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A MODEL FOR PREDICTING THE PROBABILITY OF A WIN IN BASKETBALL

by

Kathleen Jean Shanahan

A thesis submitted in partial fulfillment
of the requirements for the Master of
Arts degree in Physical Education
in the Graduate College of
The University of Iowa

May 1984

Thesis supervisor: Assistant Professor Marilyn Looney

Graduate College
The University of Iowa
Iowa City, Iowa

CERTIFICATE OF APPROVAL

MASTER'S THESIS

This is to certify that the Master's thesis of

Kathleen Jean Shanahan

has been approved by the Examining Committee for the thesis requirement for the Master of Arts degree in Physical Education at the May 1984 graduation.

Thesis committee: ______________________
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CHAPTER I

INTRODUCTION

Many coaches are faced with a variety of decision-making and strategy problems in their sport. These coaches demand answers that are based on probability statements derived from sound assumptions and empirical data (Schultz, 1980). Solutions to these coaching problems can enhance the chance of winning which is the primary purpose of competitive sport. The one source that can provide many solutions and is readily available to the coach are game statistics. Sports produce an almost endless source of easily measured outcomes and behaviors in a game, usually in the form of individual and team statistics.

Cohen stated in Friedman's The World of Sport Statistics (1978) that statistics which are analyzed and used correctly can convert a loser into a winner. The statistical data are obviously available but the question is, what methodology for the mathematical analysis of these data is also available? Many coaching decisions have been based solely on descriptive statistics in terms of averages and percentages. Only recently, however, have the appropriate tools for examining decision processes, probability structures, and predictions been made available to the applied researcher (Shultz, 1980). Decision-making models combining probability theory with experience and judgment of the coach have been developed for several professional sports.

The idea of utilizing statistical techniques is not new to the world of sports and these techniques have been very helpful in professional baseball and football. However, in the sport of basketball, there are very few statistical models that assist the coach with strategy and management decisions.

Since most basketball coaches are challenged with producing a winning team each year, a coach would want a planning tool that could assist him or her in analyzing the team weaknesses and provide alternate remedies. The goal of many basketball teams is to be the conference champion or even national champion. A certain number of victories would enable a team to win its conference or receive a national play-off bid. Price and Rao (1977) developed a model that would utilize "a most likely estimate" of performance of any existing National Basketball Association team to determine the probable number of victories by that team. This concept could be expanded to include the prediction of the probability of winning a college basketball game and eventually the conference title. This would aid the college coach in determining his or her team's chances of receiving a national tournament bid since many conference winners receive automatic berths.

Most importantly, though, a coach would want a statistical tool that not only predicted the probability of a win but also one that would determine the significance of the predictor variables. This would assist the coach in making strategic decisions either before or during the game. Examples of such decisions would be selecting the best line-up, choosing the best shooter, the best ballhandler, the best rebounder, or any combination of those or other factors involved. Also, the relationship between the variables can be used as a planning tool by the coach in organizing practices such that skills of the most important variables or combination of variables are emphasized. Many coaches may believe that rebounding is the most important variable in basketball or that a high field goal percentage is what will win games for any team. However, every team possesses different skills and each team may be stronger in one area over another area. The significance of the variables can assist the coach in analyzing the special skills for his or her particular team that may assist them in winning games.

The significance of the variables involved can also provide the basis for recruiting players. The team's needs may be defined by the significant variables in the prediction of the probability of winning. Therefore, to increase the probability of winning, a coach may want to recruit a good ballhandler or a high percentage shooter. The study by Price and Rao (1977) aided a professional basketball team's personnel management with respect to drafts, trades, and personnel decisions.

The prediction of the probability of a win and the significance of the predictor variables can aid the coach in explaining the team's outcome of the season. Determining the most significant variables may provide the most important explanation for the team's final standing. Even though winning is not based strictly on skill variables, these are very important factors in basketball.

Statement of Problem

The purpose of this research was to demonstrate that the probability of a win in a college basketball game could be explained by a set of team statistics or variables. The set of predictor variables investigated includes field goal attempts, field goals made, field goal percentage, free throw attempts, free throws made, free throw percentage, offensive rebounds, defensive rebounds, total rebounds, rebounding percentage, personal fouls, disqualifications, turnovers, steals/interceptions, assists, drawing a charge, forced shots, blocked shots, fumbles, bad passes, defensive error, and total player points. The relationship between each variable and its significance as a predictor of the criterion, winning a game, was also examined.

In this study, the University of Iowa Men's and Women's basketball performance charts were utilized to collect the data for 1981-1982 and 1982-1983 seasons. As a secondary purpose of this study, the Men's and Women's results were compared to determine the better performance chart.

Limitations of Study

In identifying limitations of this study, two weaknesses were found. First, in developing a prediction model, it is ideal to have a winning percentage of approximately 50% to yield the best results. In this study, the data collected reflected the winning percentage at either extreme of 50% which may have altered the results. The men's data indicated a high winning percentage and the women's data showed a high losing percentage.

Second, the time span of the data collection can limit the study due to personnel changes from year to year. Every year players graduate, quit or are not selected again to be on the team while new players replace them. This change of player personnel may reflect a change in the team's performance and/or style of play. Each player that leaves a team may possess certain outstanding skills while the incoming players may have different special skills or abilities. The team may continue with the same level of performance, however, the skill variables that are important to winning may change from year to year. Therefore, a prediction model developed from two or more seasons of data may alter the results of the prediction if major personnel changes occur during those seasons.

CHAPTER II

REVIEW OF LITERATURE

The review of literature is divided into four sections. The first section deals with prediction studies in team sports and the second reviews the significance of basketball skill variables and their relationship to winning. The third section presents prediction studies in basketball, and finally, the last section reviews the use of the logistic regression technique in prediction studies.

Prediction Studies in Team Sports

In the past, prediction studies in sports usually have involved baseball or football statistics. According to Lindsey (1977), baseball is particularly well suited for scientific analysis because it is a stop and go game, meaning baseball has frequent pauses at which the state of play can be specified by a small number of variables and decisions can be made regarding the strategy for the next play. Baseball is unique among sports in that every action taken by a player can be compiled into an official statistic (Featherstone & Studenmund, 1974). This is also very true for the game of football, although there is some strategic action away from the ball that is not recorded as a statistic. However, basketball is a continuously moving sport which makes it even more difficult to analyze from a scientific approach.

In professional baseball, it has been found that a win can be predicted from the team batting average, team home runs, team fielding average, and team earned run average (Featherstone & Studenmund, 1974). A multiple linear regression framework was used in Featherstone & Studenmund's study to determine the importance of these skill variables and their relationship to winning. The data for Featherstone and Studenmund's study were collected from the American and National League professional baseball games from 1962 to 1966. Featherstone and Studenmund also used a rank method to predict team position finish in the respective leagues. The earned run average was by far the most important explanatory variable in determining games won and the team's position finish in the leagues.

In football, Goode (1977) compiled a list of 115 statistical variables based on four years of data in the National Football League. Goode reduced the list of variables to 20 significant predictors of the outcome of football games. This was done through factor analysis. The 20 variables were incorporated into a multiple regression equation with the criterion measure defined as a composite of the offensive points scored and the defensive points allowed. The results indicated that these 20 variables accounted for 96% of the variance in scoring in the National Football League. More importantly, Goode applied these equations to predict outcomes and successfully predicted the outcomes of 75% of the games in a given season.

Both Goode (1977) and Featherstone and Studenmund (1974) produced statistical models for professional teams that can be used to predict outcomes of the season. This ability to explain the outcome of a regular season statistically can be used as a planning tool for the future or to predict the outcome of the postseason games. Goode (1976) applied this statistical technique to the 1974 Super Bowl and correctly picked the Miami Dolphins as winners by 7 points.

On the intercollegiate level, Haberman (1977) investigated predicting the results of Ivy League football games played from 1964 through 1966. It was found that through linear regression analysis, the final scores of Ivy League games could be predicted from the box-score statistics of the games. However, the 21 predictor variables Haberman used could only account for 79% of the variance in the final scores. Haberman also investigated the possibility of predicting box-score statistics which is different than predicting final scores. The prediction of box-score statistics were based on previous years of box-score statistics. The results, however, indicated that neither the knowledge of the teams playing nor knowledge of the year can assist in predicting these box-score statistics.

Other than football and baseball, there are few studies in the literature that involve team statistics in predicting an outcome or team performance. Studies involving volleyball have examined the relationship between team performance and selected skill components

(Cox, 1974; Gorton, 1970; Scott, 1971). Gorton (1970) used two selected skills, serving and service return, in volleyball as predictors of team performance. Both skills were found to be highly predictive of team performance, however, serving was more closely related than service return. Scott (1971) investigated spiking and service reception as they related to team performance. He concluded that spiking was more closely related to team performance. A few years later, Cox (1974) investigated six predictor variables, including those in the studies by Gorton (1970) and Scott (1971), to determine the variables' relationships to team performance and to each other. Through discriminant analysis, Cox (1974) found two volleyball predictor variables, spiking and spiking defense, that made a decisive difference between winning and losing. Cox also found that six predictor variables accounted for 87% of the variance in the team's performance.

Significance of Basketball Skill Variables

There are a few early studies that relate to the importance of basketball skill variables and their relationship to winning a game. It should first be stated that, in the opinion of Miller and Horky (1970), many statistics of basketball skill variables should be kept, such as rebounding, assists, turnovers, field goals, free throws, fouls, and stolen balls. However, evidence from earlier research has shown that rebounding, field goals, and free throws are the main variables in determining a win in a basketball game.

According to the statistics in a study by Wilson (1948), nearly all basketball games were won by the team that secured a higher percentage of rebounds, both offensively and defensively. A few years later, however, Galatin (1954) found that two of the most important criteria in winning or losing basketball games on the high school, college, and professional levels were the number of field goals scored and the number of field goals attempted. A greater percentage of shots made and a smaller number of shots attempted were indicative of winning a game (Galatin, 1954). In support of free throws as an important criterion for determining a win, Ginerich (1946) concluded that, in individual games, the percentage and number of free throws made are important factors in winning. However, over a number of games, the difference in points scored from free throws by the winning and losing teams did not vary much.

These early studies did not apply mathematical techniques to the data. The conclusions were drawn from descriptive statistical measurements from which inferences were made. However, the relationship of one variable to another or to a combination of variables, was not tested. Also, the game of basketball has changed in both rules and style since the time of those early studies. These changes may affect the significance of the variables in predicting the probability of a win for a game.

Prediction Studies in Basketball

Several researchers have investigated the prediction of team performance, playing ability, and selection of players in basketball (Gordon, 1978; Hoehn, 1979; Peterson, 1980; Hopkins, 1980). However, these studies involved psychomotor, cognitive, physiological, anthropometric measures, and skill tests as predictor variables. Some recent research has analyzed game statistics in basketball as these statistics pertain to point total difference and half court defenses used on the high school level. However, the analyses did not investigate relationships between the variables to predict the win of a game. Evenhouse (1979) found that three variables, (point per possession, difference in shooting percentage, and difference in defensive rebounds) together accounted for 75% of the variance in point total difference. The three variables were significantly related to point total difference and Evenhouse concluded that a team that achieves .70 points per possession should win the game.

Breitlow (1979) analyzed field goal shooting, rebounding, and team success with respect to various half court basketball defenses. The effects of these three variables on the opponent's man-to-man, zone, and combination defenses were analyzed by descriptive statistics. The significance of these three variables on the various half court defenses was based on comparison of the means and value judgments based on past experiences.

The only study that analyzed team statistics to determine the characteristics that produced winning basketball was done by Price and Rao in 1977. The goal of using these characteristics was to evaluate trade, draft, or other personnel decisions. This study analyzed team statistics that attempted to model player-aquisition decisions in the professional ranks of the NBA. Price and Rao used eight game statistics (field goals attempted, field goals made, free throws attempted, free throws made, rebounds, assists, personal fouls, and disqualifications) as the basic factors that determined success. Success was defined as winning percentage or participation in the post play-off series. Finally, Price and Rao established seven transformations of the eight original variables (field goal percentge, free throw percentage, field goals made per assist, field goals made per rebound, free throws attempted per personal foul, field goal x free throw interaction, and rebound x assist interaction) to be included in the prediction of success, as well. Through factor analysis, the results showed free throw percentage, rebounding, and assists to be important determinants for explaining the variation in winning percentage. The discriminant analysis resulted in field goal percentage, free throw percentage, rebounding and personal fouls as the important variables for discriminating between postseason participation or nonparticipation. None of the analyses clearly identified any of the new or special transformed variables. Price and Rao, therefore, performed a regression analysis using the 15 variables in various combinations as predictors. The results identified personal fouls, interaction of rebounding with assists, and interaction of field goal percentage with free throw percentage as effective predictors of winning percentage. From these results, Price and Rao estimated a multiplicative model in the following form:

$$PCT = a_0\, x_1^{a_1}\, x_2^{a_2}\, x_3^{a_3}\, x_4^{a_4}\, x_5^{a_5}$$

where PCT was the dependent variable, and _xs_ were the independent variables (x_1=field goal percentage, x_2=free throw percentage, x_3=total rebounds, x_4=personal fouls, x_5=assists); the _as_ were constants. It was concluded that the use of this information and other factors, such as judgmental information, made it possible to develop a model for personnel decisions including trading and drafting.

Logistic Regression

In the past, prediction studies in team sports used multiple linear regression analysis, discriminant analysis, or factor analysis to analyze the data (Cox, 1974; Featherstone & Studenmund, 1977; Goode, 1976; Haberman, 1977; Price & Rao, 1977). The data analysis from the early studies which investigated the significance of basketball skill variables and their relationship to winning did not include mathematical techniques of analysis. The inferences were made from descriptive statistics and the relationship of one variable to another or to a combination of variables was not tested.

In the present study, logistic regression was used for data analysis. Logistic regression sets up a linear model to predict or explain the probability of an event (Hildebrand, Laing, & Rosenthal, 1977). Goode (1976) used a multiple regression equation to predict the team which would win the 1974 Super Bowl. However, he attempted to predict the event itself, not the probability of the event. Predicting probabilities has a fundamentally different focus than predicting events (Hildebrand, Laing, & Rosenthal, 1977).

The basic goal of multiple linear regression is to produce a linear combination of independent variables which will correlate as highly as possible with the dependent variables (Nie et al, 1975). Nie and colleagues (1975) stated that this linear combination can then be used to "predict" values of the dependent variable, which is measured as interval-ratio. The importance of each of the independent variables in that prediction can also be assessed. The goal of logistic regression is basically the same; however, the dependent variable is dichotomous and the independent variables can be manipulated in the same way as in the multiple linear regression analysis (Feinberg, 1980).

In the past, discriminant analysis has been used when a researcher's aim was prediction, not discrimination (Feinberg, 1980). With discriminant analysis, a researcher calculates the effects of a collection of interval-level independent variables on a nominal dependent variable (Nie et al, 1975). Linear combinations of independent variables that best distinguish between cases in the categories of the dependent variable are found (Nie et al, 1975). Feinberg (1980) stated that even when discrimination is the actual aim, if the independent variables do not follow a multivariate normal distribution with equal covariance matrices for each group or level of the dependent variable, the use of standard discriminant function predictors will not be statistically consistent. Press and Wilson (1978) described the relative merits of discriminant analysis and logistic regression and gave two illustrations between the methods. The superiority of logistic regression over discriminant analysis in the examples was slight when used as a classification procedure. But as Press and Wilson (1978) noted, if discriminant analysis is used for a prediction problem, prediction for small and large probabilities may be different as compared to that of logistic regression analysis.

Factor analysis is a much more generalized procedure for locating and defining a smaller subset of variables from a relatively large group of variables (Nie et al, 1975). Goode (1977) and Price and Rao (1977) used factor analysis in their research to locate a smaller number of significant variables from a larger set of independent variables. These subsets of predictor variables were the most significant independent variables for predicting the dependent variable in multiple regression. As in multiple regression, logistic regression can use subsets of predictor variables.

A stepwise logistical regression analysis was performed as the analysis of the data for this study. The logistic regression analysis predicts the probability of an event. The predicted value of the event is a probability and therefore ranges between the value of 0 and 1. The model statement consists of all the independent variables in the analysis. The data is then fitted to the logistical model:

$$Pr(y=1) = \frac{e^{v}}{1 + e^{v}},$$

where $v = b_0+b_1x_1+b_2x_2+. \; . \; .+b_nx_n$,

and y is the dependent variable taking on the value of either 0 or 1 depending on the outcome of the event, the x_1, x_2, . . ., x are the independent variables, and the b_1, b_2, . . ., b are the constants in the model. The procedure is followed in a stepwise manner, entering and removing one or a combination of independent variables from the model at each step. In entering or removing the independent variable(s) from the model statement, the predicted probability of the event will be affected. Also, the significance of each independent variable can be determined by removing the variables from the model.

Summary

There have been many prediction studies in the professional sports world, especially football and baseball. However, there are very few prediction studies in the sport of basketball and even fewer studies on the intercollegiate level. Several researchers have investigated team performance, playing ability and team selections in basketball, however, these studies did not use game statistics as predictor variables.

Research that has used team statistics in basketball characterized winning for an NBA team for the purpose of making trading, drafting and personnel decisions. The aim of this study was not for prediction purposes. Also, past research used multiple regression and discriminant analysis as the statistical analysis to predict events. The logistic regression analysis used in this study provides for predicting the probability of a win rather than predicting the event of winning or losing.

CHAPTER III

METHODOLOGY

The methodology discussion is divided into two sections: data collection and data analysis. The data collection section discusses the use of team statistics from the performance charts for both the men's and women's basketball teams. The data analysis section includes a brief review of the logistic regression computer program and an example of the computer output.

Data Collection

Team Statistics

The University of Iowa Men's and Women's basketball team statistics from the 1981-1982 and 1982-1983 season were collected. The total number of games the women's basketball team played was 51 games for both seasons. The total number of games the men's basketball team played was 59 games for both seasons. The total numbers of games included regular season tournaments and postseason tournaments in which both the men's and women's teams participated during the two seasons.

Performance Charts

The team statistics were collected from the performance charts used by the men's and women's basketball coaching staffs (see

Appendix A). The men's player performance chart differs from the women's player performance chart in two ways:

1. The men's chart utilizes 21 categories to record game statistics while the women's chart utilizes 17 categories to record game statistics.

2. The men's chart follows a point system. A point value is assigned to each category. The point value may range from 1 to 3, either positive or negative, depending on the category. The women's chart utilizes a simple tally procedure to record game statistics for each category.

<u>Independent Variables</u>

The categories listed on the men's performance chart that were used as predictor (independent) variables are as follows: assists, forced shots, field goals made, field goals missed, field goal percentage, free throws made, free throws missed, free throw percentage, offensive rebounds, defensive rebounds, total rebounds, defensive errors, turnovers, fumbles, bad passes, personal fouls, interceptions/steals, forced errors, drawing a charge, blocked shots, and total player's points.

The categories listed on the women's performance chart that were used as predictor (independent) variables are as follows: field goals made, field goals attempted, field goal percentage, free throws made, free throws attempted, free throw percentage, offensive rebounds, defensive rebounds, total rebounds, rebounding percentage, assists, turnovers, drawing a charge, steals/interceptions, blocked shots, personal fouls and disqualifications.

Data Analysis

Logistic Regression

The data were analyzed by a computer program, PLR, from the Biomedical Statistical Package. The program, designed by Laslo Engelman (1981), performs a stepwise logistic regression analysis. PLR selects predictor (independent) variables in a stepwise manner and estimates the coefficients for a logistic regression. The dependent (outcome or response) variable is a dichotomous variable coded as 0 or 1. The dependent variable records events such as success or failure, response or no response, etc. In this study the outcome (dependent) variable was win or lose, with a win coded as 1 and a loss coded as 0.

At each step in the process, an independent variable or set of independent variables is added to or removed from the model. A hierarchial rule allows an interaction into the model only if all its lower-ordered interactions and main effects are in the model. The stepping computations are based on either the maximum likelihood ratio (MLR) or an approximate asymptotic covariance (ACE). In this study, the maximum likelihood ratio (MLR) was used because this method is more exact than the asymptotic covariance estimate.

Example of PLR

Three basketball game statistics from the first 15 games from the 1981-1982 season for the University of Iowa women's basketball team had been used as data for the following example. The probability of a win was to be predicted from only these three independent variables (total rebounds, field goal percentage, and free throw percentage).

Initially, the three independent variables were included in the computation at step 0. Having all the variables included at step 0 allowed for the computation of their regression coefficients for the forming of an initial model statement. The model statement at this step predicted the probability of a win from all three variables, regardless of their significance as predictor variables. Also computed at step 0 was the goodness of fit chi-square which is a statistic that tests the hypothesis that the model fits the data at that particular step. At every step the improvement chi-square statistic was computed which tests the hypothesis that the variable entered or removed at that step significantly improves the prediction tool. The improvement chi-square value was computed from the log of the ratio of the current versus previous likelihood function values. A small p-value for the improvement chi-square indicated a significant improvement in the prediction at that step.

At every step, the p-values for the variables were given so that the computer could decide which variable should be entered or removed at the next step. The remove limit was a p-value that must be greater than 0.15 and the enter limit was a p-value that must be less than 0.10. After a variable was entered or removed at each step, three different goodness of fit chi-square values were computed for the new model. The p-values were computed for the chi-square statistics. The most important p-value was the one associated with the C.C. Brown goodness of fit chi-square. A small p-value indicated that the logistic model is not appropriate for the data. Also, the regression coefficients for the variables remaining in the model at that step were computed. It was here that the model statement could be formed to predict the probability of a win.

The program continued to analyze the remaining variables to be entered or removed, and continued to the next step in the process. If, however, the p-values of the variables did not meet the limit requirements, then a summary of the stepwise results were given.

In the example, the coefficients for all three variables were computed at step 0. Thus, the initial model statement formed was:

$$Pr(y=1) = \frac{e^v}{1 + e^v}$$

where $v = 20.1 + 0.047x_1 - 36.4x_2 - 10.4x_3$,

$y = 1$ is the dependent variable, a win,

x_1= total rebounds,

x_2= field goal percentage,

x_3= free throw percentage.

The only variable that met the remove limit was total rebounds, where the p-value for total rebounds was 0.8150. Field goal percentage had a p-value of 0.0088 and free throw percentage had a p-value of 0.1469. By removing total rebounds from the model, the variable, total rebounds, was no longer significant in predicting the probability of a win for this particular set of data.

The improvement chi-square p-value was 0.815, implying that the removal of the variable, total rebounds, did not improve the prediction greatly. The new model statement formed at step 1 would be as follows:

$$Pr(y=1) = \frac{e^v}{1 + e^v},$$

where $v = 22.1 - 39.0x_2 - 9.62x_3$.

At this point in step 1, the p-values for the remaining two variables were analyzed again but neither variable met the remove limits. The C.C. Brown goodness of fit chi-square value was 0.784 which indicated that the logistic model is appropriate for the data.

It was found in this set of data that rebounding was not a significant variable for predicting the probability of a win. Total rebounds was removed from the model at step 1. Field goal and free throw percentages remained in the final model, however, it was evident that field goal percentage was the best predictor variable of the three variables because the p-value for field goal percentage was the lowest value, 0.088.

In summary, the prediction of the probability of a win in a basketball game was estimated by a prediction model formed through logistic regression analysis. The possible predictor variables were defined and their relationship between each other was examined. As a secondary purpose of this study, the performance charts from the men's basketball team and the women's basketball team were compared to determine the better chart to record game statistics for prediction purposes.

CHAPTER IV

RESULTS AND DISCUSSION

After collecting the game statistics for both men's and women's basketball teams, the data were analyzed using two computer statistical packages, SPSS and BMDP. The results of these two separate analyses are divided into two subsections of this chapter with the first section presenting the factor analysis and the second discussing the logistic regression analysis.

Factor Analysis

A factor analysis was conducted using SPSS for each of the men's and women's data in order to define a smaller subset of predictor variables for the subsequent logistic regression analysis. It had been determined through previous trial runs of the logistic regression analysis that the complete set of possible predictor variables was too large for the limitations of the computer program. It was also determined that some of the predictor variables were dependent on each other.

Women's Data

Information from the results of the factor analysis was used to reduce the set of possible predictor variables from 17 to 13 variables. The elimination of the four variables was based on the communality of each variable and the intercorrelations among the variables as determined by the factor analysis. The communality of a variable is the variance it shares with other variables

(Kerlinger & Pedhazur, 1973). The communality indicates how much that variable has in common or how redundant that variable is with the other variables in the set. The intercorrelations of the variables were used to support the decision in eliminating the variables based on their communality values.

The following variables were eliminated as possible predictor variables based on their communality in their respective groups as shown in Table 1: field goals made, free throws made, offensive rebounds, and disqualifications. In the field goal group, field goals made had the highest communality (.88) and therefore, was eliminated as a possible predictor variable. Free throws made had a communality value of .99 which was the highest in the free throw group. Disqualifications was a variable dependent on personal fouls because five personal fouls for one player disqualifies that player from the rest of the game. Disqualifications had a higher communality (.69) than personal fouls (.50) and was therefore eliminated from the set of possible predictor variables. In the rebounding group, defensive rebounds had the highest communality value of .99. However, based on coaching strategy, offensive rebounds was eliminated as a possible predictor variable. In basketball, defensive rebounds and total rebounds are used more often as game statistics in analyzing the team's performance.

The intercorrelation coefficients for the set of possible predictor variables supports the decision of removing field goals made, free throws made, and disqualifications. The

Table 1. Communalities for the Set of Predictor Variables for the Women's Basketball Team

Group	Variable	Communality
Field Goal	Field Goals Made	0.88*
	Field Goals Attempted	0.70
	Field Goal Percentage	0.79
	Assists	0.74
Free Throw	Free Throws Made	0.99*
	Free Throws Attempted	0.92
	Free Throw Percentage	0.67
Rebounds	Offensive Rebounds	0.90*
	Defensive Rebounds	0.99
	Total Rebounds	0.97
	Rebound Percentage	0.65
Recoveries	Drawing a Charge	0.20
	Interceptions/Steals	0.29
	Blocked Shots	0.42
Errors	Turnovers	0.33
	Personal Fouls	0.50
	Disqualifications	0.69*

* Variables eliminated as possible predictor variables.

intercorrelations of the four variables eliminated in their respective groups are presented in Table 2. All the variables eliminated had the highest correlation in their group of variables except for offensive rebounds (.56). Defensive rebounds correlated more highly with total rebounds (.79) and moderately with rebounding percentage (.57). Total rebounds also correlated highly with rebounding percentage (.72).

Based on the correlations, communality values, and coaching strategy, the remaining possible predictor variables were field goals attempted, field goal percentage, free throws attempted, free throw percentage, defensive rebounds, total rebounds, rebounding percentage, assists, turnovers, drawing a charge, interceptions/steals, blocked shots, and personal fouls. This set of possible predictor variables was entered in the stepwise logistic regression analysis to determine the set of predictor variables for the criterion, a win, for the women's data.

Men's Data

The factor analysis results were used to reduce the original 21 possible predictor variables to a smaller subset of 15 variables. The elimination of the six variables were based on their communality values and the intercorrelations of the 21 variables. Four of the variables (total team points, field goals made, free throws made, and offensive rebounds) were eliminated as possible predictor variables based on their communalities in their respective groups as shown in Table 3. Total team points, which

Table 2. Intercorrelations of the Predictor Variables for the Women's Basketball Team

	Field Goals Made	Field Goals Attempted	Field Goal Percentage	Assists
Field Goals Made	1.00	--	--	--
Field Goals Attempted	0.45	1.00	--	--
Field Goal Percentage	0.57	0.35	1.00	--
Assists	0.58	0.41	0.21	1.00

	Free Throws Made	Free Throws Attempted	Free Throw Percentage
Free Throws Made	1.00	--	--
Free Throws Attempted	0.96	1.00	--
Free Throw Percentage	0.47	0.23	1.00

	Offensive Rebounds	Defensive Rebounds	Total Rebounds	Rebound Percentage
Offensive Rebounds	1.00	--	--	--
Defensive Rebounds	-0.02	1.00	--	--
Total Rebounds	0.56	0.79	1.00	--
Rebound Percentage	0.43	0.57	0.72	1.00

(Table 2 continued)

	Disqualifications	Personal Fouls	Turnovers
Disqualifications	1.00	--	--
Personal Fouls	0.62	1.00	--
Turnovers	-0.14	-0.02	1.00

Table 3. Communalities for the Set of Predictor Variables for the Men's Basketball Team

Group	Variable	Communality
	Total Team Points	0.99*
Field Goal	Field Goals Made	0.83*
	Field Goals Missed	0.89
	Field Goal Percentage	0.86
	Assists	0.79
	Forced Shots	0.38*
Free Throw	Free Throws Made	0.85*
	Free Throws Missed	0.76
	Free Throw Percentage	0.90
Rebounds	Offensive Rebounds	0.77*
	Defensive Rebounds	0.87
	Total Rebounds	0.94
Recoveries	Drawing a Charge	0.64
	Interceptions/Steals	0.51
	Blocked Shots	0.35
	Forced Errors	0.75

* Variables eliminated as possible predictor variables.

** Two variables combined into one predictor variable.

(Table 3 continued)

Errors	Defensive Errors	0.57
	Violations	0.58
	Fumbles	0.39**
	Bad Passes	0.46**
	Personal Fouls	0.64

* Variables eliminated as possible predictor variables.

** Two variables combined into one predictor variable.

was calculated by adding all the points for each variable, was dependent on all of the possible predictor variables. The communality of total team points was the highest of all the possible predictor variables (.99). In the field goal group, field goals missed had the highest communality value of .89. However, field goals made was eliminated because it was obvious to the author that field goals made would be a major contribution to winning a game. What is of interest is the effect of missed field goals on winning a basketball game. Free throw percentage had the highest communality value (.90) in the free throw group. Free throws made and free throws missed were used to form free throw percentage in a game. This relationship may have caused such a high communality for free throw percentage but based on coaching experience, free throw percentage remained as a possible predictor variable. However, free throws made was eliminated from the group based on the same reasoning for field goals made and because free throws made had a higher communality (.85) than free throws missed (.76). Total rebounds had the highest communality value in the rebounding group (.94). Offensive rebounds and defensive rebounds were added together to form total rebounds in a game. This relationship caused the high communality for total rebounds, but by removing either offensive or defensive rebounds, the communality of total rebounds decreased. Based on coaching strategy, it was decided to remove offensive rebounds because defensive rebounds is used most often as a game statistic for game analysis.

Forced shots was eliminated because the variable's value became too small to compute during the logistic regression analysis. The mean value of forced shots was -.37. The reason forced shots had such a small negative value was because it was a negative category on the performance charts and there were usually no more than one or two forced shots a game for the team. Bad passes and fumbles were combined into one variable labeled as "mishandled" because the effects of poor ballhandling skills were important to include as a possible predictor variable. The combining of the variables, bad passes and fumbles, into one variable was based on the two variables having the same weighted point values and both describing poor ballhandling skills.

The intercorrelations for the set of possible predictor variables support the decision of removing total team points, free throws made, and offensive rebounds. However, the intercorrelations for field goals made was lower than field goals missed with respect to field goal percentage. This does not support the decision to remove field goals made. The intercorrelations are shown in Table 4. Total team points correlated positively and more highly with the variables with positive point values than those with negative point values. This would be expected since coaches would like the positive performances to outweigh the negative performances of their team's play. Field goals missed correlated more highly with field goal percentage (.64) than it did with field goals made (.43). Free throws made correlated more highly with free throw percentage (.63) than did free throws missed (.45). Offensive rebounds correlated moderately with total rebounds (.56), whereas, defensive rebounds correlated highly with total rebounds (.84).

Based on the correlations, communalities, and coaching strategy, the remaining possible predictor variables were field goals missed, field goal percentage, free throws missed, free throw percentage, assists, defensive rebounds, total rebounds, defensive errors, violations, mishandled, personal fouls, interceptions/steals, forced errors, drawing a charge, and blocked shots. This set of possible predictor variables was entered in a stepwise logistic regression analysis to determine a set of predictor variables for the probability of a win for the men's basketball team.

Table 4. Intercorrelations of the Predictor Variables for the Men's Basketball Team

	Field Goals Made	Field Goals Missed	Field Goal Percentage
Field Goals Made	1.00	--	--
Field Goals Missed	-0.27	1.00	--
Field Goal Percentage	0.43	0.64	1.00

	Free Throws Made	Free Throws Missed	Free Throw Percentage
Free Throws Made	1.00	--	--
Free Throws Missed	-0.26	1.00	--
Free Throw Percentage	0.63	0.45	1.00

	Offensive Rebounds	Defensive Rebounds	Total Rebounds
Offensive Rebounds	1.00	--	--
Defensive Rebounds	0.09	1.00	--
Total Rebounds	0.56	0.84	1.00

(Table 4 continued)

	Total Team Points
Total Team Points	1.00
Field Goals Made	0.62
Field Goals Missed	0.07
Field Goal Percentage	0.51
Assists	0.76
Forced Shots	-0.06
Free Throws Made	0.29
Free Throws Missed	-.0.20
Free Throw Percentage	0.07
Offensive Rebounds	0.24
Defensive Rebounds	0.33
Total Rebounds	0.41
Defensive Errors	0.02
Violations	0.09
Bad Passes	-0.05
Fumbles	-0.17
Personal Fouls	0.19
Interceptions/Steals	0.51
Forced Errors	0.44
Drawing a Charge	0.10
Blocked Shot	0.42

Logistic Regression Analysis

The data for both the men's and the women's teams were analyzed using the subprogram, PLR, of BMDP. The subprogram performed a stepwise logistic regression analysis on the set of possible predictor variables for both the men's and the women's data. A backward stepping process was used which put all the variables in the model initially and then the insignificant variables were removed step by step. At each step the regression coefficients for each of the remaining variables were computed.

Women's Data

Initially, all 13 possible predictor variables started in the analysis at Step 0. Having all the variables included at Step 0 allowed for the computation of the regression coefficients so the initial prediction model statement could be formed. The following is the initial prediction model formed at Step 0:

$$Pr(y=1) = \frac{e^v}{1 + e^v}, \qquad (1)$$

where $v = (b_0+b_1x_1+b_2x_2+. \; . \; .+b_{13}x_{13})$,
y = win,
b_0= -4.55, b_1= -.02, b_2= 50.1 b_3= .31, b_4= -3.49,
b_5= .07, b_6= .64, b_7= -64.0, b_8= -.08, b_9= -.61,
b_{10}= .96 b_{11}= .25, b_{12}= -.68, b_{13}= -.33;

x_1= field goals attempted, x_2= field goal percentage,
x_3= free throws attempted, x_4= free throw percentage,
x_5= defensive rebounds, x_6= total rebounds,
x_7= rebounding percentage, x_8= assists,
x_9 = turnovers, x_{10}= drawing a charge
x_{11}= interceptions/steals, x_{12}= blocked shots
x_{13}= personal fouls.

The p-values of the F test of significance for each of the variables were analyzed at every step to decide which variable would be removed from the initial model. The improvement chi-square and the goodness of fit chi-square were also computed at each step. The improvement chi-square and its p-value determined if the removal of the variable improved the model statement formed at each step. A decrease in the p-value from step to step would show an improvement in the model. On the final step, a low p-value indicated a significant improvement in the model. The goodness of fit chi-square and its p-value determined the fit of the data to the prediction model at each step. A high p-value meant that the data fit the model.

The stepwise procedure began by selecting the most insignificant variable, field goals attempted. This variable was selected because it had the highest p-value (.88) for the F test of significance at this step. The second variable removed was defensive rebounds with a p-value of .81. In the third step, assists was eliminated because it had the highest p-value of .62. The stepwise procedure found free throw percentage as the next predictor variable to be removed. The p-value of free throw percentage was .78. The fifth and final step eliminated drawing a charge from the model. The p-value of drawing a charge was .22. In summary, the five variables in order of their removal from the prediction model were (a) field goals attempted, (b), defensive rebounds, (c) assists, (d) free throws percentage, and (e) drawing a charge. The results of the stepwise procedure can be found in Table 5.

Eight predictor variables remained in the model, however, not all of the eight variables were statistically significant. The final set of predictor variables were field goal percentage, total rebounds, free throws attempted, rebounding percentage, turnovers, interceptions/steals, blocked shots, and personal fouls. There were three statistically insignificant variables included in the model which were interceptions/steals, blocked shots, and personal fouls. The ratio of the regression coefficient divided by its

Table 5. Stepwise Logistic Regression Analysis Summary for the Women's Basketball Data

Step Number	Term Removed	df	Improvement Chi Square	p	Goodness of Fit Chi Square	p
0					21.025	0.984
1	Field Goals Attempted	1	0.013	0.908	21.038	0.988
2	Defensive Rebounds	1	0.033	0.857	21.071	0.992
3	Assists	1	0.142	0.706	21.213	0.994
4	Free Throw Percentage	1	0.047	0.828	21.260	0.995
5	Drawing a Charge	1	1.004	0.316	22.264	0.995

Model Chi Square (8) = 22.264, df = 42, $p \doteq .995$.

standard error should have been above 2.0 for a variable to be statistically significant. This ratio was a t-statistic (df=60, $p \leq .05$). The three variables, however, remained in the model because they contributed to the stability of the model. If the three variables were to be removed, the improvement chi-square and goodness of fit values would change so that the model would not have improved and the data would not have fit the model.

The regression coefficients and F ratios were computed for all the remaining variables in the final step of the stepwise procedure. The regression coefficients are the raw-score betas and had to be converted to standardized beta in order to describe the relationship between the predictor variables. The standardized betas and F-values for each variable are presented in Table 6. Total rebounds contributed the most to the prediction than any of the predictor variables with $\beta = 3.47$, $F(1,41) = 10.11$, $p \leq .01$. In summary, the eight predictor variables in order of their contribution were: (a) total rebounds, (b) rebounding percentage, (c) turnovers, (d) field goal percentage, (e) free throws attempted, (f) interceptions/steals, (g) personal fouls, and (h) blocked shots.

The model chi-square at the final step was 22.26 (df=42, p=.995) which indicated the data fits the final model. The improvement chi-square was 1.004 with its p-value having decreased from .908 to .316. This signifies that the removal of the variables at each step improved the prediction model. It should be noted that the final prediction model which was a result of this study made it possible to compute the probability of a win for the University of Iowa women's basketball team given the team's field goal percentage, total rebounds, free throws attempted, rebound percentage, turnovers, interceptions/steals, blocked shots, and

Table 6. Logistic Regression Results for the Women's Basketball Team

Variable	BETA	F
Field Goal Percentage	2.42	11.52
Total Rebounds	3.47	10.11
Free Throws Attempted	2.19	10.04
Rebounding Percentage	-3.13	7.59
Turnovers	-2.97	7.26
Interceptions/Steals	1.01	4.39
Personal Fouls	-1.00	3.80*
Blocked Shots	-0.88	2.59*

[a] $F(1,49) = 4.044$, $p \leq .05$.

* not significant $\alpha = .05$.

personal fouls. The equation for the prediction of the probability of a win is presented below with the raw-score regression coefficients:

$$Pr(y=1) = \frac{e^v}{1 + e^v}, \qquad (2)$$

where $v = (-6.52+40.7x_2+.29x_3+.58x_6-54.6x_9+.25x_{11}-.50x_{12}-.25x_{13})$,
y = win,
x_2= field goal percentage, x_3= free throws attempted,
x_6= total rebounds, x_9= turnovers,
x_{11}= interceptions/steals, x_{12}= blocked shots,
x_{13}= personal fouls,

The percentage of information explained by the predictor variables in the model statement provides information required to predict all 51 outcomes of the games. The following is the calculation of the percentage of information explained by the model:

$$1 - \frac{SS\ res}{SS\ total},$$

where SS res is the sum of square of the residuals and SS total is the sum of squares of the total. In logistic regression, the SS res is approximately the goodness of fit chi-square of the model and SS total is approximately the goodness of fit chi-square for the y-intercept. The goodness of fit chi-square for the intercept on y is computed in the following formula (Ash, 1965):

$^2 = 2 \times (W)\ln(\frac{1}{p}) + 2 \times (L)\ \ln\ (\frac{1}{q})$ which reduces to

$^2 = 2(T)\ln(T) - (W)\ln(W) - (L)\ln(L)$

where W = number of wins,

L = number of losses,

T = total number of games,

p = total number of games/number of wins,

q = total number of games/number of losses

The percentage of information explained by the initial prediction model that included all 13 variables was 66%. For the final prediction model, the percentage of information explained by the predictor variables was 64%.

The percentage of information in logistic regression is comparable to the R in multiple regression analysis. Therefore, it was of interest to analyze the statistical significance of the difference between the initial percentage of information and the final percentage of information. In multiple regression analysis, the statistical significance of variables added to the regression equation is tested by calculating an F-ratio. The question that must be answered by analyzing the difference between percentage of information: Does having 13 variables add significantly more to the prediction than the contribution of the eight variables? To answer this question the F ratio was calculated for the difference between the two percentages of information by the following formula (Kerlinger & Pedhazur, 1973):

$$F = \frac{(R^2_{y.1,2,\ldots k_1} - R^2_{y.1,2\ldots k_2})/(k_1 - k_2)}{(1 - R^2_{y.1,2\ldots k_1})/(N - k_1 - 1)}$$

where N = total number of games

k_1= number of independent variables of the larger R^2,

k_2= number of independent variables of the smaller R^2.

In this case, $F(5,38) = .341$ which is less than one and therefore, not significant. Thus having all 13 variables in the prediction model does not significantly improve upon the prediction model with eight variables.

When the probability model was applied to predict outcomes, 90% of the games in a given season were predicted correctly for the women's basketball team. The equation also correctly predicted 80% of the wins for the women's games.

Men's Data

Initially, all 15 predictor variables started in the analysis at Step 0. Having all the variables included in Step 0 allowed for the computation of the regression coefficients for the formation of an initial prediction model. The following is the initial model statement:

$$Pr(y=1) = \frac{e^V}{1 + e^V} \qquad (3)$$

where $v = (b_0 + b_1 x_1 + b_2 x_2 + \ldots + b_{15} x_{15})$,
y = win,

$b_0 = -27.0$, $b_1 = .09$, $b_2 = 36.9$, $b_3 = -.05$, $b_4 = -.14$,
$b_5 = 6.32$, $b_6 = -.24$, $b_7 = .53$, $b_8 = -3.01$, $b_9 = .20$,
$b_{10} = .04$, $b_{11} = .63$, $b_{12} = .43$, $b_{13} = .38$, $b_{14} = .37$,
$b_{15} = -.36$;

x_1 = field goals missed, x_2 = field goal percentage,
x_3 = assists, x_4 = free throws missed,
x_5 = free throw percentage x_6 = defensive rebounds,
x_7 = total rebounds, x_8 = defensive errors,
x_9 = violations, x_{10} = mishandled,
x_{11} = personal fouls, x_{12} = interceptions/steals,
x_{13} = forced errors, x_{14} = drawing a charge,
x_{15} = blocked shots.

The p-values of the F test of significance for each of the variables were analyzed at every step to determine which variable would be removed from the initial model statement. The improvement chi-square and goodness of fit chi-square with their p-values were also computed at every step. The stepwise procedure began by selecting the most insignificant variable, assists, because it had the highest p-value (.99) of the F test of significance at this step. The variables continued to be removed at each step in order of their insignificance to the model. The following results were the order of the variables' removal from the prediction model: Step 2 - mishandled ($p=.79$); Step 3 - defensive errors ($p=.64$); Step 4 - free throw percentage ($p=.44$); Step 5 - free throws missed ($p=.31$); Step 6 - blocked shots ($p=.32$); Step 7 - defensive rebounds ($p=.35$); Step 8 - field goals missed ($p=.16$), and Step 9 - violations ($p=.16$). The final prediction model included the following predictor variables: field goal percentage, total rebounds, personal fouls, drawing a charge, interceptions/steals, and forced errors. The summary of the stepwise procedure can be found in Table 7. Of the six predictor variables, two insignificant variables were included in the prediction model, interceptions/steals and forced errors. The ratios of the regression

Table 7. Stepwise Logistic Regression Analysis Summary for the Men's Basketball Team

Step Number	Term Removed	df	Improvement Chi Square	p	Goodness of Fit Chi Square	p
0					23.887	0.992
1	Assists	1	0.000	0.995	23.887	0.994
2	Mishandled	1	0.060	0.806	23.947	0.996
3	Defensive Errors	1	0.300	0.584	24.248	0.997
4	Free Throw Percentage	1	0.548	0.459	24.796	0.997
5	Free Throws Missed	1	0.831	0.362	25.627	0.997
6	Blocked Shots	1	0.766	0.382	26.392	0.997
7	Defensive Rebounds	1	0.924	0.337	27.316	0.996
8	Field Goals Missed	1	1.650	0.199	28.966	0.994
9	Violations	1	1.505	0.220	30.471	0.993

Model Chi Square (6) = 30.471, df = 52, p=.993.

Table 8. Logistic Regression Results for the Men's Basketball Team

Variable	BETA	F
Field Goal Percentage	1.50	7.07
Total Rebounds	1.60	10.11
Personal Fouls	-2.23	9.93
Interceptions/Steals	2.11	5.41
Forced Errors	2.12	4.94
Drawing a Charge	1.62	7.89

[a] $F(1,51) = 4.034$, $p \leq .05$.

coefficient divided by the standard error fell below the minimum value of 2.0. This ratio was a t-statistic (df=60, $p \leq .05$). However, the two variables did contribute to the stability of the model.

The regression coefficients and F ratios were computed for all remaining variables in the final step of the stepwise procedure. The raw score betas were transformed to standardized betas in order to analyze the relationship between variables. The standardized betas and F ratios can be found in Table 8. The variable that contributed the most to the prediction model was personal fouls with $\beta = 2.2$, $F(1,51) = 9.93$, $p \leq .01$. In summary, the six predictor variables in order of their contribution were: (a) personal fouls

(b) forced errors, (c) interceptions/steals, (d) drawing a charge, and (e) total rebounds, and (f) field goal percentage.

The model chi-square at the final step was 30.47 with df=52, p=.993 and the improvement chi-square was 1.505 (df=1, p=.220) as shown in Table 7. The model chi-square indicated that the data fit the model. At this point, the final prediction model was used to compute the probability of a win for the University of Iowa Men's basketball team given the team statistics for field goal percentage, total rebounds, personal fouls, drawing a charge, interceptions/steals and forced errors. The equation for the prediction of the probability of a win is presented below with the raw-score coefficients:

$$Pr(y=1) = \frac{e^v}{1 + e^v}, \tag{4}$$

where $v = (-18.0+23.8x_2+.23x_7+.52x_{11}+.33x_{12}+.28x_{13}+.37x_{14})$,

where y = win,
x_2= field goal percentage, x_7= total rebounds,
x_{11}=personal fouls, x_{12}= interception/steals,
$x13$= forced errors, x_{14}= drawing a charge.

The percentage of information explained by the prediction variables in the model provides the information required to predict all 59 outcomes of the games. The percentage of information explained by the initial prediction that included all 15 variables was 65%. The percentage of information explained by the final prediction model of the six predictor variables was 56%. The test of significance for the differences between the percentages is an

F-test. In this case, F(9,45) = .88 which is less than one and therefore not significant. This indicated that by having all 15 variables as the set of predictors, the prediction model was not any more accurate than the six variable model in predicting the probability of a win.

When the equation was applied to predict the outcomes, 88% of the games in a given season were predicted correctly. The model also correctly predicted 93% of the games as wins for the men's games.

Discussion

The probability of a win for the women's basketball team was explained by a set of predictor variables that included field goal percentage, total rebounds, personal fouls, interceptions/steals, blocked shots, free throws attempted, turnovers, and rebounding percentage. The predictor variable that contributed the most to the prediction model was total rebounds. Total rebounds, along with field goal percentage, interceptions/steals, free throws attempted, and rebounding percentage indicate the importance of ball possession. Since all these variables are involved with possession of the ball, the characteristics of winning for the women's team is offense-oriented. Field goal percentage is obviously an offensive statistic in the game of basketball. A team can only make or miss shots on the offense. Total rebounds, however, can be divided into offensive and defensive rebounds. An effective use of either offensive or defensive rebounds would be to transform a rebound into at least a field goal attempt. Interceptions/steals indicates either good defense or poor offensive skills by the opponents. Nevertheless, an interception/steal does mean possession of the ball with the possibility of gaining two points at the expense of the opponent's losing the possibility of gaining two points. Finally, free throws attempted indicates the potential of gaining a point due to the opponent's fouling. The prediction model does indicate that some defensive characteristics such as blocked shots, personal fouls, and interceptions/steals are of importance to the women's basketball team. By blocking the opponent's shots, the team had good defensive position with the possibility of securing the rebound and obtaining possession of the ball. The opponents lose the possibility of gaining two points by having their shots blocked. Personal fouls would be a characteristic of an aggressive defense, poor body control by the players or inconsistent officiating. Obviously, personal fouls contributes negatively to the prediction model. Interceptions/steals means gaining possession of the ball by the team, which may be due to good defense. Finally, turnovers is an offensive characteristic, however, it means that the offense loses possession of the ball. Turnovers are an indication of poor ballhandling skills and/or mental errors. More importantly, turnovers represent the potential loss of four points by the team which indicates the variable contributes negatively to the prediction model.

The men's basketball team's probability of a win was explained by the following set of predictor variables: field goal percentage, total rebounds, personal fouls, interceptions/steals, drawing a charge, and forced errors. The first four men's predictor variables were the same as the women's basketball team. However, the characteristic of winning for the men's team is defense-oriented. The defensive skills (personal fouls, interceptions/steals, drawing a charge, and forced errors) are the dominant predictors. The effects of personal fouls and interceptions/steals as defensive characteristics of a team were already explained in the analysis of the women's team. Forced errors is definitely a defensive characteristic since it forces the opponents out of their flow of offense. By forcing the opponents to make an error on offense, it may lead to possible interceptions or steals by the defense. Drawing a charge is also a defensive characteristic that forces the opponents to lose possession of the ball. Drawing a charge represents excellent defensive position and the gain of a personal foul by the opponent's player. Total rebounds is both an offensive and defensive characteristic whose effect was explained in the women's analysis. The only pure offensive characteristic for the men's team was field goal percentage, which did not contribute as much to the prediction model as it did for the women's team.

The common predictor variables for both the men's and women's team were field goal percentage, total rebounds, interceptions/

steals, and personal fouls. Although these variables are common to both teams, they do not share the same statistical and weighted significance. Statistically, total rebounds is most significant for the men and field goal percentage is most significant for the women. Personal fouls contributed the most to the prediction model of the men's team while total rebounds contributed the most to the women's prediction model. For both the men's and the women's teams, three of the variables, field goal percentage, total rebounds, and personal fouls, agreed with the results in Price and Rao's 1977 study. The multiplicative model formed in Price and Rao's study used winning percentage for NBA teams as the criterion and found field goal percentage, free throw percentage, total rebounds, personal fouls, and assists as the parameters of the model. Price and Rao found field goal percentage, free throw percentage and personal fouls to be the most significant variables followed by rebounds and assists for NBA teams in the 1972-1973 season. In the seasons from 1968 to 1971, Price and Rao found field goal percentage, free throw percentage and rebounds to be the most significant variables followed by personal fouls and assists. The change in significance for personal fouls and rebounds was probably due to the change in the rules and style of play over the years in the NBA.

The percentage of information explained by the set of six predictor variables for the men's team was 56%. Originally, the set of 15 predictor variables explained 65% of the percentage of information. The difference between the two percentages of information was not signiciant. The set of eight predictor variables accounted for 64% of the required information for predicting the outcomes for the women's team. The original set of 13 predictor variables explained 66% of the percentage of information. Like the men, there was no significant difference between the two percentages for the women's team. The women's set of predictor variables, however, does account for more information than does the set of predictor variables for the men.

The difference in percentage of information explained for both the men's and women's models may be due to a bias in the winning percentage for both teams. In a prediction study, ideally the winning percentage should be approximately 50% to obtain the best predictions. In this study, the men's winning percentage was 73% while the women's winning percentage was 30%. Having the winning percentage at either extreme of 50% may have caused some biased results.

The final prediction models for each of the teams were the best model for that particular team. Even though the initial model may have accounted for more information explained by the predictor variables, there was no significant difference between the final and initial models. The final model, however, is a more accurate and stable model in predicting the probability of a win. In the final model, the set of predictor variables are the best combination of predictors that contribute the most to predicting the probability of a win. The initial model accounts for all the variables regardless of their importance to the prediction.

The major difference in the prediction model for the men and the women were the characteristics for winning. The predictor variables for the women were more offensively oriented with field goal percentage and total rebounds contributing the most to the model. The men's set of predictor variables were predominantly defense-oriented with emphasis on personal fouls, forced errors, and total rebounds. Overall, the predictor variables for the women's team explained more of the percentage of information required to predict outcomes than did the men's team set of predictors. The prediction model for the women's team also did predict 90% of the outcomes of a given season correctly while the men's model correctly predicted 88% of the outcomes.

In summary, the prediction models were formed for both the men's and women's basketball teams from a set of game statistics used as predictor variables. From these predictor variables the following variables were significant in contributing to the prediction model for the women's basketball team: field goal percentage, personal fouls, interceptions/steals, blocked shots, free throws attempted, turnovers, and rebounding percentage. The most important variables in predicting the probability of a win for the men's basketball team were: field goal percentage, total rebounds, personal fouls, interceptions/steals, forced errors, and drawing a charge. The predictor variable that contributed the most to the prediction for the women's team was total rebounds while for the men's team personal fouls contributed the most to the prediction model. Overall, the women's prediction model provided more explanation for the percentage of information than did the men's prediction model. However, it must be noted that the prediction models were developed from data from the University of Iowa Men's basketball team and the University of Iowa Women's basketball team. The predictions are specific to these teams and also to the particular charts that each team used. The models formed in this study should not be used to predict the probability of a win for other teams until the generalizability of the models is established.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This study developed prediction models using logistic regression for predicting the probability of a win in a basketball game. The results of this investigation has provided the first step in utilizing and analyzing game statistics as predictor variables for both men's and women's basketball teams. The game statistics were from the games played by the University of Iowa Men's (N=51) and Women's (N=49) basketball teams during two seasons, 1981-1982 and 1982-1983. As a secondary purpose of this study, the men's and women's results were compared because each team used different charting procedures.

Findings

The following findings were based on the results of this study:

1. Field goal percentage, total rebounds, personal fouls, rebounding percentage, free throws attempted, interceptions/steals, blocked shots, and turnovers composed the set of team statistics that best predicted the probability of a win for the women's basketball team. Field goal percentage, total rebounds, personal fouls, interceptions/steals, blocked shots, and forced errors composed the set of team statistics that best predicted the probability of a win for the men's basketball team.

2. Total rebounds contributed the most to the prediction followed by rebounding percentage, turnovers, field goal percentage, free throws attempted, interceptions/steals, personal fouls, and blocked shots for the women's basketball team. For the men's basketball team, personal fouls contributed the most to the prediction model followed by forced errors, interceptions/steals, drawing a charge, total rebounds, and field goal percentage.

3. The proportion of information explained by the set of eight predictor variables was 64% for the women's model. The proportion of information explained by the original set of 13 predictor variables was 66%. No significant difference was found between the two proportions of information. The women's model predicted correctly 90% of the games in a given season and predicted 80% of those games as wins for the women's team.

4. The proportion of information explained by the set of six predictor variables was 56% for the men's model. The proportion of information explained by the original set of 15 predictor variables was 65%. No significant difference was found between the two proportions of information. The men's model predicted correctly 88% of the games in a given season and predicted 93% of those games as wins for the men's team.

5. The set of predictor variables for the women's basketball team was predominantly offense-oriented, whereas the men's basketball team's predictor variables were predominantly defense-oriented.

Conclusions

Based on the percentage of information explained, the women's model predicts more accurately the probability of a win for the team. The set of predictor variables for the women's team provides 64% of the information required to predict the outcomes of games whereas the men's model only provides for 54% of the information required. The difference may be due to each team using a different peformance chart for recording game statistics. The women's basketball team records the game statistics as raw-scores whereas the men's basketball team uses a weighted point system to record game statistics. The weighted point system may not reflect the full value of each game statistic as it contributes to the total team performance. Some statistics may be arbitrarily weighted higher or lower than others depending on their importance to the coach. A coach who stresses defense may weight the defensive statistics higher in value than the offensive statistics. In doing this, the coach may be getting biased results as to the team's actual performance. The women's performance chart has no built in bias as to which game statistics contributes the most to the prediction.

Based on the results of this study, a raw-score statistical chart, such as the women's basketball team's performance chart, should be used to record data for use in developing a prediction model. The results from using a raw-score statistical chart yields an accurate and stable prediction model for a team without adding any biased weighting to each individual game statistic.

Implications

This study was an initial effort at examining team statistics on a game by game basis to predict the probability of a win in basketball. Developing a prediction model is a possible solution to the problem that basketball coaches have in determining their chances of winning the conference title or securing a post season tournament bid. If in a conference each team plays the other twice, then the coach can develop a prediction model from the statistics of the first half of the conference season to statistically analyze the outcomes for the second half of the conference season. The prediction model can provide further insight in trying to increase the probability of winning in the second half of the conference season. For those teams not in conferences, the prediction model can be developed from past team statistics and be used to predict the present season's outcomes.

The model can also help the basketball coach identify the team's strengths and weaknesses or personnel gaps. The prediction model and the importance of the set of predictors can be used by a coach to assist him or her in making strategical decisions, practice planning, and recruiting. Every team possesses different skills that are characteristics of that team. Determining the set of predictor variables can assist basketball coaches in analyzing their team's characteristics of winning. However, many coaches have their own coaching characteristics or coaching style such as "defense-oriented" or "reboundng specialist," etc. The set of predictor variables may be influenced by the coaches' characteristics or their style of coaching. However, the importance of the prediction model is to increase the team's chances of winning and finding the best factors contributing to the model.

This statistical analysis will have to be supplemented with some judgements on behalf of the coach if it is to be a useful model for making coaching decisions in basketball. Coaches may have a better understanding of their team's characteristics from the prediction model, but the opponent's characteristics should be of consideration in the decision-making process. The chances of winning a game are not strictly based on team statistics that reflect just the skill level of a team. There are many other factors that contribute to the probabilty of winning a game such as psycho-social and physiological factors. Also, team statistics in basketball do not account for every movement in the game as do baseball statistics. However, this statistical analysis provides basketball coaches with a new, scientific alternative for making decisions that no longer have to be based on descriptive statistics such as averages and percentages. This prediction model can provide the coach with a systematic technique in analyzing the team's chances of winning and objectively identifying the important skill components for their particular team.

Recommendations

In addition to the coaching applications of this prediction model, the following recommendations are made for future study:

1. Further investigation is needed to generalize the model at different levels of basketball, such as a prediction model for the professional league, college ranks, high school level, etc.

2. There is a need to explore further the use of logistic regression analysis for game analysis in other sports.

3. There is a need to investigate the effects on the stability of the prediction model as the winning percentage fluctuates.

4. Further research is needed to investigate using certain team statistics as predictor variables combined with certain psycho-social, cognitive, physiological, and anthropometric predictor variables to develop a total prediction model in basketball.

5. Develop a prediction model to predict the probability of a win in basketball based on a team's and their opponent's game statistics.

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APPENDIX A

THE PERFORMANCE CHART

H.T.: 34-24
Final 68-51
IOWA VS. Indiana
H (A)
DATE: 4/30/83

$\frac{35}{100} = .35$ TOTAL REB. EFFICIENCY (%)

PERFORMANCE CHART

5 TURNOVERS/MH

MINS./Fouls/FGP/FTP	FGM/FTM	FGA/FTA	OFF.REB.	DEF.REB	FORCED ERRORS	ASSISTS	S,C,L,5 BP,3,T,DP	DC	STEALS	INTER.	POST FD	BLK SHOTS
22 .000 H. ANDERSEN		IIII I (6)	III 3	(3)	I		LL 5 3 TO					
34 .231 L. ANDERSON .500	II (2)	IIII II (9) / I (2)		II (2) 2	I	II	DD (D)L 2 TO 1 MH			I	IIII IIII	I
31 .385 R. ANDERSON IIII .667	IIII (5) / II (2)	IIII IIII III (13) / III (3)	II 2	IIII (5) 4	I	III	LL 5 LL 5 3 TO 1 MH		I		IIII I	
11 .000 BAKER I 1.00	/ II (2)	III (3) / II (2)	I 1	II (3) 2								I
30 .462 FREITAG III .50	IIII I (6) / I (1)	IIII IIII III (13) / II (2)	IIII 4	IIII (8) 4	I		(D)(D) DD EF 1 TO 3 MH			I	III	
12 .000 GENZEN IIII .000	II (2)	IIII II (5) / II (2)	II 2	(2)	I		TT 5 5 4 TO				I	
GRAUER												
JOHNSON												
KILDAHL												
28 .571 LEE III	IIII (4)	IIII II (7)	I 1	III (4) 3	IIII	II	(D)(D)(D)(D) EF 1 TO 3 MH	I		II	IIII	I
11 .25 McALPINE II	I (1)	IIII (4)		I (1) 1	I	II	LP 1 TO					
21 .25 NELSON II 1.00	II (3) / II (2)	IIII III (8) / II (2)	II 2	IIII (6) 4	I	I	5 5 2 TO					I
MIN. 200 TEAM TOTAL FGP .338 FOULS 18 FTP .583	22 / 7	65 / 12	15 $\frac{15}{47} = .313$	(35) 20 $\frac{20}{52} = .385$	12	10	17 TO 8 MH	1	1	4	24	1

PLAYER EVALUATION

Final Score 76-65

OPPONENT: NAVY

HOME ☒ AWAY ☐

DATE: 11-3-82

PLAYER	TOTAL PERFORM. + (plus)	TOTAL PERFORM. − (minus)	TOTAL PERFORM. POINTS	FIELD GOALS MADE +2	FIELD GOALS MISSED −2	FIELD GOALS TOTAL	FIELD GOALS %	ASSISTS +2	FORCED SHOT −2	FIELD GOALS POINTS	FREE THROWS MADE +1	FREE THROWS MISSED −2	FREE THROWS TOTAL	FREE THROWS %	FREE THROWS POINTS	REBOUNDS OFFENSIVE +2	REBOUNDS DEFENSIVE +1	TOTAL REBOUNDS	REBOUNDS TOTAL POINTS	ERRORS DEFENSIVE −2	VIOLATION −2	BAD PASS −2	FUMBLE −2	PERSONAL FOULS −1	TOTAL ERR. PTS.	RECOVERIES INTERCEPTION +2	STEAL +2	FORCED ERR. +2	DRAW CHARGE +3	JUMP BALL RECOVERY +1	BLOCK SHOT +1	TOTAL RECOVERY POINTS	TOTAL BALL POSSESSION PTS Plus/Minus
41 Sackes	40	-7	+33	||||	||||	5/10	.50	|||		+6	||||	|	4/7	.57	+4	|||	|||	11	+15	2	|			|||	-7			||||	|		||||	+15	
42 Payne	18	-12	+6	|	|||	3/6	.33	|		-4	|||||	|	5/6	.83	+3	||	|	5	+8		||		|	||	-8		|	|	|			+7	
44 Gannon	17	-3	+14	|||||	||||	6/11	.545	||		+8	||		2/2	1.00	+2		|	1	+1			|		|	-3		||	|				+6	
24 Hanson	41	-5	+36	|||||	||||	7/11	.63	|		+8	|||||	||	8/10	.80	+4	|||||	||||	11	+17		S			|||	-5		|||	||				+12	
15 Garfine	18	-10	+8	||	|||||	2/8	.25	||||||		+6	||		2/2	1.00	+2		||	2	+2		T	||	|	||	-10		||	||				+8	
10 King	6	-1	+5		|	0/1	.0	||		+2					0			0						|	-1			||				+4	
11 Banks	7	-5	+2	|		1/1	1.00			+2					0	|		1	+1		T	|		|	-5			||				+4	
34 Anderson	2	-2	0							0					0							|		(|)	-2		|					+2	
25 Berkenpas	0	0	0	||	||	2/4	.50			0					0				0						0							0	
51 Lenius	5	-3	+2					|		+2	|	|	1/2	.50	+1						L			|	-3						|	+2	
32 Dennard	7	-1	+6	|		1/1	1.00	|		+4						|	|	1	+3					|	-1							0	
				26/53 = .471%							24/29 = .828%					32 Rebounds				14 TURNOVERS													
TEAM TOTALS			+142	+52	-54			+36	0		+24	-10				+28	+18			-2	-14	-10	-4	-15		0	+18	+30	+6		+4		

ERROR KEY DESCRIPTION

DEFENSIVE	VIOLATION
B – BASELINE DRIVE	C – CARRY
D – DOGGING	DD – DOUBLE DRIBBLE
H – HELP	G – GOALTEND
L – LINE OF BALL	L – LINE
P – BEHIND POST	OB – OVER & BACK
R – REACH	T – TRAVELING
S – SCREEN OUT	3 – 3 SECOND
T – TRAILCUTTER	5 – 5 SECOND
PP – PRESSURE PASSER	10 – 10 SECOND
PD – PERIMETER DROP	
CO – COMMUNICATION	
SB – STOP BALL	

OUR TEAM REBOUNDS	OPP. DEFENSIVE REBOUNDS	OPP OFFENSIVE REBOUNDS	OPPONENT 2nd SHOTS	OPPONENT TURNOVERS

COMMENTS: Half 37-25

FG 16/26 = .615% TURNOVERS 7

FT 5/8 = 625%

REB 9 REB

©SPORTS PROMOTIONS – 408 HIGHLAND CT., IOWA CITY, IOWA 52240

APPENDIX B

RAW DATA

WOMEN'S 1982-1983 DATA

ID	W	FGM	FGA	FGP	FTM	FTA	FTP	OR	DR	TR	RP	AS	TO	DC	I/S	BS	PF	DS
01	1	37	73	.506	11	17	.647	12	30	42	.433	24	24	02	21	07	24	00
02	1	20	47	.447	24	31	.774	14	15	29	.414	07	19	00	12	02	18	00
03	0	31	64	.464	13	18	.772	10	18	28	.378	10	20	00	08	00	24	02
04	0	28	73	.384	10	12	.833	11	19	30	.323	16	25	01	07	02	19	00
05	0	28	76	.368	07	13	.538	16	22	38	.409	18	21	00	12	03	21	00
06	1	33	82	.397	08	11	.727	19	31	50	.495	20	16	01	08	00	16	00
07	1	27	69	.391	17	24	.708	17	20	37	.378	17	21	02	17	00	16	00
08	0	31	69	.449	09	10	.900	14	19	33	.351	13	17	01	11	00	22	01
09	0	18	67	.273	20	26	.769	16	21	37	.407	12	23	00	10	02	14	00
10	0	27	67	.403	08	15	.533	12	18	30	.345	15	21	00	05	00	16	00
11	1	23	56	.411	20	26	.769	11	28	39	.371	13	22	00	08	02	20	01
12	0	25	70	.357	06	09	.667	09	23	32	.344	11	22	03	13	04	17	01
13	0	25	62	.403	12	22	.545	13	29	42	.442	18	32	00	15	06	17	00
14	0	21	61	.344	05	11	.467	19	18	37	.430	12	25	00	13	03	22	01
15	0	20	46	.434	17	22	.772	09	18	27	.391	05	27	00	08	01	18	00
16	0	22	65	.338	07	12	.583	15	20	35	.350	10	17	01	05	01	19	00
17	0	29	59	.492	11	14	.786	07	15	22	.379	10	18	01	20	01	16	00
18	1	25	53	.472	26	37	.703	13	19	32	.360	14	21	00	14	02	22	00
19	0	19	60	.317	15	23	.652	13	22	35	.417	07	21	00	10	02	29	02
20	0	30	74	.405	09	13	.690	14	16	30	.353	15	19	00	11	01	24	00
21	0	23	59	.390	13	19	.684	08	21	29	.367	10	14	01	10	03	27	01
22	0	25	62	.403	07	07	1.00	12	17	29	.420	09	15	02	08	02	15	00
23	0	17	66	.258	10	17	.588	09	19	28	.308	07	19	01	08	00	19	00
24	0	23	60	.383	07	11	.636	06	16	22	.293	08	15	01	11	02	21	01
25	0	24	63	.381	06	12	.500	12	17	29	.349	13	38	01	12	04	16	00
26	1	28	61	.459	16	18	.889	10	22	32	.390	12	11	00	15	01	16	00
27	0	26	66	.394	10	16	.625	11	17	28	.438	13	14	01	14	03	16	00

WOMEN'S DATA 1981-1982

01	0	22	71	.310	08	14	.571	10	19	29	.269	11	20	00	10	04	28	04
02	1	29	62	.468	12	15	.800	05	24	29	.377	09	17	00	07	04	14	00
03	1	28	62	.459	17	22	.773	03	20	23	.271	05	21	00	11	02	23	00
04	1	23	55	.418	18	22	.818	13	26	39	.424	01	16	00	03	05	17	01
05	0	22	62	.355	12	14	.852	08	29	37	.451	05	17	01	03	01	18	00
06	0	26	54	.481	28	39	.710	05	25	30	.385	14	21	01	04	06	21	01
07	0	28	71	.409	14	19	.736	10	28	38	.494	14	29	01	05	01	22	00
08	0	24	60	.400	03	07	.429	07	25	32	.390	09	24	02	04	05	20	00
09	1	23	50	.460	23	27	.851	08	22	30	.323	14	15	01	10	03	19	02
10	0	24	49	.490	09	15	.600	03	18	21	.300	11	22	02	06	02	21	00
11	1	26	74	.351	20	30	.667	19	17	26	.364	16	13	03	09	01	25	02
12	1	28	62	.452	10	14	.714	12	19	31	.323	21	23	02	08	00	27	02
13	1	28	64	.438	06	11	.545	11	12	23	.319	07	17	00	15	00	15	00
14	0	21	64	.328	11	19	.579	14	20	34	.333	09	22	01	10	01	21	02
15	0	18	64	.281	07	11	.636	10	16	26	.277	03	21	00	06	01	19	00
16	0	25	67	.373	04	09	.444	11	26	37	.411	18	18	01	07	01	15	01
17	0	25	63	.390	16	19	.844	15	16	31	.425	11	12	00	07	03	27	01
18	0	20	68	.294	23	31	.742	09	28	37	.359	07	20	00	04	04	24	02
19	0	23	60	.383	18	24	.750	07	19	26	.295	04	21	00	11	03	25	02
20	0	23	68	.338	08	11	.727	12	20	32	.360	04	16	00	09	00	19	01
21	0	28	72	.388	05	10	.500	12	10	22	.247	10	15	00	10	00	26	01
22	1	28	66	.424	12	15	.800	11	21	32	.381	08	07	00	08	01	17	00
23	0	29	69	.420	06	07	.857	07	15	22	.272	14	20	03	04	01	24	01
24	0	24	67	.358	04	08	.500	05	21	26	.313	05	14	02	05	03	21	02

```
MEN'S DATA 1982-83
ID W ITPFGMFGI FTP ASFSFTMFTI FTP OR DRTR DE VI BP FU PF IS FE DC BS
01 1 112 52-54.471 36 0 24-10.828 28 1933-02-14-10-04-15 18 30+06 05
02 1 112 72-76.486 50-2 24-20.705 32 4254-14-02-12-14-23 08 20+06 05
03 1 122 70-48.593 46 0 17-16.680 22 2845 00-08-30-06-21 18 16 21 05
04 0 051 60-80.429 34 0 06-20.600 26 2538-02-04-20-06-19 10 12+06 04
05 1 090 76-52.590 36 0 15-18.630 28 2438-06-12-10-02-20 12 10+03 08
06 1 049 44-50.468 16 0 22-20.687 24 2032 00-08-14-06-17 08 10+12 07
07 0 101 54-66.450 46 0 12-14.632 32 2541 00-04-08-06-16 10 10+06 08
08 1 044 40-46.465 26-2 07-12.538 18 1423 00-08-02-04-14 12 10 00 04
09 1 140 74-66.528 54-2 11-20.523 36 1836-02-06-08-14-20 28 38+09 09
10 1 048 52-76.406 38 0 04-12.400 32 1430-04-04-16-02-14 14 18+03 04
11 1 054 50-60.454 24 0 24-26.648 26 1629 00-04-10-08-16 12 10+06 05
12 1 102 52-36.590 40 0 13-16.619 14 1525-02-06-06-06-15 16 22+06 03
13 1 074 56-66.482 40 0 17-16.680 26 2235 00-10-16-08-15 14 08+06 05
14 1 081 52-46.530 38 0 14-16.636 20 2535 00-10-10-02-14 08 16 00 04
15 0 050 46-60.434 26 0 10-06.769 14 1522 00 00-14 00-14 02 22 00 01
16 1 075 62-78.443 38 0 19-18.679 28 2337 00-06-06-04-23 12 16+09 01
17 1 080 52-60.464 30 0 10-12.625 18 3241 00-08-10-06-12 16 14+03 04
18 0 040 46-46.500 28 0 14-12.700 12 2228 00-24-08-08-18 08 18+09 02
19 0 044 46-56.451 36 0 18 001.00 16 1422 00-14-08-04-16 04 12+09 02
20 1 041 44-52.458 26 0 11-08.733 12 1930 00-10-18-04-17 12 14+09 04
22 1 062 56-62.474 34 0 10-10.667 18 1729 00-04-08-06-15 06 10+12 03
23 1 062 44-48.456 26 0 13-18.590 14 1634 00-12-06-06-11 24 22 00 04
24 0 029 60-48.555 32 0 08-08.667 10 2025 00-12-18-02-23 06 06+03 09
25 1 131 72-56.554 54 0 20-14.740 24 2234-06-14-14-06-18 26 40 00 08
26 0 058 60-82.422 28 0 04-06.571 28 1125 00 00-04 00-14 12 10+06 03
27 1 056 50-70.417 30 0 10-16.556 26 3348 00-12-12-06-21 08 22 00 05
29 0 036 48-54.470 18 0 10-18.526 16 2735 00-08-14-04-25 20 12+06 06
30 1 086 50-44.531 26 0 24-10.627 14 2533 00-04-06-06-10 22 04 00 05
31 1 063 40-68.489 24 0 24-16.750 32 2238 00-12-04-02-20 18 12+06 05
32 1 097 52-40.565 30 0 25-16.758 14 3136 00-08-04-02-14 12 06 00 06
33 0 040 48-58.452 22 0 12-10.555 18 2131 00-02-08-10-15 16 08 00 03
MEN'S DATA 1981-82
01 1 055 68-62.523 34-6 16-16.667 30 2843-16-20-16-10-26 18 26+03 02
02 1 031 54-62.465 32 0 17-12.739 36 1432-58-10-08-06-13 18 18+06 05
03 1 047 54-76.415 34 0 14-18.560 30 2540-12-02-12-06-22 16 14+09 04
04 1 098 62-70.469 38 0 17-14.708 28 2337-06-06-06-02-18 24 18+06 05
05 1 126 76-66.541 54 0 08-08.667 38 2746-22-04-06-18-16 30 28+06 06
06 1 077 62-80.437 36-2 18-10.783 46 2144 00-14-14-06-17 18 14+03 05
07 0 012 44-72.377 26 0 08-08.667 22 2233-02-06-06-12-20 10 08 00 04
08 1 047 46-66.411 34-4 14-20.583 30 2540-10-12-06-14-17 08 24+03 02
09 1 063 44-32.579 32 0 13-14.650 12 1420 00-06-08-08-14 10 16+03 02
10 1 082 50-30.625 34 0 12-10.706 10 2328 00-10-08-06-14 16 14+03 04
11 1 055 36-30.545 24 0 20-16.714 10 2126-02-10-08-14-11 16 12+03 04
12 0 047 46-56.460 30 0 10-08.714 20 2131-02-14-08-04-24 10 20+03 02
13 1 081 60-34.526 34-2 18-16.692 22 2334-02-16-06-20-15 28 12+12 03
14 1 060 38-72.345 34 0 11-08.550 30 1530 00-14-06-04-18 28 26+06 03
15 1 078 44-56.440 40 0 12-10.588 14 2229 00-10-06-14-13 26 14+09 05
16 1 082 56-42.577 36 0 20-14.741 22 1425 00-10-08-10-16 16 14+12 01
17 1 085 56-42.571 36-2 06-18.400 16 2735 00-08-10-04-12 14 18+03 05
18 1 072 54-58.482 40 0 15-06.833 24 2032 00-12-14-10-15 18 08+03 05
19 1 076 46-68.403 36 0 16-12.615 26 1933 00-12-06-06-19 18 36+03 02
20 0 034 40-30.400 18 0 16-24.600 18 1928 00-06-12-02-27 12 20+09 02
21 1 064 34-42.447 24 0 25-10.833 20 2535 00-14-10-02-18 10 16+03 02
22 0 024 52-72.419 24 0 06-06.667 30 1833 00-12-12-10-23 06 16+06 02
23 1 097 68-48.586 30 0 11-22.500 30 2540 00-10-20-04-09 18 24 00 04
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58.	24	0	046	48-60.444	22	0	07-10.583	28	1327	00-08-06-04-13	10	14+03	01
59.	25	0	052	46-60.434	32	0	21-12.778	20	2737	00-14-06-12-20	14	12+03	04
60.	26	0	060	54-38.587	30	0	11-12.647	16	1016	00-18-08-04-21	10	18+06	04
61.	27	1	080	52-58.472	34	0	18-08.818	18	2635	00-08-16-10-22	18	26+03	05
62.	28	1	057	56-58.493	34	0	11-16.579	20	1626	00-02-12-08-27	14	12+18	02