THE RELATIONSHIP BETWEEN NCAA VOLLEYBALL STATISTICS AND TEAM PERFORMANCE IN WOMEN'S INTERCOLLEGIATE VOLLEYBALL

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Nancy L. Estabrook

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Author: Nancy L. Estabrook

Read and Approved by: Francis X Short

Daniel E. Smith

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Cindy Houston-Wilson
Chairperson, Department of
Physical Education and Sport

Abstract

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The purpose of this investigation was to determine relationships among NCAA statistical categories and the success of women's intercollegiate volleyball teams. The investigator used 1994 NCAA box score statistics collected by the NCAA statistics department. These data were entered into a computer and analyzed using sub-programs from SPSSX. Means and standard deviations for each match statistic by match record and divisional alignment were run along with correlational coefficients for all statistics and indices of success (points per game, game record, and match record). Multiple regression equations were run to predict success as defined by points per game. Attack percentage was found to be the most important correlate of team success regardless of divisional alignment. Blocking was also important for Division I and II teams, but serving was more critical to Division III success. The resultant regression equations were able to account for 64-88 percent of the variance in predicting team success across the three divisions. The results demonstrated that success can be predicted to some extent in women's intercollegiate volleyball using NCAA match statistics, but prediction accuracy might be

improved by including statistics currently missing from NCAA box scores (eg., passing accuracy).

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CHAPTER I

Introduction

Women's volleyball has grown in popularity throughout high school and collegiate levels, and with this growth comes the need for quality guidance and coaching (Nelson, 1980). Still there are many areas of the game for which we have little knowledge. Volleyball coaches must understand all aspects of the game if their teams are to compete effectively. The evaluation of volleyball teams and their skills is crucial if coaches want to improve team performance. The ability to accurately evaluate the performances of teams, as well as that of opponents, is often a significant factor in determining the success of advanced volleyball programs. Volleyball ability can be evaluated many ways. A coach's subjective assessment of performance often can be inaccurate (Eon, 1989), therefore methods which would increase the accuracy of the assessment would greatly help coaches in their effort to improve performance. One method has been to evaluate volleyball performance through the use of statistics.

Statistics exist for virtually every sport, and volleyball is no exception. Recording statistics for match play in volleyball is becoming an important function for any team. Statistics can establish a relationship between a constant statistical game and a winning effort (Whalgren, 1971). Coaches keep detailed records of the statistics for each player and

running totals of team statistics in many categories. Most collegiate coaches use National Collegiate Athletic Association (NCAA) statistics. International coaches tend to develop and use their own methods of statistical evaluation. By collecting these statistics, the coach seeks to gain valuable knowledge and information about the team performing, in accordance with the game plan and/or how an individual player is performing. Up to this point, the attention to standardized volleyball statistical categories, being in existence for only a few years, has been somewhat limited. A more practical application of these categories seems necessary.

There have been a number of statistical studies using volleyball skills done at the international level (Wilson, 1952; Smith, 1953; Robins and Vangas, 1958; Lowell, 1966b; Coleman and Neville, 1968; Larsen, 1975; Coleman, 1975b; Peterson, 1969; Scates, 1972; Velasco, 1975; Coleman, 1991; Robins, 1967; Eon, 1989; Dimitrov, 1970; Coleman, 1975a; and Lowell, 1966a). The majority of these studies however, has been limited to men's volleyball, within specific tournaments or matches, using a variety of statistics, with many of these analyses focusing on statistical collection techniques. Many of the studies also addressed the relationship of the particular skills to team success. The majority of the research has involved individually developed statistics, which, in many cases, do not allow for any consistency across the studies.

There has been little research which deals with statistical

analysis at the collegiate level. Women's volleyball has also been somewhat neglected in this type of research. Of the volleyball research cited for this project, only three (Gorton, 1970; Nelson, 1980; and Rose, 1978) utilized women's volleyball. For these three studies, the researchers data collection also stemmed from researcher-designed systems rather than standardized systems.

So, although information has been made available on the relationship between volleyball statistics and team success, previous research has focused primarily on the men's game at the international level and has studied a variety of statistics. Thus far, no study has attempted to determine the relationship between NCAA standardized statistics and team success in women's volleyball.

Statement of the Problem

The purpose of this study was to investigate relationships among NCAA statistical categories and the success of women's intercollegiate volleyball teams. A sub-problem of this study was to determine if the relationships varied as a function of NCAA divisional alignment (I, II, III).

Significance of the Study

Women's volleyball has continued to attract more and better athletes as the sport progresses. There are few studies involving competitive performances as well as the six major

techniques. Presently, no statistical studies have been done solely with the top women's teams, international or collegiate. The lack of focus on women's games is interesting, considering the relative number of participants in the categories of both genders. To date, there are a total of 759 women's NCAA teams and only 65 men's NCAA sanctioned teams (NCAA, 1994 & 1995). With such an emphasis on volleyball statistics, this study will hopefully add a new dimension to volleyball knowledge by establishing a systematic relationship which may be used to evaluate performance at the top levels of women's competition.

There are other practical applications for this study. The coach may utilize this data for recruiting as well as practice purposes. New athletes or transfers to new institutions, may be screened as potential players given their personal statistics. If the coach needs to replace a defensive specialist, for example, he/she may recruit candidates having high statistics in the dig category. The coach may also collect statistics throughout the season and be able to design practice sessions around the skill(s) necessary to achieve a higher rate of success.

These methods of evaluation would increase the accuracy of team assessment, which would greatly assist coaches in their effort to improve performance. This study deals specifically with NCAA women, across the three divisions of volleyball, therefore the results should interest a significant number of coaches. It may also provide coaches in other sports the

interest to perform a similar study for their individual use.

Delimitations

This study was delimited to the NCAA statistics in Division I, II, and III collected in the 1994 NCAA Women's Volleyball Championship.

Limitations

A limitation of the current study was that the data were collected by the host schools' statistics committee. There are no requirements or training procedures provided by the NCAA with regard to recording statistics. However, the American Volleyball Coaches Association (AVCA) has made available a statistics video which assists the person collecting the data in the interpretation of this information. To date this is not required for any statistics collection committee. The AVCA has also provided definitions of each statistic to assist with interpretation. These definitions are provided below.

Definition of Terms

These definitions are a guide for uniform interpretations for the definitions of statistical categories in volleyball. These terms are found on the official NCAA volleyball Box Score sheet (Appendix A) and are taken directly from the National Volleyball Statistics Manual written by the American Volleyball Coaches Association (AVCA, 1992).

KILLS- are awarded to any player any time an attack is unreturnable by the opposition and is a direct cause of the opponent not returning the ball; of, any time the attack leads directly to a blocking error by the opposition. A KILL leads directly to either a point or a side-out.

ATTACK ERROR- is charged to a player whenever an attack or attacker: hits the ball out of bounds; hits the ball into the net; is blocked down by the opposition to the same side as the attacker, and cannot be kept in play as a direct result of the block; is called for a center line violation; is called for an illegal contact on the attack; hits the ball into the antenna. When a player is awarded an ATTACK ERROR remember that this also counts as an attempt and is counted in the player's total attempts.

TOTAL ATTEMPTS- equals the sum of KILLS, ERRORS, and "O ATTACKS."

"O ATTACKS"- Any attack attempt that is kept in play by the opposition and is not a kill or an error.

ATTACK PERCENTAGE- the total number of ERRORS subtracted from the total number of KILLS, all divided by the total number of ATTEMPTS.

ASSIST- Awarded whenever that player passes, sets, or digs the ball to a teammate who attacks the ball for a KILL.

SERVICE ACE- A serve which results directly in a point.

SERVICE ERROR- is charged to a player: if the serve hits the net or falls short; if the serve is out of bounds or hits the antenna; if the server foot-faults on the serve or takes too much time; if a player serves out of rotation the SERVICE ERROR is charged to the player who should have been serving.

RECEPTION ERROR- is charged to a player: if the serve strikes the floor in the area of the player; if the player passes the serve but it cannot be kept in play by her team; or if the player is called for a reception violation by the official.

DIG- is awarded to a player whenever a player passes the ball which has been attacked by the opposition. They are only given when players receive an attacked ball that is kept in play.

BALL HANDLING ERROR- is a call made by the official which ends play (i.e. a double hit, thrown ball, or a lifted ball).

BLOCK SOLO- awarded to a player whenever that player blocks the ball into the opposition's court leading directly to a point

or a side-out. That player is the only blocker attempting to block the ball.

BLOCK ASSIST- is awarded whenever two or three players block the ball into an opponent's court for a point or a side-out. Each player receives a BLOCK ASSIST even if only one player actually blocks the ball.

BLOCKING ERROR- occurs when an official calls a blocker for a violation; such as: a net violation, line violation, a back row player is called for blocking, and a blocker is called for reaching over the net.

CHAPTER II

Review of the Literature

Observations of volleyball experts have spanned from early studies finding particular beliefs to be different from one another, to present investigations using statistical charting systems developed to analyze a few skills or as many skills at a time. The author found supporting literature in which statistical charting systems were developed or modified in order to analyze skill effectiveness, as well as finding investigations in which skills were valid in predicting the success of a volleyball team. The review of literature has been broken down into five sub-sections including a section encompassing related volleyball studies as well as specifying the four major skill determinants for success in volleyball (blocking, passing, serving, and attacking).

Related Volleyball Studies

Robins and Vangas (1958), as cited by Coleman (1975b), supported the concept of evaluation to determine: A. How the best teams perform, and B. The general usage in understanding and improving the game. They charted 40 games at the United States Volleyball Association (USVBA) National Championships and tabulated data in six areas of the games:

(1) percent of correct spikes
(2) percent of opponents spikes returned by the block
(3) the percent of opponents spikes returned by back court

defense
(4) percentage of first balls over the net
(5) the number of serve reception errors per game
(6) the number of serving errors per game.

The following observations were made: (1) the percentage of correct spikes and spikes returned by the block were approximately constant for the teams observed, (2) the successful teams returned more balls by the defense than the unsuccessful teams, (3) the receiving errors ranged from three to ten per game, (4) the average number of service faults was six per game, and (5) three to 28 percent of the balls were played across the net without an attack.

Robins (1967) reported results of a comparison study between the level of play in 1961 to that of 1966 at the National Championships to determine if there had been any improvement. Two observations were made. Robins concluded that: (1) his comparison results showed no significant improvement in play from 1961 to 1966 which he found surprising due to the differences in skill techniques in receiving the serve, and (2) findings most relevant dealt with the comparison of results between team performance and the skills charted.

In 1968, Lowell reported intercollegiate statistics on determining success. He studied the Church College of Hawaii statistics of serve reception, spiking percentage, number of attacks by the front court, block percentage, and back court defense. The two factors which he cited for intercollegiate success were outstanding physical training and sound execution of fundamentals, which was supported by his statistical analysis.

Coleman and Neville (1968) devised one of the initial statistical systems used by many authors cited in this review of literature. The evaluation of a play was made on the basis of the contribution of that play to the success of the team. They described the system as follows. In general, the scoring for each phase of the game would be given in the following manner:

4- the play scored
3- very good execution, but no score occurred from it (Often the requirement was that you received a "free ball" from the play)
2- average execution
1- poor execution, but the point is not lost. (Often the requirement is that a "free ball" was given to the opponents on the play)
0- a complete misplay costing the point or side out.

A point average similar to an average calculated for academic grades in school is then tabulated for each phase of the game evaluated. The system became known as the "four point" statistical system. Because five digits were used, the system became a "five point" system. Today, many individuals refer to either title for this particular system.

Coleman, Neville and Miller (1971) attempted to apply the "five point" statistical system to backcourt defensive play of the United States National Men's team in training. They related the backcourt performance of the players to the composite opinion of the coaching staff. They found a .44 spikers correlation coefficient and a .72 setters correlational coefficient with defensive play. The data revealed that the opinions of a coaching staff quite often differ from the actual performance of the players.

Blocking as a Determinant for Success

Lowell (1966a) studied international volleyball teams and found that at least 50 percent of their scoring is done by the blockers. He concluded that at this level, this skill was important and should be emphasized during practice.

Lowell (1966b) reported that 55 percent of all contacts with the ball were made using the forearm pass. He also reported that during international play, 20 to 30 percent of the attacks were soft spikes. Lowell suggested that more practice time be spent on proper techniques and ranked blocking as the most important skill in determining success in international volleyball.

Peterson (1969) ranked blocking as the most important skill in determining success in international volleyball. She felt that a strong block enabled the defense to pass more successfully, thus building a stronger volleyball team.

Scates (1972) also ranked blocking as the most important skill in determining success in international volleyball. He supported Lowell's (1966a) findings through statistical analysis that over 50 percent of points are the result of effective blocking.

Velasco (1975) also ranked blocking as the most important skill in determining success in international volleyball. He reported that, in his survey of 53 national volleyball experts, 45 felt blocking was the number one skill which produced wins.

Larsen (1975) evaluated the same matches as Coleman (1975b) for spike defense in men's international volleyball. He looked

closer at spike defense, specifically blocking and digging. The information that was recorded to evaluate the skills of blocking and digging included: the number of digs and type of digs; the number of blocks and type of blocks; and the percent of spike defense plays that resulted in the completion of play.

The breakdown of the types of blocks and digs possible were as follows:

Block A - The spiker spiked the ball out of bounds, into the net, or fouled.
Block B - A stuff kill.
Block C - A stuff by the defense that was played again by the offense.
Block E - A ball blocked on the defensive side of the net that remained in play and was spiked by the defense.
Block F - A ball blocked on the defensive side of the net that remained in play but was returned as a free ball to the offense.
Block G - A ball that was not blocked but was dug by the backcourt.
Block H - A ball that was not blocked and also not dug; resulting in a point or a side out.
Block I - A ball that was blocked out of play or into the net, or a block on which the blockers fouled.
Block K - A ball on which there was no attempt to block, that was immediately killed.
Dig 1 - A ball that was dug enabling the setter the option of a multiple offense.
Dig 2 - A ball that was dug enabling the setter the option of setting two spikers.
Dig 3 - A ball that was dug enabling the setter to set only from one spiker.
Dig 4 - A ball that was dug back over the net, giving the offensive team a free ball.
Dig 5 - A ball that was dug on the defensive team's side of the net but had to be passed over as a free ball.
Dig 6 - A ball that touched the block and was immediately set or a ball which was dug and resulted immediately in a spiked ball.
Dig 7 - A ball doug out of bounds, over the net out of play, or a ball not dug.

Larsen's analysis applied percentages for each block and dig, and those percentages determined the grouping of categories

in the final charting system. A number was given to each group which was determined by the percent of success that group had. Performance levels were calculated for spike defense. A correlation was computed to determine the relationship between successful team performance and spike defense. To determine the relationship between blocking and digging and to determine how the various blocks related to other blocks, and how the various digs relate to other digs, multiple correlations were computed for all blocking variables and all digging variables. When applied to the outcomes of success (points scored, place or win/loss record) Larsen found the following R^2 values:

Points scored	Place	Wins/Losses
Dig 6 = .85	Dig 3 = .88	Block A = .89
Block F = .98	Block A = .989	Block H = .89
Dig 1 = .998	Dig 6 = .999	Block E = .999
Block H = .999	Block F = 1.00	Block F = 1.00

Larsen's results found that in determining points scored, place, or the number of wins/losses could be found by specific statistical relationships. The relationship between spike defense and final finish order was computed and found to be very high, (1.00) thus showing that specific blocks and digs are related to the final finish order and that the ability to predict the final finish order is possible if these specific measures are known.

Coleman felt more recently that previous statistical studies have continued to rate blocking as the first or second "determinant of success" at the international level, with attacking being the other major determinant. He also felt that attacking statistics collected in studies thus far had been well validated and documented.

Passing as a Determinant for Success

Coleman (1967) had his own theory, which stated that in international competition, defense was the key to success. He charted statistics at the 1965 World Cup Matches.

Keller (1968) believed that good forearm passing made it possible for teams to utilize a precision offense. Serve reception was the most important skill. He also believed that teams which tended to serve strong, would win the majority of games. Keller also felt that the serve could produce "instant points," and that a strong team should work for high percentage serves.

Dimitrov (1970) reported that international teams were highly effective at service reception. He felt that good passing made it possible to use the offense to beat the defense. With better passing, he felt that the setters could execute quicker offensive patterns against the defense with the intention to give spikers an opportunity to attack against fewer blockers.

Largey (1975) reported a positive correlation between serving and reception after surveying collegiate and amateur

coaches. He believed that good forearm passing made it possible for teams to utilize a precision offense. He also felt passing to be the determinant for success. He reported a positive correlation between serving and reception after surveying collegiate and amateur coaches.

Nelson (1980) utilized the statistical analysis system used by Coleman (1975a) and Larsen (1975) for both men's and women's collegiate volleyball. The serve, serve reception, spike, and spike defense (blocking and digs) were observed in order to determine the relationships of performance levels of skills for the final four teams in the 1979 AIAW and 1980 NCAA women's and men's championships. Mean scores were calculated for each skill for each team throughout the competitions. Overall means were also calculated for each skill. Correlation coefficients were calculated relating mean scores for each skill with the finish order. Correlation coefficients were also calculated relating the mean scores for each skill and the ratio of points won to points lost. A regression analysis was computed relating the mean scores for skills and the finish order, as well as one relating the mean scores for skills and the ratio of points won to points lost. He found that the pass and serve were major contributors to success. Serving and passing were most highly related and would be expected to be the major contributors in the final coefficient of determination. However, this result did not occur. Regression coefficients of determination relating the means to finish order appeared as such: Passing = 96%; Passing

and Spiking = 99%; Serving = 77%. There appears to be a relationship between skill performance levels and final team ranking.

Serving as a Determinant for Success

Wilson (1952) a leader in volleyball and former coach for the men's Olympic team, commented on volleyball skills and team performance in one of his early studies. Wilson discussed some possible methods of charting the serve and serve reception for determining player performance. The general concept for his research was recording errors. He considered that an effective team should be able to make 90 percent of their serves "good" with ten percent aces against their opponents. He also concluded that a team should make "good" passes 75 to 85 percent of the time.

Gorton (1970) conducted the first scholarly attempt to evaluate the relationship between skill performance and team performance in women's volleyball. Gorton used Coleman and Neville's (1968) "five point" statistical system to evaluate the serve and serve reception of three levels of women's teams in the 1970 Chicago Women's Volleyball Association. The objective of her study was to determine if there was a difference in serving and passing performances of AA, A, and B level girls' volleyball; and to determine, on each skill level, whether serving or passing was most related to team success. She reported the following findings:

(1) Serving averages were highest on level B and decreased correspondingly with an increase in the level of competition
(2) Passing averages were highest at level AA and decreased correspondingly with a decrease in the level of competition
(3) Level A had the highest percentage of service aces
(4) Level AA had the least percentage of being aced by the opponent
(5) At level AA the team with the higher serving average won 83.1 percent of the time, at level A 69.0 percent of the time and level B 80.6 percent.

She also found that 77 percent of games were won by teams with an effective serve, and 68 percent of games were won by teams with the most effective passing. Passing ability appeared to determine the level of competition at which a team played. Second, the winning team could be predicted a high percentage of the time by the serving and passing averages. Finally, serving average was better than passing as an indicator of which team won on a given level.

Coleman, Neville, and Gorton (1971) developed a statistical system for volleyball and used it in the Chicago Women's Association. The purpose for their study was to introduce a statistical system and to give a report of it's use. They charted spiking, passing (which included serve reception), and serving. Statistics were taken from monthly tournaments of the Association from December 1969 to April 1970 from three levels of volleyball. Thirty-six games were charted from the AA division, 2 games from the A division, and 31 games from the B division. There were two round-robin tournaments at each level. They found that serving appeared to be much better at the AA level as well as the passing. There were a high percentage of aces at the B

level, which may be explained by the ineptness of passing at that level, which in turn most likely determined the level of competition. They also found that serving effectiveness was the best indicator of which team should win.

Coleman (1975a) found a statistical agreement between serving scores and success for international men's volleyball. He observed relationships between serving, passing, setting, attacking, and winning in men's international volleyball. He randomly chose 31 games during the 1974 season and charted the serve, serve reception, the set and the attack. Mean scores were calculated for each technique for each team through the games and throughout the competition. Sequential relationships were investigated by determining coefficients of correlation between performance levels for each of the techniques, for each team. Performance levels were also calculated, for each technique, as a function of the level of performance of the preceding technique. The relationships between team performance for each technique and overall team performance was investigated a number of ways. First, correlation coefficients were calculated relating mean scores for each techniques with the finish order. Next, regression analyses were calculated relating point spread in each game to the difference in mean scores, for each technique recorded during that game. Finally, the number of games won by the team with the superior statistics in each of the techniques was tabulated.

Coleman found a high correlation of .86 in 1971 between

national rank and finish order passing averages. He found the correlation to be .82 in 1974. The level of competition, at which a team can compete is determined by its ability to receive serves. It was also found that passing and setting had a strong relationships, as well as the attack had the greatest influence on game outcome.

Attacking as a Determinant for Success

The purpose of Scott's (1971) study was to determine the relationship of charting specific volleyball skills under game conditions to team success. Eleven UCLA players were charted in 85 games during the 1971 season. Passing and attacking were observed. Correlation coefficients were calculated to determine the relationships among different groups of data. These coefficients were computed comparing the pass to the attack; the pass to team success; the attack to team success; and the pass and attack combined to team success. Point ratios showed correlations with spiking at .561 and showed .215 with passing. He found little relationship between efficient passing and efficient attacking. Attacking was found to correlate higher to team success than passing. It was proposed that passing efficiency and attack efficiency were contributors to predicting offensive success.

Cox (1973) studied the relationships among selected skill components and team performance in mens double A teams during the 1972-73 NorthWest double A volleyball tournament. Using an

adaptation of Coleman and Neville's (1968) 4-point statistical charting system, he studied the serve, serve reception, set, spike, spike defense (block and dig scores combined) and the free ball pass. Teams were compared by their win/loss record or points scored ratios. Using discriminant analysis, Cox determined the model selection in terms of group dispersion and centroid differences. The strength of the relationship was described in terms of a hit rate formed from cross tabulations of actual and expected memberships of the normal group. The nature of the relationship was depicted in the form of a pre-determined multiple linear regression model, which indicated all six predictor variables investigated. An example of a sample prediction was calculated using the chosen regression equation with a 95% confidence level placed on it. The multiple correlation between the six predictors and team performance was .866 with a coefficient of determination of .750. The R^2 of .750 indicates that 75% of the variance of the team performance variable is accounted for. The skill variable most influential in determining success in terms of winning and losing was spiking. To determine team performance Cox also found spike defense to have the greatest multiple correlation with team success. These differences did not represent contradictions in analysis, but differences due to the nature of the criterion variable. That is, if one wishes to predict winning or losing regardless of point spread, the discriminant analysis was found to offer the best ordering of predictors. Conversely, if one is

more interested in points scored and in point spread than merely winning or losing, the multiple correlation ordering was found to be most appropriate.

Statistically evaluating skills for men's volleyball at the 1974 World's volleyball championships, Coleman (1975b) observed the top six teams. He charted the serve, serve reception, the set, attack, block, and back court defense while trying to predict success on three levels. Immediate success (I) was defined as a favorable termination of play (I success/chances = % success). Eventual success (E) was determined by the favorable termination of play after the ball crossed the net at least twice (I + E success/tries = % success). Finally, unsuccessful measures were determined by I success/I + failures. Mean scores were calculated for each technique in each game, as well as each technique for each team throughout the competition. A grand mean was calculated for each technique and correlation coefficients were determined between the performance levels for each of the techniques for each of the teams. Performance levels for each technique were also calculated as a function of the level of performance of the preceding technique. The setting mean following each level of passing; the attacking mean following each level of passing; the attacking mean following each level of setting; and the blocking mean following each level of serving.

Relationships between performance levels for each technique and overall team performance were determined. Correlation coefficients were calculated relating mean scores for each

technique with the finish order in the championships. Correlational coefficients were also calculated relating the mean scores for each technique and the percent of games won by each team. A regression analysis was performed relating point spread and point ratios in each game to the difference in mean scores for each technique recorded during that game. A simple tabulation was made relating the differences between mean scores for each technique to the actual outcome of the game.

Performance levels were calculated and trends were observed when studying sequential plays. The level of play depended on the level of the preceding plays. There was a relationship between the performance levels of the various techniques and the final finish order. Coleman also determined that the general trend for all statistics was to be higher for the winning teams. The exception was setting. Attacking and blocking were the best predictors of point spread in any five games. Predictors for victory were correct 94% of the time when attacking values were used and 90% when blocking values were used. The serve, pass, and dig scores were correct predictors 75% of the time and setting scores were correct 65% of the time.

Rose (1978) analyzed skill components of the three levels of women's volleyball in relation to team performance using the five point charting system. While observing 256 games, he charted the serve, serve reception, spike, and spike defense (blocking and digging) to determine the possible point differential between teams. A step-wise multiple regression equation was used to

measure the contributions of each of the variables to team success as shown by point spread differential between the teams. The variables were ranked by the investigator in an order that would show the relationship of the variables to team success. In the multiple regression analysis, a validity coefficient was determined which represented the correlation between the independent variable skill components with point spread. He found a high correlation existed at the national level of competition for the spike (.73) and spike defense (.73). Validity coefficients were highest within all levels in the skills of spike and spike defense. The regression analysis also revealed the progressive increase of the correlations of all of the skill components, as the competition improved. At the Varsity and JV level, 65 percent of the variance included spike and serve. Spike and spike defense contributed 64 percent at the varsity level alone. At the National level, spike and spike defense contributed at a 72 percent rate. At the JV level of competition, the inability of the teams to receive the serve resulted in the serve being a major indicator of team success.

Rose (1980) also presented the modification of a presently existing statistical system as well as the findings from the 1981 Golden Dome Volleyball Classic. The NCAA team from UCLA was pitted against USC in the tournament. He charted the serve, serve reception, the spike, block, and back court defense. He recorded data for both teams in four matches, using the charting system developed by Coleman, Neville, and Gorton (1971). He

found that serve reception could indicate a teams level of competition. Attacking was found to be the best indicator of success for teams competing at the same level of competition. He also found a positive relationship between performance levels for the various techniques and the final finish order of the teams in the Classic. Differences in technique performance means as a single predictor of victory were determined. Averages of the data were found by comparing the performance means for each of the skills between opponents for each game. Spiking showed a 94 percent average, the serve a 70 percent average, the defensive serve showed an average of 64 percent, reception showed a 62 percent average, and the block showed an average of 58 percent.

Rose felt that coaches should be very interested in the spiking statistics of their athletes as it is the most highly correlated skill with victory.

Summary of Review of Literature

The review of related volleyball literature emphasizes the need for a valid and reliable statistical system for competitive volleyball at the collegiate level. Some observations were made by volleyball experts on which skills correlated with successful measures in volleyball. Other studies were of a more scientific nature in dealing with the data collection itself. The opinions of volleyball experts have varied, but it appears that the majority of the research suggests that attack percentages and the block or block defense are most relied on as the key elements to

success in volleyball.

The studies which have been completed generally cover different skills and at different levels of competition as well as representing truly scientific approaches to analysis. These scientific studies have begun to make people aware in terms of what can be learned about using statistical analyses to improve the performance of female volleyball players at the collegiate level.

It is the author's belief that this investigation will represent a simple method of statistical analysis for a large population of the volleyball community.

CHAPTER III

Procedures

Selection of the Subjects

The subjects for the study were the participating teams in the 1994 NCAA women's volleyball championship tournament from Divisions I, II, and III. Data was collected on a total of 109 teams, 48 from Division I, 29 from Division II, and 32 from Division III. The teams were selected to the NCAA tournament the following way for each division:

Division I

At least one team from each of the following regions was selected: Mideast, South, West and Northwest. There were seventeen conferences which were automatically qualified:

Atlantic Coast Conference	Midwestern Collegiate Conference
Atlantic 10 Conference	Missouri Valley Conference
Big East Conference	Pacific-10 Conference
Big Eight Conference	Southeastern Conference
Big Ten Conference	South West Conference
Big West Conference	Sun Belt Conference
Great Midwest Conference	West Coast Conference
Mid-American Athletic Conference	Western Athletic Conference
Metropolitan Collegiate Athletic Conference	

There were fourteen conferences which competed in play-in competition to fill the remaining seven conference berths. Play-Ins for Division I volleyball described by the NCAA are as follows:

"To provide more access to the Division I championship, the NCAA Executive Committee has implemented a play-in process for nonautomatic-qualifying conferences. The Executive Committee has determined that at least 50 percent of a championship's bracket shall be allocated for automatic-qualifying or play-in

conferences, based on the number of eligible conferences and the size of the bracket. Since the Division I Women's Volleyball Championship provides for a 48-team bracket, 24 berths have been designated for conference representatives. For the 1994 championship, 31 eligible conferences sponsor women's volleyball, which means that 17 conferences have been granted automatic qualification and 14 will participate in seven play-in competitions.

Play-in conferences are determined by the NCAA Division I Women's Volleyball Committee using statistical data from the most recent season provided by the computer-generated ratings percentage index (RPI), and conferences are notified of the status (i.e., automatic-qualifier or play-in team) approximately nine months before the championship" (NCAA, 1994).

The remaining teams were selected by a selection committee nd were given at-large berths. Their win/loss record must have ad an average above .500 to be considered for an at-large berth. nother determination which was weighted for at-large selections as head-to-head competition.

he Division I teams included:

niversity of Wyoming	San Diego State University
niversity of Washington	Loyola Marymount
niversity of Memphis	Arizona State
niversity of Wisconsin	Washington State
niversity of Northern Iowa	New Mexico
niversity of Texas	Michigan State University
niversity of Louisville	Texas A & M University
niversity of Arizona	Princeton
niversity of Nebraska	U C Santa Barbara
niversity of Houston	Central Florida
niversity of Florida	Idaho
niversity of Southern California	Montana
niversity of Hawaii	George Washington University
niversity of Colorado	Rider University
tsburgh	Iowa
l State	Brigham Young University
re Dame	Ohio State
ansas State	Illinois
rge Mason University	Georgia Tech
n State	Pacific
rgia	UCLA
alachian State University	Duke University
mson University	Stephen F. Austin
nford University	Long Beach State

ivision II

A selection committee selected four teams from each of the ollowing regions to participate: North Central, Northwest, South entral, Southwest. Three teams from each of the following egions were also selected: Atlantic, Great Lakes, Northeast and outh. There were six conferences which had automatic berths:

alifornia Collegiate Athletic Association
olorado Athletic Conference
reat Lakes Intercollegiate Athletic Conference
orth Central Intercollegiate Athletic Conference
orthern California Athletic Conference
unshine State Conference

eams below .500 were not considered unless they had tomatically qualified for their conference.

e Division II teams included:

C Davis
l Poly Pomona
ippery Rock
orida Southern College
rtland State
AFA
rtheast Missouri State Univ.
st Texas A & M
ringfield
yne State
w Haven
ry University
iversity of Minnesota (Duluth)
iversity of Northern Colorado
iversity of Nebraska (Kearney)
Cal State Bakersfield
Cal State L A
Edinboro University
Augustana College
Hawaii-Hilo
Regis
Central Missouri State Univ.
University of Central Oklahoma
Bryant
Northern Michigan
Portland State
Gannon
University of Tampa
Michigan Tech

ision III

Four teams from each region were selected: North East, New k, Great Lakes, Mid-Atlantic, Central, South, Midwest and t. There were no stated automatic berths. Schools were ermined by win/loss records as well as head-to-head

ompetition (NCAA, 1994).

he Division III teams included:

alifornia Lutheran	Occidental
mory University	Washington University
homas More College	Trinity University
hapman	U C San Diego
tony Brook	William Ephs
UNY Oswego	SUNY Brockport
ew York University	Ithaca College
ean College	Juniata College
ranklin and Marshall	Gettysburg College
uffton	John Carroll
io Northern	Kalamazoo
sconsin-Stout	Wisconsin-Oshkosh
sconsin-Eau Claire	Wisconsin-Whitewater
. Benedict	Simpson
buque	St. Olaf
stern Connecticut	MIT

urnament format

All Divisions played three-out-of-five, single-elimination tches and Divisions II and III played a third place match at e final site.

Data Collection

All data were recorded during the matches by a statistical llection committee at each host school. The statistical llection committee may have consisted of any number of people. ork Sheet was provided by the NCAA (see Appendix B) for each m that had competed. This committee sat court side and erved each game. There were no requirements for this mittee, therefore any person chosen may have collected the a. The Sports Information Director (SID) for the host itution attempted to choose people for the committee who may

have knowledge about volleyball or statistics. During the 1994 Regional tournament held at SUNY Brockport, the author was asked to be a part of the statistics collection committee. The other three on the committee included the SID for Brockport, an assistant to the SID, and a student in the physical education program at Brockport who had experience collecting statistics for other sports.

The statistical categories used by the NCAA in Box Score Form (see Appendix A) included the following: Kills (K), Attack Errors (AE), Total Attacks (TA), Attack (or kill) Percentage (AP) (which was found by: (K-E) + TA), Assists (ASST), Service Aces (SA), Service Errors (SE), Reception (passing) Errors (RE), Digs (defense) (Digs), Blocks Solo (BS), Block Assists (BA), Block Errors (BE), Total Team Blocks (TTB), and General Ball Handling Errors (GBHE). Total Team Blocks were used to represent the blocking statistics as a whole and are calculated by BS + 1/2BA.

The recording process consisted of placing a "hash" mark in the appropriate column on the Work Sheet when a player performed a particular skill, or when the execution of a skill resulted in a particular outcome. During brief breaks in the contest, the committee quickly gathered to verify related statistics such as: the number of kills per team must meet if not exceed the number of assists for each team; or the number of service aces per team must equal the number of team reception errors for the opposing team. Upon completion of the match, the SID transferred the "hash" marks on the Work Sheet to the Official Box Score Form

which was sent to the NCAA.

The box score forms are sent by the sports information director to the statistics/records department of the NCAA where the information may be used in a variety of ways. Obtaining this information from the NCAA was not difficult.

The author telephoned the statistics/records department and spoke to the individual who directly collects these box score sheets for the volleyball tournament. A copy of each box score sheet, for each match, was requested and it was photocopied and sent to Brockport via the United Postal Service.

Data Analysis

The data for each team in each NCAA tournament match, was entered into a data file in a Prime mainframe computer. The data file included an identification number, a code for divisional alignment, all NCAA match statistics, a code for whether the match was won or lost, and the points scored for every game played in the match.

Data were analyzed using sub-programs from SPSSX. Specifically, computer runs were performed to obtain the following statistics: means and standard deviations for each match statistic categorized by match outcome (i.e., winning team and losing team) and divisional alignment; correlation coefficient matrices for all match statistics and indices of success (i.e., match outcome, game record, and points per game); and values associated with a series of step-wise multiple

regression analyses utilizing NCAA match statistics to predict success. All SPSSX-generated "default" options were utilized in the multiple regression analyses.

CHAPTER IV

Results and Discussion

This chapter has been broken down into two sections, Results and Discussion.

Results

Mean scores were calculated for each skill for each division throughout the tournament. The standard deviation was also calculated for each skill for teams that won and teams that lost, for each division. These statistics are shown in Table 1.

Table 1. Means and standard deviations of match statistics for each division by match outcome (WT=winning team; LT=losing team)

		Division I		Division II		Division III	
		Mean	SD	Mean	SD	Mean	SD
Kills	WT	64.43	14.70	63.25	14.23	51.03	15.91
	LT	54.49	20.23	55.79	18.58	39.25	19.39
Attack Errors	WT	21.49	8.95	21.11	7.65	17.94	7.82
	LT	27.17	7.05	25.43	7.34	18.44	6.39
Total Attacks	WT	153.91	45.72	159.18	49.82	134.16	49.28
	LT	156.57	45.91	161.79	51.27	132.62	49.29
Attack Pct.	WT	.295	.83	.283	.81	.261	.78
	LT	.163	.76	.181	.70	.139	.90
Assists	WT	58.40	14.64	55.39	14.51	44.41	13.70
	LT	49.72	18.89	48.93	17.50	34.41	16.50
Service Aces	WT	5.66	2.69	6.82	3.27	8.59	3.12
	LT	3.91	2.52	5.14	2.88	4.84	3.08
Service Errors	WT	9.13	4.30	7.43	3.85	8.84	4.38
	LT	8.49	4.23	8.68	4.17	8.47	4.33
Reception Errors	WT	3.91	2.52	5.18	2.79	4.97	3.32
	LT	5.66	2.69	6.36	2.76	8.47	3.44
Digs	WT	64.77	20.87	73.61	29.43	65.75	26.95
	LT	59.77	22.99	72.82	32.63	60.25	30.57
Blocks Solo	WT	3.30	2.47	3.39	3.39	3.19	2.28
	LT	2.04	1.93	3.93	9.57	2.31	2.70
Block Assists	WT	16.69	7.72	14.04	6.52	8.78	4.98
	LT	11.21	7.92	14.04	6.52	8.78	3.59
Block Errors	WT	2.70	2.35	3.61	2.83	2.37	3.16
	LT	2.96	2.26	3.46	2.78	2.25	1.67
Total Team Blocks	WT	11.47	4.68	10.36	5.62	7.5	3.53
	LT	7.74	4.98	7.14	3.41	5.25	3.23
GBHE	WT	2.32	2.16	2.85	1.93	2.43	2.63
	LT	2.57	1.62	3.31	2.88	2.61	1.72
Points Per Game	WT	14.29	1.20	14.29	0.78	13.74	2.08
	LT	9.34	2.99	10.35	4.35	9.39	3.0

It appears that for a majority of the skills listed, there is an apparent trend among certain mean scores. Each match statistic across the three divisions of winning teams was observed for any similarities. The means were compared by divisional alignment to see if the numbers had a particular order. Seven out of 15 match statistics appeared to show an order per division(i.e., Division I kills mean score was 64.43; Division II kills mean score was 63.25; and Division III kills mean score was 51.03). The other match statistics showing similar score trends were hitting errors, attack percentage, assists, blocking assists, total team blocks, and points per game.

Another trend was also observed through this divisional alignment. Eleven out of 15 of the match statistics showed Division I having the highest (or better) score compared to Divisions II and III. These match statistics include kills, attack errors, attack percentage, assists, service errors*, reception errors*, block assists, block errors*, total team blocks, and general ball handling errors. (An * denotes those match statistics where a lower score is considered a better score.) The match statistic denoting points per game for Division I was tied with Division II, and aces was the only match statistic that ran in reverse order, with Division III having the highest score.

In order to determine whether there was a relationship

between match statistics and team success, team success was analyzed a number of different ways. Specifically, team success was defined by match record, game record, and points per game. Each of these indices of success was correlated to each of the NCAA match statistics. Tables 2-4 show these correlations.

Table 2. Correlation coefficients between each match statistic and match record, game record and points per game (PPG) for Division I

NCAA Stats.	Match Record	Game Record	PPG
Kills	.27	.31	.53
Attack Errors	-.36	-.14	.34
Attacks	-.03	-.03	.24
Attack Pct.	.64	.73	.73
Assists	.25	.27	.49
Ace	.32	.33	.49
Service Errors	.07	.05	.20
Reception Err.	-.32	-.33	-.29
Digs	.11	.11	.33
Blocks Solo	.27	.30	.36
Block Assists	.31	.32	.44
Block Errors	-.06	-.03	.10
Total Blocks	.36	.39	.51
GBHE	-.07	-.06	.11

In Table 2 correlation coefficients among match records, game records, and points per game, with each statistical category are shown for Division I matches. The coefficients for match outcome, game record and points per game show that attack percentage (.64 - .73), kills (.27 - .53) and total blocks (.36 - .51) were among the highest correlates of team success. The

highest correlation coefficients generally were found under the points per game column. (Twelve out of 14 of the highest coefficients were associated with points per game). This index of success appears to be most sensitive to the NCAA statistics for Division I. Table 3 contains similar information at the Division II level.

Table 3. Correlation coefficients between each match statistic and match record, game record, and points per game for Division II

NCAA Stats	Match Record	Game Record	PPG
Kills	.22	.24	.52
Attack Errors	-.28	-.32	-.11
Attacks	-.02	-.03	.27
Attack Pct.	.56	.68	.68
Assists	.20	.22	.46
Ace	.27	.37	.50
Service Errors	-.16	-.14	.00
Reception Err.	-.21	-.32	-.25
Digs	.01	.04	.29
Blocks Solo	-.04	.14	.02
Block Assists	.30	.31	.47
Block Errors	.03	.00	-.03
Total Blocks	.33	.29	.41
GBHE	-.10	-.09	.02

In Table 3 correlation coefficients among match records, game records, and points per game are provided for each statistical category for Division II matches. The coefficients show that attack percentage (.56 - .68), kills (.22 - .52) and block assists (.30 - .47) were the major correlates of team success. Again the highest correlation coefficients generally were found

in the points per game column; the largest coefficient for nine of the statistics can be found in the points per game column. Table 4 shows similar information for the Division III level.

Table 4. Correlation coefficients between each match statistic and match record, game record, and points per game for Division III.

NCAA Stats.	Match Record	Game Record	PPG
Kills	.32	.36	.50
Attack Errors	-.04	-.07	.13
Attacks	.02	.03	.22
Attack Pct.	.59	.70	.64
Assists	.32	.36	.49
Ace	.52	.57	.51
Service Errors	.04	.08	.17
Reception Err.	-.47	-.51	-.40
Digs	.10	.11	.29
Blocks Solo	.17	.23	.18
Block Assists	.30	.30	.35
Block Errors	.02	-.04	.05
Total Blocks	.33	.38	.32
GBHE	-.04	-.02	.10

Correlation coefficients for Division III are shown in Table 4. These coefficients show that attack percentage (.59 - .70) aces (.51 - .57), and kills (.32 - .50) were the major correlates to the indices of success. For nine of the 14 statistics in Table 4, the highest correlation coefficients were associated with points per game.

Given the coefficients presented in Tables 2-4, it appeared that points per game is the measure of success that is most highly sensitive to NCAA statistics. Four of the six top correlation's were found in the points per game category. The other two highest coefficients were associated with game record.

Attack percentage appeared to be the number one statistic related to team success for each Division. Kills and aces also appeared to be strong correlates of success.

In order to determine the relative contributions of the match statistics (variables) to team success, a series of step-wise multiple regression analyses were run. To find out how much impact one variable has on another and to establish how good the predictive success of this model is, multiple regression analysis is used (Iversen, 1976). Multiple regression can be used to predict particular outcomes. Shondell (1971) used multiple regression to study the relationship of selected physical and anthropometric traits to successful volleyball performance. Through multiple regression techniques, he developed a battery of test items that would prove valid, reliable, and practical in identifying potentially successful volleyball players. He found that the test battery's used were able to predict the volleyball potential of college men and correlated highly with playing ability.

Since points per game appeared to have the best relationships with match statistics when compared to the other indices of success, it was selected as the criterion variable for

the regression analyses. Points (ratio, spread, etc.) have been used as the criterion variable in a number of volleyball studies which employed correlational techniques (Scott, 1971; Cox, 1973; Coleman, 1975a, 1975b; Larsen, 1975; Rose, 1978; Nelsen, 1980). Tables 5-8 show the relationship between the variable or variables used in the regression equation to predict points per game (multiple R), the adjusted correlation coefficient of determination (adjusted R^2) and standard error.

The multiple R is the measure of association between the dependent variable and the combination of two or more independent variables (Cohen, 1983). The adjusted coefficient of determination (adjusted R^2) is the square of the multiple R with the two "extreme" values removed for the calculation, giving the coefficient a measure that is a truer reading of that correlation. It is used because it indicates a more appropriate value for the dependent variable. It is the proportion of the variation in the dependent variable "explained" by the model (Norusis, 1982). Adjusted R^2 indicates what percentage of the total variance of one or more coefficients in the preferred measure of success (i.e., points per game) can be explained on the basis of differences in the other NCAA match statistics. The analysis of variance checks the amount of variance in the scores between divisions against the variation among members of the same division.

Table 5. Regression analysis for points per game for all three divisions combined

STEP	STATISTICS	MULTIPLE R	ADJUSTED R^2	STD. ERROR
1	Attack Pct.	.73	.53	2.25
2	Total Block	.82	.66	1.89
3	Ace	.85	.72	1.72
4	Digs	.87	.75	1.64
5	Rec. Error	.87	.76	1.61

Table 5 shows that for all the divisions combined, attack percentage accounts for 53% of the variance for the prediction of points per game. Five steps were included in the analysis with five statistics accounting for a total of 76% of the variance in predicting points per game.

The resultant prediction equation includes the match statistics multiplied by the weight of that particular statistic, and also included is a constant which is necessary for predicting points per game:

PPG= 3.91 + (AP)(.02) + (TTB)(.17) + (SA)(.26) + (DIGS)(.02) +

(RE) (-.13).

Table 6 includes similar information at the Division I level.

Table 6. Regression analysis for points per game for Division I

STEP	STATISTICS	MULTIPLE R	ADJUSTED R^2	STD. ERROR
1	Attack Pct.	.73	.52	2.32
2	Total Block	.83	.69	1.88
3	Ace	.85	.72	1.79
4	Digs	.87	.74	1.70

Table 6 shows that for Division I match statistics, attack percentage accounts for 52% of the variance. A total of four steps were included in the analysis with four statistics accounting for a total of 76% of the variance in predicting points per game.

The resultant prediction equation includes the match statistics multiplied by the weight of that particular statistic, and also included is a constant which is necessary for predicting points per game:

PPG = 2.46 + (AP)(.02) + (TTB)(.17) + (SA)(.25) + (DIGS)(.03).

Table 7 includes similar information at the Division II level.

Table 7. Regression analysis for points per game for Division II

STEP	STATISTICS	MULTIPLE R	ADJUSTED R^2	STD. ERROR
1	Attack Pct.	.61	.36	2.26
2	Block Asst.	.76	.56	1.88
3	Digs	.81	.64	1.69

Table 7 shows that for Division II match statistics, Attack percentage accounts for 36% of the variance. A total of three steps were included in the analysis with three statistics accounting for a total of 64% of the variance in predicting points per game.

The resultant prediction equation includes the match statistics multiplied by the weight of that particular statistic, and also included is a constant which is necessary for predicting points per game:

PPG = 2.94 + (AP)(.02) + (BA)(.14) + (DIGS)(.03). Table 8 includes similar information at the Division III level.

Table 8. Regression analysis for points per game for Division III

STEPS	STATISTICS	MULTIPLE R	ADJUSTED R^2	STD. ERROR
1	Attack Pct.	.80	.63	2.14
2	Ace	.89	.78	1.64
3	Attack Err.	.92	.84	1.42
4	Serve Error	.94	.87	1.28
5	Total Block	.95	.88	1.21

Table 8 shows that for Division III match statistics, attack percentage accounts for 63% of the variance. A total of five steps were included in the analysis with five statistics accounting for a total of 88% of the variance in predicting points per game.

The resultant prediction equation includes the match statistics multiplied by the weight of that particular statistic, and also included is a constant which is necessary for predicting points per game:

PPG = 2.12 + (AP)(.02) + (SA)(.36) + (AE)(.13) + (SE)(-.17) +(TTB)(.13).

All four tables indicate that Attack Percentage is the main variable which accounts for at least 36% (Division II) and as much as 63% (Division III) of the variance for predicting success by points per game. The final variance for all of the tables show that 64 to 88% of success can be predicted for NCAA Volleyball.

Discussion

The purpose of this study was to determine relationships among NCAA statistics and success. The author defined success by using points per game (PPG) using the statistics adopted from the NCAA. The relationships were defined by a pearson r and multiple regression equations for each division. This section has been divided into three sub-sections: correlation, multiple regression and includes additional relationships.

Correlation

This investigation found that attack percentage was the number one statistic in predicting success for all divisions. Correlation coefficients relating PPG to attack percentage were moderate to high across the three divisions (r= .73 for Division I; .68 for Division II; and .64 for Division III). Kills also generated pearson r's above .50 for each division, indicating a moderate relationship with points per game. Aces also

demonstrated a moderate relationship with points per game for each division, but total blocks was a stronger correlate for Division I.

These results were similar to trends in previous studies. Scott (1971), Cox (1973), Coleman (1975b), Rose (1978, 1980) all felt that the attack was a major determinant for success in volleyball. These studies however, focused primarily on men's competition. Among these studies, only Rose's (1978) study looked at women's volleyball. Of the other studies that focused on the women's game [Gorton (1970), Coleman, Neville and Gorton (1971)], none identified the attack as the number one correlate of success.

Gorton (1970) evaluated the relationship of skill performance to the team performance in women's volleyball. She found that passing ability appeared to determine the level of competition at which a team played.

Coleman (1975a) also evaluated serving scores and success for international men's volleyball.

Multiple Regression

The major NCAA statistics, which the author found contributing to predicting success for Division I was attack percentage, combined with total blocks, aces, and digs, accounting for 74 percent of the variance. Division II statistics favored attack percentage in combination with block assists, and digs. Sixty-four percent of the variance was

explained for Division II using these statistics.

Division III favored attack percentage in combination with service aces, attack error, service error and total team blocks, explaining 88 percent of the success. So, 64 - 88 percent of the variance in team success was accounted for by NCAA statistics across the three divisions. These values seem to be consistent with the results of other studies using regression techniques.

Nelson's study in 1980 determined that 77-90 percent of variance in men's and women's volleyball could be predicted for selected skills in determining the teams performance in the NCAA and AIAW National volleyball Championships. He found passing to be the highest correlate. Cox (1973) was able to predict 75 percent of the team performance variable which is accounted for by the six chosen independent variables (serve, serve reception, set, spike, spike defense and free ball pass).

Rose (1978) was able to show the distinction between levels of women's volleyball given selected volleyball techniques. Seventy three to 78 percent of variance was found in significant differences for all skill components investigated, for all levels. This supported the superiority of the performance of the teams at the National versus Junior Varsity levels.

Some of the highest R^2 values in the literature for predicting success from volleyball statistics were reported by Larsen (1975). He used multiple regression to predict three measures of successful team performance and found 84-99 percent of the variance can be explained for the four variables used in

his charting system specifically for spike defense.

His study looked at spike defense, specifically blocking and digging, in men's volleyball. He found the relationship between spike defense and final finish order to be very high.

Coleman (1975b) determined performance means for each technique. Team performance was found to be almost 95 percent predictable, using passing and blocking variables together, which was described as "an excellent means of predicting tournament rank."

Prediction equations generally seem to be reasonable especially in light of previous research. The authors' study shows that 64-88 percent of the variance for each division, per given variables, can predict points per game. Given the references cited using percent variance, the authors' results are comparable to most of the other studies in the ability to predict success.

The success of the team, as determined by this study, is determined by points per game. The given variables for each divisional prediction equation appears to be weighted appropriately. One curiosity however is associated with the Division III equation [PPG= 2.12+ (AP)(.02)+ (SA)(.36)+ (AE)(.13)+ (SE)(-.17)+ (TTB)(.13)].

The weight for attack errors is positive, suggesting that the more attack errors made, the more successful the team will be with regards to points per game. This is not the case. The pearson r in attack errors and PPG = .13 indicating little or no

relationship, although the pearson r's for the other two division's were negative. Logically, if the weight had this negative value, it would have been thought more appropriate for the equation.

In correlations studies such as these, it is important to remember that correlation describes the degree of relationship between any variables, but that relationship is not necessarily cause and effect. So, in this case the positive relationship between attack errors and PPG reflects the data of the Division III national championships, but does not imply that to do well in Division III calibre play we should make many attack errors.

The correlation coefficients in table 4 were shown strongest in the game records column. If a multiple regression equation was formulated with this given success predictor, the equation would look as such: Game Record= (ATT %)(.01)+ (ACE)(.23)+ (TTB)(.11)+ (SE)(-.08)+ (-.29).

This equation may be more appropriate in determining success for Division III. However, because the author opted to consistently run multiple regression equations using points per game as determinants for success, it may have attributed to this large weight factor for the errors variable. With either perspective, the results in this study support the use of multiple regression in using particular NCAA statistics to determine team success for women.

Summary

One of the uses of this study is to give NCAA coaches a basis perhaps for which to recruit athletes. According to the results of the author's research, coaches should recruit and practice attacking for all divisions. Division I and II coaches should also focus on blocking, where Division III coaches should focus on serving and receiving as well.

These skills showed a high relation to team success. These R^2 values may increase if a measure of passing accuracy were to be recorded, an example being Larsen's (1975) study. His research found high R^2 values, yet the statistical collection process would not be practical at the NCAA level.

Many statistics were used for this particular research, however some of these statistics (TA, Asst., RE, BS, BE, and GBHE) are not highly related to PPG or helpful in predicting success. They could be eliminated, particularly if some measure of passing accuracy were to be added.

CHAPTER V

Summary and Conclusions

The purpose of this study was to investigate relationships among NCAA statistical categories and the success of women's intercollegiate volleyball teams. A sub problem of this study was to determine if the relationships varied as a function of NCAA divisional alignment (I,II, and III).

NCAA match statistics from 1994 were collected on a work sheet by host schools' statistics committees. These committees' transferred the match statistics to Box Score sheets and sent them to the NCAA. It was the statistics department at the NCAA where the author obtained a copy of each Box Score form, for each match. These data were entered into a file in a Prime mainframe computer and were analyzed using sub-programs from SPSSX. Means and standard deviations for each match statistic by match record and divisional alignment were run; in addition to correlation coefficients for all match statistics and indices of success. A series of step-wise multiple regression analyses using the NCAA match statistics were used to predict success.

The author found that attack percentage was the number one variable for predicting success in women's NCAA volleyball. Kills appeared for Division I and II while aces appeared as second strongest for Division III. Seven of 15 match statistics appeared to show order per divisional alignment. In addition to order, there were 11 of 15 Division I statistics that were higher than Division II or III. Additionally, percent of variance was

found to predict 64-88 percent of success for this study.

Conclusions

Based upon the results of this investigation, the following conclusions were made:

1. NCAA statistics account for a reasonable percentage of the variance in predicting success.
2. At least half of all NCAA statistics showed a ranking order with regard to divisional alignment.
3. Prediction equations are most accurate for Division III and least accurate for Division II.
4. Spiking (Attack percentage and Kills) appears to be the single best correlate of success in women's collegiate volleyball regardless of division.
5. Blocking appears to be more important to success for Divisions I while serving is more important for Division II and III.

Recommendations

The following recommendations for further statistical volleyball research are suggested:

1. Replicate prediction equations for each division with 1995 NCAA women's statistics or replicate study with men's NCAA volleyball statistics.
2. Utilize a NCAA match statistical charting team so that collecting statistics may become more consistent.
3. Include passing accuracy to see if R^2 values would increase.

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APPENDICES

APPENDIX A

FFICIAL NCAA® VOLLEYBALL BOX SCORE FORM

te: _____ Date: _____ Attendance: _____

EAM			ATTACK				SET	SERVE		PASS	DEF	BLOCK			GEN.
IO.	PLAYER	GP	K	E	TA	PCT.	A	SA	SE	RE	DIG	BS	BA	BE	BHE
EAM TOTALS:															

EAM ATTACK PER GAME: TOTAL TEAM BLOCKS:

Game 1					
2					
3					
4					
5					

GAME SCORES:	1	2	3	4	5	TEAM RECORDS:

EAM			ATTACK				SET	SERVE		PASS	DEF	BLOCK			GEN.
O.	PLAYER	GP	K	E	TA	PCT.	A	SA	SE	RE	DIG	BS	BA	BE	BHE
AM TOTALS:															

AM ATTACK PER GAME: TOTAL TEAM BLOCKS:

Game 1					
2					
3					
4					
5					

KEY

A = Assists	BHE = Ball-Handling Errors	SA = Service Aces
K = Kills	TA = Total Attempts	SE = Service Errors
E = Errors	RE = Receiving Errors	GP = Games Played
D = Digs	BS = Block Solos	TEAM BLOCKS = BS + 1/2 BA
PCT = %	BA = Block Assists	KILL PCT = (K - E) ÷ TA
	BE = Block Errors	

gth of Match: _____ 1st Referee: _____ 2nd Referee: _____

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APPENDIX B

NCAA® VOLLEYBALL WORK SHEET

: ____________________ SITE: ____________________ ____________________ VS. ____________________

PLAYER	NO.	GAME 1	GAME 2	GAME 3	GAME 4	GAME 5	K	E	TA	PCT.

G KEY:	K	E	TA	PCT.	K	E	TA	PCT.	K	E	TA	PCT.	K	E	TA	PCT.	K	E	TA	PCT.				

TTACK ATT. (ZERO)
LL
RROR TA = O + Ø + ●

PLAYER	NO.	ASSISTS	SA	SE	RE	DIGS	BS	BA	BE	BHE