemen, and shortstops. Second basemen appear to be shorter and weigh less than all other subgroups while first basemen appear to have more lean body weight and catchers appear to possess more body fat weight than all other subgroups. Differences in the physical characteristics of height and weight may be due to differing physical demands of various positions. Also, sample size in some instances may not have been large enough to get a good description of players at that position, and unequal sample sizes could have created a problem with power of the statistical tests.

When comparisons are made between the present study and the study conducted by Coleman (1981), it is revealed that as a group the baseball players studied by Coleman appear to be taller, weigh more, have slightly more body fat weight and have more lean body weight. When subgroups are compared, it is revealed that the pitchers, infielders, and outfielders of Coleman's study appear to be taller, weigh more, and possess more lean body weight than those of the present study. However, only the pitchers studied by Coleman appear to have more body fat weight than those of the present study as the infielders and outfielders of the present study appear to have more body fat weight than the infielders and outfielders studied by Coleman.

When the subgroups are each infield position, the catchers of Coleman's (1981) study appear to be taller, weigh more, have more body fat weight, and possess more lean body weight. The first basemen of the two studies appear to be similar in height, however, those studied by Coleman appear to be heavier and possess more lean body weight while the first basemen of the present study appear to have more body fat weight. The second and third basemen of Coleman's study appear to be taller, weigh more, and possess more lean body weight while the second and third basemen of the present study appear to possess more body fat weight. The shortstops of the two studies appear to be similar in height, however, those studied by Coleman appear to weigh more and possess more lean body weight while the shortstops of the present study appear to have more body fat weight.

Somatotypes

The mean somatotype rating for the baseball players (n=132) of this study for the components of endomorphy, mesomorphy and ectomorphy were 4.62, 5.04 and 2.33, respectively. Pitchers were found to possess a different mean somatoplot than outfielders as they displayed more endomorphy and less ectomorphy than the outfielders. Shortstops appear to have a different mean somatoplot than the other subgroups as they appear to possess more ectomorphy and less mesomorphy. Catchers appear to display a different mean somatoplot than other subgroups in that they appear to possess more mesomorphy. Third basemen appear to possess a different mean somatoplot than do shortstops as third basemen appear to be more endomorphic and mesomorphic.

The study conducted by Imlay (1966) revealed mean values for the three components of endomorphy, mesomorphy and ectomorphy to be 4.00, 5.00 and 2.50, respectively. When converted from the Parnell technique of somatotyping, which uses phenotyping to the Heath-Carter method of somatotyping these mean values became 3.80 for endomorphy, 5.00 for mesomorphy, and 2.70 for ectomorphy. A summary of comparisons between Imlay's study and the present study can be found in Table 14. As a group, the players of the present study appear to display more endomorphy and slightly less ectomorphy than those studied by Imlay (1966). However, the mesomorphy component for both groups of players appears to be quite similar. The cause of these differences may be that the two groups studied practice under differing conditions because the players studied by Imlay probably practiced outdoors much more than the players of the present study due to geographic locations. Also, changes in the types of physiques required to play baseball may have occurred during the time period between the two studies.

TABLE 14

The Somatotype Ratings of Imlay (1966) and the Present Study

Position	Imlay's Study	Present Study
All Players	3.80-5.00-2.70*	4.62-5.04-2.33
Pitchers	3.73-4.81-2.63**	4.69-4.73-2.63
Catchers	4.13-5.15-1.78**	5.00-5.35-1.93
First-Third Basemen	3.73-5.24-2.16**	4.75-5.32-2.17
Second Basemen-Shortstops	3.08-4.79-2.85**	4.47-4.70-2.57
Outfielders	3.25-5.26-2.55**	4.31-5.33-2.06

* Carter's rerating using the Heath-Carter method is shown for the total group of baseball players studied by Imlay.
** Imlay's phenotype ratings have been converted to somatotype ratings by subtracting 1/4 point from the first and third components as suggested by Heath and Carter (1966). These adjustments which have been made, however, are only estimates as they were not made on the raw data.

Using the subgroups of pitchers, catchers, first-third basemen, second basemen-shortstops and outfielders this study revealed mean values for the somatotype ratings of endomorphy, mesomorphy and ectomorphy of 4.69-4.73-2.63, 5.00-5.35-1.93, 4.75-5.32-2.17, 4.47-4.70-2.57 and 4.31-5.33-2.06, respectively. The same subgroupings were used by Imlay (1966) who reported the findings of his subgroups to be 3.98-4.81-2.88, 4.38-5.15-2.03, 3.98-5.24-2.41, 3.33-4.79-3.10 and 3.50-5.26-2.80, respectively. When these phenotype ratings are converted to Heath-Carter somatotype ratings by subtracting 1/4 point from the first and third component (Heath & Carter, 1966), the ratings are estimated to be 3.73-4.81-2.63 for pitchers, 4.13-5.15-1.78 for catchers, 3.73-5.24-2.16 for first-third basemen, 3.08-4.79-2.85 for second basemen-shortstops, and 3.25-5.26-2.55 for outfielders. A somatotype rating comparison of the present study and the study conducted by Imlay (1966) for these subgroups is presented in Table 14. Pitchers, catchers and first-third basemen of the present study appear to be similar to those studied by Imlay (1966) in the components of mesomorphy and ectomorphy. Differences do seem to exist in the endomorphy component as the pitchers, catchers, first-third basemen, second basemen-shortstops, and outfielders of the present study displayed more than did those studied by Imlay (1966). The subgroups of second basemen-shortstops and outfielders of the two studies appear to be similar in amount of mesomorphy, however, the players of the present study appear to display less ectomorphy than the players studied by Imlay. Again differences between the two studies may be due to differing practice schedules and practice content due to geographic locations, small numbers of players in each group, and changes in the game over the past few years which may have caused a change in the type of physique the various positions demand. Also, two different methods of determining somatotypes were used which may have caused differences to be found between the two studies.

Fat Free Body Regression Line Analysis

The baseball players (n=132) of this study were found to be slightly above the regression line of non-athletes with a mean number of SEE for FFB at 0.47 and possessed 66.17 kg of FFB. This reveals that baseball players of the present study possessed more musculo-skeletal size and more fat free body than did the non-athletic population from which the regression line was established. The significance of the FFB regression line analysis is that it provides a method whereby athletic populations can be compared with each other and against a non-athletic population in terms of musculo-skeletal mass. Slaughter and Lohman (1980) feel that more direct evidence is provided by this method than by somatotyping, which has indicated that athletic populations differ greatly. Subgroup comparisons to the regression line of non-athletes indicated that pitchers (n=43) had a mean number of 0.31 SEE, infielders (n=60) had a mean number of 0.47 SEE, and outfielders (n=29) had a mean number of 0.70 SEE. Catchers (n=15) had a mean number of 0.68 SEE while first basemen and third basemen were similar with mean number of SEEs of 0.69 and 0.66, respectively. Second basemen and shortstops deviated little from the regression line of non-athletes as they had mean number of SEEs of 0.07 and 0.18, respectively.

Differences between the various subgroups appears to be present as pitchers, infielders and outfielders seem to differ from each other. Second basemen and shortstops appear to be similar to the non-athletic population which was studied by Slaughter and Lohman (1980). The subgroups of outfielders, catchers, first basemen and third basemen appear to be similar in the number of SEE they are from the regression line of non-athletes. Differences which are present may be due to differing physical demands which are required by the various positions.

Slaughter and Lohman (1980) have taken data collected on baseball players (n=17) by Sinning and have computed FFB and SEE mean values. These values are presented in Table 13. The mean values which they have derived are 72.00kg for FFB and 0.80 for SEE. These differ from the results of the present study and may be due to geographic location of the two different groups or in the fact that not enough subjects were studied to get a precise description of how far baseball players deviate from the regression line of non-athletes.

Summary of Discussion

The analyses of variance results tend to support some of the comments which sportscasters have made such as pitchers are taller than players of other positions, first basemen are taller than players of other positions and shortstops are taller than second basemen. Second basemen appear to be the group of players that differ from the rest of the positions as they seem to have a distinct profile at least in height, weight and lean body weight. This may be due to the demands of the position. Differences may be misleading due to the number of players in each subgroup being small and therefore causing problems with statistical power. Pitchers and outfielders showing significant differences in somatoplots might again be due to differing physical requirements of the respective position with pitchers possibly needing the extra bulk to be successful and outfielders needing to be more ectomorphic to maintain as much speed as possible.

The results of the data analysis indicate that there were recognizable profiles for baseball players by subgroups. Second basemen were shorter, weighed less and possessed less lean body weight than other subgroups. Pitchers and first basemen were taller and usually heavier than other subgroups which might be explained somewhat by the fact that many of the pitchers played first base as their second position and first basemen pitched as a second position. However, to make the claim that distinct profiles exist would be misleading as physiques of various types were found at each position.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to determine the body composition and body type of NCAA Division II baseball players. In addition, physical characteristics and body composition of subgroups were determined to see if the subgroups had distinct profiles.

Hypotheses

The following hypotheses were investigated:

1. There is no significant difference among the subgroups of pitchers, infielders and outfielders for each of the following skinfolds; sum of skinfolds, body density, body fat percent, body fat weight, lean body weight and somatotype.

2. There is no significant difference among the subgroups of catchers, first basemen, second basemen, third basemen and shortstops for the following dependent variables: age, height, weight, sum of skinfolds, body density, body fat percent, body fat weight, lean body weight and somatotype.

Methodology

One hundred thirty-two baseball players of seven NCAA Division II baseball teams participated in the study. All subjects were members of their respective 1983 North Central Conference baseball team's traveling squad.

The subjects revealed their age and were measured for determination of body composition and somatotype during a four week period of the 1983 spring semester. Determination of body composition was done by utilizing the body density formula established by Jackson and Pollock (1978) and the percent body fat formula established by Siri (McArdle, Katch, & Katch, 1981). These formulas were implemented after skinfolds were measured using a Harpenden Skinfold Caliper. Somatotype was determined by utilizing the Heath-Carter Anthropometric Method (Carter, 1980). This was utilized after skinfolds were measured using a Harpenden Skinfold Caliper, bone widths were measured using a Harpenden Anthropometer, muscle girths were measured with a Gulick Tape, weight was measured using standard weight scales, and height was measured using a stadiometer.

Descriptive statistics were applied to the data for the purpose of describing physical characteristics of baseball players. Means, standard deviations, and maximum and minimum values for age, height, weight, seven skinfolds (chest, abdomen, thigh, triceps, subscapular, supraliliac, and calf), humerus and femur widths, biceps and calf girths, body density, body fat percent, body fat weight, lean body weight, sum of skinfolds, and somatotype ratings were computed for the group and each positional subgroup.

For the subgroups of pitchers, infielders and outfielders one-way analyses of variance were conducted to analyze the variables of age, height, chest, abdomen and thigh skinfolds, sum of skinfolds, body density, body fat percent, body fat weight, weight, lean body weight and somatoplot dispersion distance from the mean. For the subgroups of catchers, first basemen, second basemen, third basemen and shortstops one-way analyses of variance tests were conducted to analyze the variables of age, height, sum of skinfolds, body density, body fat percent, body fat weight, weight, lean body weight, and somatoplot dispersion distance from the mean. Tukey's test was conducted to test a posteriori comparisons.

The total group of baseball players and each of the subgroups of baseball players were compared to non-athletes by calculating how many SEE they deviated from the regression line established by Slaughter and Lohman (1980).

Findings

Analyses of the data resulted in the following findings:

1. Among the subgroups of pitchers, infielders and outfielders, pitchers were significantly taller than the infielders and outfielders. The pitchers' mean somatoplot also differed significantly from the mean somatoplot of outfielders as pitchers displayed more endomorphy and less mesomorphy than did the outfielders. No other significant differences were found among these subgroups.

2. For the subgroups of catchers, first basemen, second basemen, third basemen and shortstops significant differences were found for the variables height, weight and lean body weight. First basemen, third basemen and shortstops were found to be significantly taller than second basemen. For weight, second basemen were found to be significantly lighter than first basemen and catchers, and second basemen were found to possess significantly less lean body weight than each of the other groups. No other significant differences were found among these subgroups.

3. The baseball players of this study were found to be slightly above the regression line of fat free body of non-athletes. Among the subgroups of pitchers, infielders and outfielders, pitchers were closest to the regression line of fat free body of non-athletes and outfielders had the largest deviation from the regression line. Among the subgroups of catchers, first basemen, second basemen, third basemen and shortstops, second basemen were closest to the regression line of fat free body of non-athletes and first basemen had the greatest deviation from the regression line.

Conclusions

On the basis of the results the following conclusions have been made:

1. Pitchers and first basemen have distinct profiles in that they are taller and weigh more than players of other positions. The fact that these two groups are similar shows that players of these

positions may be able to interchange roles. This seemed to be the case in the North Central Conference where several of the pitchers also played first base and vice versa.

2. Second basemen have distinct profiles in height, weight and lean body weight as they are shorter, weigh less and possess less lean body weight than each of the other subgroups.

3. No distinct differences exist for body fat percent among the various subgroups. This is possibly due to the fact that specialization of position at this level of performance is not present to the extent found in the major leagues, but rather players are capable of and do play various positions.

4. As a group, NCAA Division II baseball players have similar profiles in body composition when compared to major league baseball players.

Implications

There is no attempt made to imply that these measurements can decide the issue of what position a baseball player should play, however, baseball coaches may find determination of physical characteristics, body composition and body type to be beneficial in aiding in the decision of what position a player should play.

Recommendations

The following recomendations have been made for further investigation:

1. There is a need to investigate baseball players physical characteristics, body composition and somatotype at various levels of performance, from high school to professional baseball players, within the same study so comparisons could be made to determine if differences in these variables exist at various levels of performance.

2. Since this study was limited by the number of subjects in each subgroup and limited by the fact that subgroup sizes were unequal, a comparison of subgroups of larger and equal sample size needs to be conducted.

3. This study investigated physical characteristics, body composition and somatotypes of baseball players. It would be interesting to investigate the fitness level of baseball players by studying cardio-respiratory endurance and anaerobic power to obtain a more complete profile of baseball players.

REFERENCES

Behnke, A.R., & Royce J. (1966). Body size, shape and composition of several types of athletes. The Journal of Sports Medicine and Physical Fitness, 6, 75-88.

Behnke, A.R., & Wimore, J.H. (1974). Evaluation and regulation of body build and composition. Englewood Cliffs, N. J.: Prentice-Hall, Inc.

Brozek, J., Grande, F., Anderson, J.T. & Keys, A. (1963). Densitometric analysis of body composition: revision of some quantitative assumptions. Annals of New York Academic Science, 110, 113-140.

Burke, E.J., Winslow, E., & Strube, W.V. (1980). Measures of Body composition and performance in major college football players. Journal of Sports Medicine and Physical Fitness, 20, 173-180.

Carter, J.E.L. (1968). Somatotypes of college football players. Research Quarterly, 39, 476-481.

Carter, J.E.L. (1982, 27 October). Telephone interview.

Carter, J.E.L. (1980). The Heath-Carter somatotype method. San Diego, California: SDSU Syllabus Service.

Carter, J.E.L. (1970). The somatotypes of athletes - a review. Human Biology, 42, 533-569.

Clarke, D.H., Wrenn, J.P., & Vaccaro, P. (1979). Muscular performance and body size characteristics of elite collegiate basketball players. American Corrective Therapy Journal, 33, 178-183.

Coleman A.E. (1982). Physiological characteristics of major league baseball players. The Physician and Sportsmedicine, 10, 51-57.

Coleman, A.E. (1981). Skinfold estimates of body fat in major league baseball players. The Physician and Sportsmedicine, 9, 77-82.

Coleman A.E. (1982, 18 November). Telephone interview.

Cureton, T.K. (1951). Physical fitness of champion athletes. Urbana, Illinois: University of Illinois Press.

Durnin, J.V.G.A. & Womersley, J. (1974). Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. British Journal of Nutrition, 32, 77-97.

Forsyth, H.L. (1970). The estimation of lean body weight in male athletes. Ph. D. Dissertation, Springfield College.

Fox, E.L., & Mathews, D.K. (1981). The physiological basis of physical education and athletics. Philadelphia: Sauders College Publishing.

Golding, L.A. (1966). Physical fitness of major league baseball players. Reprint. The Journal of the Arizona Association for Health, Physical Education and Recreation, 10.

Haronian, F., & Sugerman, A.A. (1965). A comparison of sheldon's and parnell's methods for quantifying morphological differences. American Journal of Physical Anthropology, 23, 135-142.

Heath, B.H., & Carter, J.E.L. (1966). A comparison of somatotype methods. American Journal of Physical Anthropology, 24, 87-100.

Imlay, R.C. (1966). The physiques of college baseball players in san diego, california. Master's thesis, San Diego State College, San Diego.

Jackson, A.S., & Pollock, M.L. (1978). Generalized equations for predicting body density of men. British Journal of Nutrition, 40, 497-504.

Jackson, A.S., Pollock, M.L., & Ward A. (1980). Generalized equations for predicting body density of women. Medicine and Science in Sports and Exercise, 12, 175-182.

Katch, F.I., & McArdle, W.D. (1977). Nutrition, weight control, and exercise. Boston: Houghton Mifflin Company.

Keys, A., & Brozek J. (1953). Body fat in adult man. Physiological Reviews, 33, 245-325.

Kollias, J., Buskirk, E.R., Howley, E.T., & Loomis, J.L. (1972). Cardio-respiratory and body composition measurements of a selected group of high school football players. Research Quarterly, 43, 472-478.

Lohman, T.G. (1981). Skinfolds and body density and their relation to body fatness: a review. Human Biology, 53, 181-225.

Lohman, T.G., & Pollock M.L. (1981). Which caliper? how much training? Journal of Physical Education and Recreation, 52, 27-29.

McArdle, W.D., Katch, F.I., & Katch, V.L. (1981). Exercise physiology, energy, nutrition, and human performance. Philadelphia: Lea and Febiger.

Nie, N.H., Hull, C.H., Jenkins, J.G., Steinbrenner, K., & Bent, D.H. (1975). Statistical package for the social sciences (2nd ed.). New York: McGraw-Hill Book Company.

Novak, L.P., Hyatt, R.E., & Alexander, J.F. (1968). Body composition and physiologic function of athletes. The Journal of the American Medical Association, 205, 764-770.

Parr, R.B., Wilmore, J.H., Hoover, R., Bechman D., & Kerlan, R.K. (1978). Professional basketball players: athletic profiles. The Physician and Sports Medicine, 6, 77-84.

Parnell, R.W. (1958). Behaviour and physique. London: Edward Arnold Ltd.

Pascale, L.R., Grossman, M.I., Sloane, H.S. & Frankel, T. (1956). Correlations between thicknesses of skinfolds and body density in 88 soldiers. Human Biology, 28, 165-176.

Rathbun, E.N., & Pace, N. (1945). Studies on body composition: I. the determination of the total body fat by means of the body specific gravity. The Journal of Biological Chemestry, 158, 667-676.

Sheldon, W., Dupertuis, C.W., & McDermott, E. (1970). Atlas of men. Darien, Conn.: Hafner Publishing Company.

Sinning, W.E. (1975). Experiments and demonstrations in exercise physiology. Philadelphia: W.B. Sauders Company.

Slaughter, M.H., & Lohman, T.G. (1980). An objective method for measurement of musle-skeletal size to characterize body physique with application to the athletic population. Medicine and Science in Sports and Exercise, 12, 170-174.

Slaughter, M.H., & Lohman, T.G. (1976). Relationship of body composition to somatotype. American Journal of Physical Anthropology, 44, 237-244.

Slaughter, M.H., Lohman, T.G., & Boileau, R.A. (1977). Relationship of heath and carter's second component to lean body mass and height in college women. Research Quarterly, 48, 759-768.

Sloan, A.W. (1967). Estimation of body fat in young men. Journal of Applied Physiology, 23, 311-315.

Tanner, J.M. (1964). The physique of the olympic athlete. London: George Allen and Unwin Ltd.

Wickkiser, J.D., & Kelly, J.M. (1975). The body composition of a college football team. Medicine and Science in Sports, 7, 199-202.

Willgoose, C.E. (1961). Evaluation in health education and physical education. New York: McGraw-Hill Book Company.

Wilmore, J.H. (1982, 16 October). Assessment of body composition for estimating optimal body weight. Speech delivered at Third National YMCA Consulatation on Health Enhancement, Chicago.

Wilmore, J.H. (1970). Validation of the first and second components of the heath-carter modified somatotype method. American Journal of Physical Anthropology, 32, 369-372.

Wilmore, J.H., & Behnke, A.R. (1969). An anthropometric estimation of body density and lean body weight in young men. Journal of Applied Physiology, 27, 25-31.

Wilmore, J.H., & Behnke, A.R. (1968). Predictability of lean body weight through anthropometric assessment in college men. Journal of Applied Physiology, 25, 349-355.

Wilmore, J.H., & Haskell, W.L. (1972). Body composition and endurance capacity of professional football players. Journal of Applied Physiology, 33, 564-567.

Wilmore, J.H., Parr, R.B., Haskell, W.L., Costill, D.L., Milburn, L.J., and Kerlan, R.K. (1976). Football pros'-strengths and weakness-charted. The Physician and Sportsmedicine, 4, 45-54.

Appendix A

NORTH CENTRAL CONFERENCE BASEBALL TEAMS

North Division

Mankato State University, Mankato, Minnesota*

North Dakota State University, Fargo, North Dakota*

St. Cloud State University, St. Cloud, Minnesota

University of North Dakota, Grand Forks, North Dakota*

South Division

Augustana College, Sioux Falls, South Dakota*

Morningside College, Sioux City, Iowa*

South Dakota State University, Brookings, South Dakota*

University of Nebraska-Omaha, Omaha, Nebraska

University of South Dakota, Vermillion, South Dakota*

* indicates the teams who participated in the study.

Appendix B

INFORMED CONSENT FORM

I understand that the purpose of this study is to describe physical characteristics of collegiate baseball players. The physical characteristics will consist of body composition and somatotype which require the measurement of various skinfolds, anthropometric widths and girths, as well as, the measurement of height and weight. The subjects will also reveal their age to the nearest month. The investigation will require approximately 30 minutes per subject.

I acknowledge that I have been informed of the measurement procedures and that the possible risk involved is minimal. I also confirm that my participation, as a subject, is entirely voluntary. No coercion, of any kind, has been used to obtain my cooperation.

I acknowledge that I have the right to ask questions of the researcher and that I may be informed of the results upon request. I understand that I may withdraw my consent and terminate my participation at any time during the investigation. I also understand that all data collected will remain confidential.

I wish to participate as a subject in the research study conducted by Ronnie Carda.

Signature of volunteer ___________________________

Date _________________

Appendix C

HEATH-CARTER SOMATOCHART

HEATH-CARTER SOMATOTYPE RATING FORM

NAME .... AGE .... SEX: M F NO: ....

OCCUPATION .... ETHNIC GROUP .... DATE ....

PROJECT: .... MEASURED BY: ....

Skinfolds mm

Triceps =

Subscapular =

Supraliac =

TOTAL SKINFOLDS = [ ]

Calf =

TOTAL SKINFOLDS (mm)

Upper Limit	10.9	14.9	18.9	22.9	26.9	31.2	35.8	40.7	46.2	52.2	58.7	65.7	73.2	81.2	89.7	98.9	108.9	119.7	131.2	143.7	157.2	171.9	187.9	204.0
Mid-point	9.0	13.0	17.0	21.0	25.0	29.0	33.5	38.0	43.5	49.0	55.5	62.0	69.5	77.0	85.5	94.0	104.0	114.0	125.5	137.0	150.5	164.0	180.0	196.0
Lower Limit	7.0	11.0	15.0	19.0	23.0	27.0	31.3	35.9	40.8	46.3	52.3	58.8	65.8	73.3	81.3	89.8	99.0	109.0	119.0	131.3	143.0	157.3	172.0	188.0
FIRST COMPONENT	½	1	1½	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	10½	11	11½	12

Height cm [ ]

Humerus width cm [ ]

Femur width cm [ ]

Biceps girth [ ] -T* [ ]

Calf girth [ ] -C* [ ]

Height	139.7	143.5	147.3	151.1	154.9	158.8	162.6	166.4	170.2	174.0	177.8	181.6	185.4	189.2	193.0	196.9	200.7	204.5	208.3	212.1	215.9	219.7	223.5	227.3
Humerus width	5.19	5.34	5.49	5.64	5.78	5.93	6.07	6.22	6.37	6.51	6.65	6.80	6.95	7.09	7.24	7.38	7.53	7.67	7.82	7.97	8.11	8.25	8.40	8.55
Femur width	7.41	7.62	7.83	8.04	8.24	8.45	8.66	8.87	9.08	9.28	9.49	9.70	9.91	10.12	10.33	10.53	10.74	10.95	11.16	11.36	11.57	11.78	11.99	12.21
Biceps girth	23.7	24.4	25.0	25.7	26.3	27.0	27.7	28.3	29.0	29.7	30.3	31.0	31.6	32.2	33.0	33.6	34.3	35.0	35.6	36.3	37.0	37.6	38.3	39.0
Calf girth	27.7	28.5	29.3	30.1	30.8	31.6	32.4	33.2	33.9	34.7	35.5	36.3	37.1	37.8	38.6	39.4	40.2	41.0	41.7	42.5	43.3	44.1	44.9	45.6

SECOND COMPONENT	½	1	1½	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9

Weight kg =

Ht. / ∛Wt. = [ ]

Upper limit	39.65	40.74	41.43	42.13	42.82	43.48	44.18	44.84	45.53	46.23	46.92	47.58	48.25	48.94	49.63	50.33	50.99	51.68
Mid-point	and	40.20	41.09	41.79	42.48	43.14	43.84	44.50	45.19	45.89	46.32	47.24	47.94	48.60	49.29	49.99	50.68	51.34
Lower limit	below	39.66	40.75	41.44	42.14	42.83	43.49	44.19	44.85	45.54	46.24	46.93	47.59	48.26	48.95	49.64	50.34	51.00
THIRD COMPONENT	-½	1	1½	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9

	FIRST COMPONENT	SECOND COMPONENT	THIRD COMPONENT	
Anthropometric Somatotype				BY: ....
Anthropometric plus Photoscopic Somatotype				RATER: ....

*Biceps girth in cm corrected for fat by subtracting triceps skinfold value expressed in cm.

*Calf girth in cm corrected for fat by subtracting medial calf skinfold cm.

Appendix D

LETTER TO COACHES

Dear Coach:

Your cooperation in allowing members of the baseball team to participate in my study is greatly appreciated. I am writing to confirm your agreement made during our recent phone conversation. At this time, I would like to explain, in more detail, the purpose of the study.

The study will be an attempt to describe physical characteristics, especially body composition and somatotype of collegiate baseball players, in a position by position analysis. The goal is to measure at least six North Central Conference teams, but hopefully measuring all nine teams can be accomplished. The study will allow for comparisons to be made with previous studies on major league and collegiate baseball players. The comparisons will be made to see if profiles of collegiate baseball players differ from those of major league players.

Various skinfolds, anthropometric girths and widths will be measured, as well as players height and weight. They also will reveal their age. The amount of time required to measure one subject will be approximately 30 minutes. The players will be selected on a volunteer basis and should be members of your traveling squad.

When the study is completed, a copy of the results will be sent to you because you and your team will have played an important role in the study. Also, each team member who volunteers will be notified of his body composition and somatotype, once they are determined.

Thank you for your time and cooperation. It is appreciated very much.

Sincerely,

Ronnie Carda

Appendix E

RAW DATA

ID	TEAM	POS	AGE	BICEP GIRTH	CALF GIRTH	SCAP SKIN	TRI SKIN	CHEST SKIN	SUPRA SKIN	ABDOM SKIN	THIGH SKIN	CALF SKIN	HUM WIDTH	FEM WIDTH	HT	WT
1	1	1	22.50	31.73	37.67	9.27	10.00	10.00	21.23	22.17	13.63	9.10	6.90	9.33	178.50	164.24
2	1	7	22.50	36.93	38.87	8.67	7.17	6.70	13.13	14.20	11.07	5.00	7.12	9.15	182.90	179.65
3	1	1	21.48	33.47	36.80	7.87	6.83	7.23	12.73	10.63	6.83	5.43	7.12	9.54	181.50	172.61
4	1	7	22.55	36.43	39.40	9.47	11.63	8.03	16.67	20.80	11.27	4.90	7.28	10.18	185.40	192.70
5	1	6	20.75	37.10	38.43	11.10	16.43	9.83	21.40	18.13	17.60	7.33	6.88	9.35	182.30	183.99
6	1	1	21.07	35.60	39.77	17.33	20.30	8.20	30.77	26.60	15.27	10.30	7.20	10.44	188.40	200.21
7	1	1	21.60	33.97	38.90	8.50	8.27	6.70	8.93	8.37	12.87	4.83	6.73	9.68	183.70	171.27
8	1	5	21.47	35.27	37.90	9.37	10.60	7.37	12.90	11.23	10.57	7.80	7.78	10.82	186.20	185.92
9	1	1	19.42	32.57	36.47	8.03	8.33	8.80	13.50	17.27	12.60	7.13	6.81	9.67	182.00	163.28
10	1	7	20.58	32.90	36.40	9.13	7.23	7.87	12.37	12.57	8.67	4.53	6.96	10.22	184.00	165.78
11	1	3	21.83	34.80	36.90	10.17	7.40	8.07	20.07	20.13	11.37	7.27	7.32	9.77	185.50	176.27
12	1	4	20.05	34.60	35.50	11.00	9.40	7.80	21.63	20.97	8.17	5.77	7.09	9.80	174.40	151.02
13	1	2	22.10	34.03	39.63	13.33	16.77	13.70	20.47	24.80	23.00	10.03	7.43	10.83	176.40	180.23
14	1	2	22.80	37.93	39.03	11.03	13.53	15.50	26.20	22.70	18.97	8.73	7.40	10.20	185.30	195.28
15	1	4	21.75	34.03	38.13	14.60	14.40	16.97	22.73	22.47	13.97	7.90	6.79	9.74	179.60	165.59
16	1	1	23.00	33.47	36.63	9.20	7.30	8.37	12.23	18.07	6.87	4.90	7.74	10.15	191.10	175.79
17	1	7	21.00	34.47	38.90	14.00	10.63	11.60	19.67	22.30	12.80	4.90	7.08	9.42	176.80	172.30
18	1	3	22.87	38.33	36.97	10.17	11.73	10.03	20.27	26.43	7.63	5.47	7.72	10.46	190.20	194.60
19	1	1	22.90	37.33	40.67	21.43	16.30	14.40	25.53	30.87	17.50	10.57	7.14	9.91	177.30	196.05
20	2	7	21.95	33.57	39.83	11.40	11.17	11.80	21.87	25.03	13.17	5.37	6.64	9.32	174.20	160.84
21	2	1	22.05	35.27	38.27	22.07	17.93	7.07	37.80	31.23	19.93	11.00	7.09	9.78	175.80	178.99
22	2	5	22.05	33.50	37.33	6.97	10.57	7.00	11.90	12.57	10.27	6.40	7.37	9.47	182.50	160.80
23	2	7	20.60	33.37	39.20	9.37	7.97	6.70	13.67	12.17	10.43	7.80	6.86	9.54	176.30	170.58
24	2	4	21.83	30.33	32.37	10.30	13.57	10.27	19.20	17.40	11.80	9.60	6.47	8.88	166.40	129.54
25	2	2	22.40	33.00	34.97	8.13	6.43	6.67	13.10	9.03	9.27	7.23	6.69	9.17	180.20	156.56
26	2	1	23.05	32.90	38.73	15.00	17.47	15.67	23.93	17.53	14.43	12.50	7.08	9.84	179.30	162.69
27	2	3	22.33	35.27	39.77	18.90	13.50	18.73	23.83	25.47	11.47	8.73	7.33	10.79	190.80	197.90
28	2	1	22.28	34.50	35.27	9.43	7.10	7.23	15.03	17.13	8.27	5.40	7.04	9.69	182.60	166.49
29	2	1	20.83	31.87	37.67	9.83	9.97	10.80	13.50	21.13	14.23	8.83	6.93	9.49	187.00	165.10
30	2	1	19.95	32.60	38.87	8.80	10.87	9.03	18.97	18.70	13.07	5.70	6.97	10.23	185.30	178.90
31	2	6	19.42	35.17	39.00	7.97	6.63	6.63	12.50	12.00	6.50	5.27	7.23	10.01	191.40	178.42
32	2	7	21.83	32.10	36.50	8.90	9.10	9.43	18.67	13.20	8.07	6.20	7.47	9.77	173.10	146.33
33	2	2	19.70	32.57	39.33	9.00	9.27	8.37	13.90	23.53	7.37	5.17	7.13	9.58	185.40	174.28
34	2	6	20.83	32.20	39.33	10.37	16.37	16.10	23.13	19.27	12.27	4.07	7.42	9.89	187.20	178.28
35	2	7	20.41	33.40	36.43	11.53	10.40	9.10	15.80	15.90	10.80	8.27	7.03	9.83	180.00	172.23
36	2	7	20.58	30.33	34.13	7.47	9.17	6.83	10.03	13.63	7.67	5.33	6.88	9.48	184.50	147.73
37	2	5	21.00	30.27	38.57	7.20	8.17	5.37	11.03	11.10	10.23	4.23	6.68	9.67	175.00	159.33
38	2	7	21.60	35.43	38.67	10.07	10.23	11.00	19.13	19.33	11.00	5.47	6.92	9.78	179.30	171.74
39	3	1	19.05	31.80	37.20	13.93	18.90	7.83	30.37	36.07	19.10	8.03	6.97	9.61	170.50	156.71
40	3	1	22.42	31.40	37.03	13.73	11.00	11.60	22.87	21.30	14.37	7.70	7.49	9.64	179.60	168.53
41	3	4	20.83	31.00	39.40	12.30	14.47	15.23	16.90	19.47	8.13	6.17	6.82	8.97	173.30	154.92
42	3	4	23.60	32.37	39.13	10.17	7.47	8.17	11.40	15.43	11.93	6.13	7.33	9.63	173.70	160.14
43	3	1	22.67	31.67	36.87	13.80	17.20	11.57	19.73	25.13	23.43	13.37	7.46	10.15	184.60	171.53
44	3	1	20.58	37.17	40.43	10.97	11.13	9.50	12.17	13.23	9.83	4.90	8.09	10.37	186.40	190.23
45	3	5	19.67	32.40	35.33	8.27	10.43	9.80	16.40	14.30	10.87	9.13	7.83	10.20	176.60	152.42

ID	TEAM	POS	AGE	BICEP GIRTH	CALF GIRTH	SCAP SKIN	TRI SKIN	CHEST SKIN	SUPRA SKIN	ABDOM SKIN	THIGH SKIN	CALF SKIN	HUM WIDTH	FEM WIDTH	HT	WT
46	3	5	19.45	36.40	39.43	16.20	20.20	14.83	27.33	33.47	18.33	16.03	7.54	10.53	184.50	199.27
47	3	3	22.55	30.93	32.60	8.93	10.23	10.40	17.17	17.37	9.57	6.33	6.92	9.14	176.20	145.97
48	3	7	22.33	34.10	39.80	10.40	12.83	8.30	20.63	23.80	9.57	5.60	7.53	10.07	178.50	177.28
49	3	3	21.48	34.07	40.27	9.80	12.93	6.67	14.53	17.10	13.57	5.70	7.63	10.11	188.40	198.72
50	3	7	21.60	34.60	36.87	10.97	12.80	11.07	20.10	15.83	15.20	8.47	7.43	9.86	173.60	168.40
51	3	1	19.25	31.10	36.33	8.67	7.37	8.03	12.37	14.83	9.57	4.93	7.17	9.68	178.50	155.79
52	3	5	20.88	34.67	37.70	15.47	19.03	17.13	22.77	24.33	14.37	7.97	7.60	9.67	175.10	156.28
53	3	3	20.33	37.50	40.90	14.60	18.43	20.97	34.37	29.07	21.43	15.40	7.50	9.99	182.50	204.03
54	3	6	21.83	30.93	37.87	13.57	10.70	12.93	20.63	25.90	13.53	8.97	7.46	9.97	185.80	174.71
55	3	2	21.95	32.57	38.97	14.40	14.70	15.57	21.60	30.33	21.43	8.20	7.67	10.55	179.30	182.41
56	3	2	22.25	38.30	39.83	12.77	12.60	12.80	20.37	26.20	7.07	7.23	7.53	10.21	176.50	187.00
57	3	1	18.67	32.23	36.93	11.40	14.33	11.97	19.97	21.73	13.43	12.30	7.24	9.30	173.00	153.16
58	3	6	20.33	32.73	35.97	10.03	7.63	7.83	14.90	21.53	7.47	5.97	7.30	9.08	178.20	154.51
59	3	1	21.20	33.20	41.30	16.87	17.03	7.70	36.47	34.07	14.63	8.20	7.40	10.14	175.90	180.70
60	4	4	22.67	32.80	38.10	11.63	16.40	13.50	20.27	22.00	20.40	6.10	6.82	9.68	181.20	157.56
61	4	3	21.70	35.07	40.03	9.10	8.13	7.47	10.83	14.13	9.33	5.10	7.88	10.40	186.00	187.45
62	4	7	23.75	35.30	40.60	15.67	12.77	13.47	26.83	28.40	10.33	4.90	7.13	9.70	181.20	190.23
63	4	7	21.00	33.30	36.23	21.17	17.37	7.53	31.00	26.40	19.43	12.73	6.54	9.15	169.90	164.40
64	4	2	23.00	36.20	41.43	12.30	18.57	12.07	22.87	16.63	18.80	13.80	7.50	10.63	186.10	200.59
65	4	1	20.95	35.43	38.33	21.60	23.80	10.20	33.37	32.20	25.53	14.50	7.62	10.28	188.50	190.33
66	4	1	21.10	37.13	44.87	15.93	25.07	14.37	30.27	35.67	23.00	16.43	8.44	10.82	188.00	221.07
67	4	5	19.75	37.53	38.30	16.83	23.90	7.93	36.48	33.73	18.70	8.23	7.34	10.00	175.90	182.06
68	4	6	19.00	33.07	35.83	8.63	9.77	7.97	16.13	17.63	9.70	5.03	6.87	9.12	170.90	143.77
69	4	7	21.10	33.80	37.37	11.13	14.40	10.70	17.10	23.87	15.20	10.30	7.32	9.92	180.00	165.38
70	4	7	22.08	35.70	37.83	13.20	10.53	8.30	18.57	18.80	11.17	9.37	6.98	9.28	171.20	164.98
71	4	1	20.42	35.50	37.93	16.17	14.17	8.20	26.43	27.40	17.47	8.97	7.33	9.51	189.70	185.69
72	4	1	20.37	34.13	42.43	13.00	19.17	13.67	19.10	21.50	24.80	10.73	7.54	10.34	191.20	192.34
73	4	1	19.17	33.37	38.50	13.83	13.97	11.73	19.93	23.73	11.73	7.53	7.65	10.14	193.30	191.23
74	4	7	21.70	35.53	41.33	14.20	14.60	13.13	20.90	19.43	18.10	9.63	7.63	10.25	186.80	198.39
75	4	1	21.67	32.27	36.40	9.80	7.43	6.77	13.33	11.40	5.43	3.63	6.54	9.44	181.10	149.15
76	4	2	22.17	35.50	36.73	22.23	19.50	10.73	32.83	37.27	15.73	5.13	6.46	9.54	174.50	178.74
77	4	2	19.00	31.70	36.20	12.93	14.00	15.07	24.90	27.27	17.23	8.50	7.30	9.99	185.00	176.87
79	4	1	19.67	32.27	32.57	10.27	19.53	11.53	26.50	17.57	14.73	6.13	7.18	9.97	187.20	171.24
78	4	1	19.00	33.00	39.03	11.87	13.97	14.37	27.93	28.63	11.10	9.33	7.45	10.08	188.80	190.73
80	4	5	20.17	32.13	38.10	10.07	13.47	9.23	18.93	20.00	15.37	7.63	7.40	9.60	172.90	157.56
81	5	3	22.65	33.37	39.13	17.13	10.90	17.60	41.80	31.57	7.67	5.17	7.30	9.97	188.80	192.91
82	5	4	22.65	34.80	36.57	22.43	21.53	19.00	42.60	35.77	18.87	12.60	7.30	10.02	175.40	173.27
83	5	7	19.12	36.20	41.53	14.57	13.13	13.43	29.47	27.87	20.20	16.17	7.97	10.80	182.40	198.81
84	5	1	18.62	31.77	35.90	12.23	12.20	6.47	22.90	21.43	13.50	6.43	6.93	9.62	188.20	168.17
85	5	2	19.25	32.00	34.03	10.73	7.37	8.20	23.47	21.30	10.53	4.47	6.57	9.10	177.30	147.95
86	5	7	19.33	35.00	36.83	11.60	14.30	9.60	16.30	14.87	21.97	8.47	7.19	10.43	176.50	169.98
87	5	5	18.41	33.50	38.80	19.97	19.60	22.07	40.37	27.83	16.83	9.33	6.96	9.72	168.50	163.75
88	5	1	20.33	32.90	36.07	8.67	11.03	8.97	18.27	14.60	10.40	10.37	7.21	9.62	177.50	161.98
89	5	1	22.33	37.57	37.77	12.13	8.83	7.60	17.97	13.77	8.77	3.57	7.82	10.43	197.50	196.32
90	5	7	21.08	34.93	40.33	18.43	12.60	9.50	29.47	21.47	12.10	5.50	7.39	10.06	184.00	180.80

ID	TEAM	POS	AGE	BICEP GIRTH	CALF GIRTH	SCAP SKIN	TRI SKIN	CHEST SKIN	SUPRA SKIN	ABDOM SKIN	THIGH SKIN	CALF SKIN	HUM WIDTH	FEM WIDTH	HT	WT
91	5	1	18.80	31.70	36.17	8.90	8.53	8.40	16.80	17.33	11.30	6.13	7.27	10.03	178.60	145.27
92	5	7	19.62	31.10	39.97	10.47	8.30	7.60	17.17	19.53	11.03	5.83	7.00	9.23	174.50	155.99
93	6	1	20.90	32.53	38.80	9.43	7.13	7.20	16.07	16.83	9.33	6.73	7.28	9.37	177.00	160.84
94	6	3	21.58	32.53	41.13	8.03	8.97	9.47	25.00	14.30	11.20	8.93	7.72	9.88	182.70	179.21
95	6	6	18.58	33.53	35.50	12.10	12.27	7.50	21.70	26.30	15.17	4.50	7.04	9.46	180.50	173.78
96	6	4	19.51	32.00	38.87	16.10	14.30	7.83	26.17	31.63	12.23	6.63	7.52	9.58	175.30	169.56
97	6	2	19.33	34.60	39.00	11.93	6.47	7.73	17.33	12.33	9.83	4.37	7.23	9.77	182.10	172.98
98	6	3	22.00	34.50	42.57	13.83	13.13	7.77	22.77	20.83	17.30	10.60	7.67	10.75	183.70	197.14
99	6	1	19.47	33.60	36.43	11.13	10.20	7.30	17.17	21.03	10.07	7.40	7.27	9.16	180.20	167.17
100	6	1	21.42	34.47	39.03	16.20	15.17	11.03	24.77	21.53	10.37	6.03	7.22	10.10	177.90	174.21
101	6	6	21.60	33.60	37.33	13.20	14.50	9.27	26.70	19.80	15.40	9.27	7.12	9.61	179.20	172.44
102	6	1	22.58	31.60	38.43	9.13	10.03	8.10	15.47	10.67	13.30	6.50	7.76	10.09	193.00	184.75
103	6	2	22.00	33.43	41.73	19.27	13.87	12.87	26.73	24.10	10.87	11.20	7.02	10.10	184.30	198.41
104	6	7	19.67	33.63	38.80	12.20	9.50	12.43	22.10	18.57	13.80	6.83	7.48	9.66	185.20	179.66
105	6	5	19.97	33.47	36.53	10.73	10.77	9.20	19.33	16.10	9.00	6.77	6.80	10.02	176.10	195.21
106	6	1	20.12	32.43	34.80	13.53	11.23	11.40	22.27	24.73	9.53	7.63	7.25	10.03	182.00	166.02
107	6	7	22.50	35.17	40.60	11.70	10.73	7.23	22.07	19.03	7.50	5.17	7.50	9.76	179.40	188.09
108	6	1	20.42	34.10	40.27	10.77	14.40	10.13	21.47	15.33	15.57	10.53	7.48	9.87	188.00	195.82
109	6	1	19.50	35.90	39.43	10.10	10.07	12.37	17.03	17.33	8.13	4.90	8.00	9.67	191.20	198.60
110	6	2	22.67	34.30	38.50	16.40	15.40	8.27	28.37	21.30	16.60	7.50	7.42	10.02	182.20	182.15
111	6	7	23.33	35.03	39.70	13.63	12.30	10.50	25.27	25.83	14.27	8.80	6.71	9.68	175.50	197.36
112	7	5	23.00	34.17	38.17	19.03	16.60	10.33	37.00	32.93	21.77	11.70	7.00	9.51	179.90	177.05
113	7	6	21.14	32.50	35.50	10.07	11.77	8.10	17.30	19.20	21.50	9.67	6.66	8.84	173.70	156.08
114	7	7	21.67	32.80	36.80	9.73	9.40	9.23	14.10	18.00	9.73	6.80	6.68	9.63	175.00	160.08
115	7	1	20.92	32.83	40.00	17.40	12.43	8.93	26.70	25.53	13.53	6.10	7.30	9.64	178.80	185.69
116	7	3	19.14	33.53	38.00	10.20	8.77	7.80	15.40	20.00	8.57	5.13	7.20	10.17	188.30	177.53
117	7	4	19.42	28.60	34.30	9.10	8.97	6.53	15.37	12.73	12.00	5.10	6.55	9.23	169.50	134.70
118	7	1	23.42	31.00	35.33	15.40	13.23	12.30	25.87	25.47	11.77	6.93	6.92	9.38	175.10	155.30
119	7	7	20.83	34.50	35.40	13.50	8.17	7.77	17.23	17.40	10.63	4.73	6.89	9.92	183.30	170.22
120	7	4	25.17	31.43	37.07	8.77	6.23	7.33	19.60	23.40	6.30	3.63	7.49	9.48	184.20	168.17
121	7	1	18.60	30.97	37.73	7.80	11.60	10.40	24.73	17.30	12.37	6.43	7.56	10.64	191.00	179.57
122	7	2	18.75	32.50	42.27	14.00	11.50	7.67	21.47	20.47	11.07	4.43	7.12	9.45	171.30	163.59
123	7	5	21.71	34.30	39.40	9.67	8.53	9.60	16.70	14.67	10.37	6.20	7.45	9.98	180.30	174.32
124	7	3	22.50	36.67	37.13	10.70	10.73	9.30	23.70	18.97	8.53	6.00	7.20	9.88	182.20	178.50
125	7	7	22.50	34.53	39.03	9.83	14.10	7.50	19.33	23.20	15.67	5.80	7.20	9.34	179.60	169.44
126	7	1	20.67	37.80	42.23	21.30	24.90	9.33	27.50	30.45	25.70	14.07	7.62	9.92	188.90	219.09
127	7	7	24.08	32.10	36.60	10.80	10.43	8.50	21.17	27.07	11.57	5.17	6.88	8.82	173.80	156.37
128	7	3	21.75	33.80	39.23	17.00	18.67	11.03	36.53	30.30	18.20	12.73	7.17	10.13	182.10	189.28
129	7	1	22.35	34.53	39.33	12.77	10.90	6.00	30.17	25.90	11.60	3.53	6.93	9.09	175.80	171.39
130	7	2	20.17	33.27	38.47	22.23	20.47	14.03	38.03	31.47	16.57	11.60	7.02	10.07	169.80	172.47
131	7	6	18.90	33.57	38.23	12.40	15.37	10.93	21.33	23.97	17.13	9.33	7.30	10.20	189.90	191.81
132	4	7	20.33	32.30	37.43	10.57	12.00	9.77	21.10	18.17	12.43	8.33	7.56	10.10	175.10	166.45

Appendix F

FORTRAN PROGRAM FOR ANALYSIS OF VARIANCE OF SOMATOTYPE DATA

```
      DIMENSION XK(3),XCOORD(132),YCOORD(132),ECTO(132),XMESO(132),
     *ENDO(132),SDD1(132),SDD2(132),SDD3(132),K(3)
C
C*****************************************************************
C     THIS PROGRAM PERFORMS ONE-WAY ANOVA WHERE GROUP SOMATOTYPE
C     RATING IS THE DEPENDENT VARIABLE.  FORMULAS ARE TAKEN FROM
C     1980 ED. OF THE HEATH-CARTER SOMATOTYPE METHOD.
C     M. LOONEY           6/10/83       GROUPS=3
C*****************************************************************
C
C        VARIABLE LIST
      XN=132.
      N=XN+.5
      DO 25 I=1,N
         READ (5,10) SUBJ,TEAM,POS,AGE,ENDO(I),XMESO(I),ECTO(I),CLASS
  10     FORMAT (F3.0,2F2.0,F7.2,3F6.2,8X,F1.0)
         WRITE(6,20) SUBJ,TEAM,POS,AGE,ENDO(I),XMESO(I),ECTO(I),CLASS
  20     FORMAT(' ',F5.0,2F5.0,F7.2,3F6.2,10X,F3.0)
  25  CONTINUE
      WRITE(6,26)
  26  FORMAT(' ')
      G=3.
      K(1)=43
      K(2)=60
      K(3)=29
      XK(1)=K(1)
      XK(2)=K(2)
      XK(3)=K(3)
      SUME1=0.
      SUMM1=0.
      SUMEC1=0.
      SUME2=0.
      SUMM2=0.
      SUMEC2=0.
      SUME3=0.
      SUMM3=0.
      SUMEC3=0.
C
C        CALCULATE X,Y COORDINATES FOR ALL SUBJECTS
C
      DO 40 I=1,N
        XCOORD(I)=ECTO(I)-ENDO(I)
        YCOORD(I)=2.*XMESO(I)-(ENDO(I)+ECTO(I))
        WRITE(6,30) I,XCOORD(I),YCOORD(I)
  30    FORMAT(' ','X,Y',2X,I3,2F15.2)
  40  CONTINUE
      JA=K(1)
      DO 60 I=1,JA
         SUME1=SUME1+ENDO(I)
         SUMM1=SUMM1+XMESO(I)
         SUMEC1=SUMEC1+ECTO(I)
  60  CONTINUE
C           CALCULATE MEANS FOR SOMATOTYPE COMPONENTS-GROUP 1
C
      AVGE1=SUME1/XK(1)
      AVGM1=SUMM1/XK(1)
      AVGEC1=SUMEC1/XK(1)
      WRITE(6,26)
      WRITE(6,65) SUME1,SUMM1,SUMEC1,XK(1)
 65   FORMAT(' ','SUMS1',3F12.3,5X,'XK1',F4.0)
```

```
      WRITE(6,26)
      WRITE(6,70) AVGE1,AVGM1,AVGEC1
   70 FORMAT(' ','AVG-GROUP1',3F12.3)
      J=K(1)+1
      JB=J+K(2)-1
      DO 80 I=J,JB
         SUME2=SUME2+ENDO(I)
         SUMM2=SUMM2+XMESO(I)
         SUMEC2=SUMEC2+ECTO(I)
   80 CONTINUE
C
C           CALCULATE MEANS FOR SOMATOTYPE COMPONENTS-GROUP 2
      AVGE2=SUME2/XK(2)
      AVGM2=SUMM2/XK(2)
      AVGEC2=SUMEC2/XK(2)
      WRITE(6,26)
      WRITE(6,85) SUME2,SUMM2,SUMEC2,XK(2)
   85 FORMAT(' ','SUMS2',3F12.3,5X,'XK2',F4.0)
      WRITE(6,26)
      WRITE(6,90) AVGE2,AVGM2,AVGEC2
   90 FORMAT(' ','AVG-GROUP2',3F12.3)
      M=K(1)+K(2)+1
      JC=K(1)+K(2)+K(3)
      DO 100 I=M,JC
         SUME3=SUME3+ENDO(I)
         SUMM3=SUMM3+XMESO(I)
         SUMEC3=SUMEC3+ECTO(I)
  100 CONTINUE
C
C           CALCULATE MEANS FOR SOMATOTYPE COMPONENTS-GROUP 3
C
      AVGE3=SUME3/XK(3)
      AVGM3=SUMM3/XK(3)
      AVGEC3=SUMEC3/XK(3)
      WRITE(6,26)
      WRITE(6,105) SUME3,SUMM3,SUMEC3,XK(3)
  105 FORMAT(' ','SUMS3',3F12.3,5X,'XK3',F4.0)
      WRITE(6,26)
      WRITE(6,150) AVGE3,AVGM3,AVGEC3
  150 FORMAT(' ','AVG-GROUP3',3F12.3)
      WRITE(6,26)
C           CALCULATE GRAND MEAN SOMATOTYPE
C
      GMENDO=(AVGE1+AVGE2+AVGE3)/3.
      GMESO=(AVGM1+AVGM2+AVGM3)/3.
      GMECTO=(AVGEC1+AVGEC2+AVGEC3)/3.
      WRITE (6,26)
      WRITE(6,200) GMENDO,GMESO,GMECTO
  200 FORMAT(' ','GRAND MEAN SOMATOTYPE',3F12.3)
C
C         CALCULATE X,Y COORDINATES FOR GROUP SOMATOTYPES,GRAND MEAN
C
      XCORG1=AVGEC1-AVGE1
      XCORG2=AVGEC2-AVGE2
      XCORG3=AVGEC3-AVGE3
      YCORG1=2.*AVGM1-(AVGE1+AVGEC1)
      YCORG2=2.*AVGM2-(AVGE2+AVGEC2)
      YCORG3=2.*AVGM3-(AVGE3+AVGEC3)
      XCORGM=GMECTO-GMENDO
      YCORGM=2.*GMESO-(GMECTO+GMENDO)
```

```
      WRITE (6,26)
      WRITE(6,300) XCORG1,YCORG1,XCORG2,YCORG2,XCORG3,YCORG3,XCORGM,
     *YCORGM
  300 FORMAT (' ','X1-Y1',2F9.2,5X,'X2-Y2',2F9.2,5X,'X3-Y3',2F9.2,
     *5X,'XGM-YGM',2F9.2)
      SDDG1=(3*(XCORG1-XCORGM)**2+(YCORG1-YCORGM)**2)**.5
      SDDG2=(3*(XCORG2-XCORGM)**2+(YCORG2-YCORGM)**2)**.5
      SDDG3=(3*(XCORG3-XCORGM)**2+(YCORG3-YCORGM)**2)**.5
      WRITE(6,26)
      WRITE(6,304) SDDG1,SDDG2,SDDG3
  304 FORMAT(' ','SDDG1    ',F8.3,5X,'SDDG2    ',F8.3,5X,'SDDG3    ',F8.3)
C
C         CALCULATE HARMONIC MEAN
C
      ARM=G/(1/XK(1)+1/XK(2)+1/XK(3))
C
C         CALCULATE SUM OF SQUARES AMONG GROUPS
C
      SSB=ARM*(SDDG1**2+SDDG2**2+SDDG3**2)
      WRITE(6,26)
      WRITE(6,310) ARM
  310 FORMAT(' ','HARMONIC MEAN ',F15.3)
      WRITE(6,26)
C
C         CALCULATE SUM SDD SQUARED- GROUP 1
C
      SUMSD1=0.
      DO 400 I=1,JA
         SDD1(I)=(3*(XCOORD(I)-XCORG1)**2+(YCOORD(I)-YCORG1)**2)**.5
        WRITE (6,405) I,SDD1(I)
  405   FORMAT(' ','SDD1',3X,I2,F8.3)
         SUMSD1=SUMSD1+SDD1(I)**2
  400 CONTINUE
C
C       CALCULATE SUM SDD SQUARED - GROUP 2
C
      SUMSD2=0.
      DO 500 I=J,JB
         SDD2(I)=(3*(XCOORD(I)-XCORG2)**2+(YCOORD(I)-YCORG2)**2)**.5
         SUMSD2=SUMSD2+SDD2(I)**2
  500 CONTINUE
C
C        CALCULATE SUM SDD SQUARED - GROUP 3
C
      SUMSD3=0.
      DO 600 I=M,JC
         SDD3(I)=(3*(XCOORD(I)-XCORG3)**2+(YCOORD(I)-YCORG3)**2)**.5
         SUMSD3=SUMSD3+SDD3(I)**2
  600 CONTINUE
C
C       CALCULATE SUM OF SQUARES WITHIN GROUPS
C
      SSW=SUMSD1+SUMSD2+SUMSD3
C
C       CALCULATE TOTAL TOTAL SUM OF SQUARES
C
      TSS=SSW+SSB
      DFB=G-1.
      DFW=XN-G
      XMSB=SSB/DFB
```

```
      XMSW=SSW/DFW
      F=XMSB/XMSW
C
      WRITE(6,26)
      WRITE(6,800)
  800 FORMAT(' ',31X,'SS',12X,'DF',8X,'MS',14X,'F')
      WRITE(6,900)SSB,DFB,XMSB,F
  900 FORMAT(' ','AMONG',11X,F20.4,8X,F3.0,2X,F10.4,9X,F8.3)
      WRITE(6,1000) SSW,DFW,XMSW
 1000 FORMAT(' ','WITHIN',10X,F20.4,6X,F5.0,2X,F10.4)
      WRITE(6,1100) TSS
 1100 FORMAT(' ','TOTAL',11X,F20.4)
      END
```