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Review Article

A statistical examination into the structure of plays and its relationship to wins/losses in basketball games played by excellent players from the standpoint of STATS

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Abstract
We reviewed and summarized the findings from some kinds of perspectives. This allowed us to realize that no consistent findings can be obtained in terms of what plays/factors contribute most to wins/losses and the sequence of plays leading to scoring, that discriminant analysis is commonly used in the studies, and that for structural analysis, no rotational technique was used. Based on these findings, we devised the following new proposals: 1) Researchers need to exert more effort to analyze various kinds of games in the future, 2) We can recommend logistic regression analysis, but not only discrimination analysis. 3) For structural analysis, to make the research findings useful, the rotation of axes or principal components should be actively utilized.

Keywords: Basketball ; Game-statistics ; Wins/Losses.

1. Introduction

In major international or nationwide basketball games, not only game outcomes but also various plays or violations/fouls as well as the playing times of players have been published. They have been utilized not only for press releases, the selection of VIP players, and countermeasures against teams in upcoming games but also for studies to grasp the tendencies/characteristics of general basketball games. They are referred to as STATS or box scores and are well known among basketball-related people. In the STATS of basketball games, many items are employed to provide information not only on the success of the shot but also on the play during the shooting process, such as shot failures (shot attempts) and pass cuts (steals) leading up to the shot. For this reason, in the research field of game analysis, many researchers examine the relationship between these STATS and the wins/losses of games or the association among STATS using data centering on these STATS. Thus, this study reviews studies examining the relationship among plays or between plays and wins/losses of games by statistically analyzing these STATS or similar statistics of the plays, summarizes their findings, and proposes new directions for further studies by pointing out some problems.

2.The relationship between individual plays and game outcomes

Tamaki (2007) reported that the analysis of 2-point and 3-point shooting in games in the quarterfinals or later at the Kanto Women's University Championships indicated that winning teams made more 2-point shots attempts or successful 2-point shots than losing teams and that center players predominantly made many more scores. However, he avoided generalizing this conclusion because the center players in winning teams were taller than those in losing teams which influenced the team's strategies. Again, after comparing the successful shot rates of 2-point and 3-point shooting between entire games and an individual game in the WJBL (Women's Japan Basketball League), Yaita and Nodera (2007) defined the games in which the latter excelled the former as "Good condition" and the games in which the latter was worse than the former as "Bad condition," as well as examined the association between these and game outcomes. As a result, they reported that although no relationship was found in free throws, a significant relationship was detected among 2-point and 3-point shooting. They proposed that coaches should consider making a flexible

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change in their own team's strategies in the event of a "Bad condition" where the successful shooting rates of their own teams are low even against weak teams, or in event of a "Good condition" where the successful shooting rates of the opponents' teams are high. Also, Kozar et al. (1994) found that the scores by free throws accounted for approximately 20% of all the scores in 490 games of the NCAA (National Collegiate Athletic Association) Division 1. They did not find any significant difference in field goals between winning and losing teams, and discovered that the winning teams got more scores by free throws than the losing teams. They also asserted that when comparing the first 35 minutes and last 5 minutes, the winning teams got significantly more scores by free throws in both close (slight-difference-score) and unbalanced (large margin) games, indicating that the scores resulting from the last-5-minute free throws are a decisive factor in determining a win or loss.

By examining the association between the success rates of assists and the rates of plays leading to getting scores in games of the NBA (National Basketball Association), Maeyama (1996) found a significant correlation between them ($r=0.777$, $p<0.05$). They added that in order to win the game, not only must the shooter have excellent shooting ability, but also required are assists to enable the shooters to effectively make scores.

Goto and Iwaki (2006) reported that in the official games at the Kansai University Championships, teams with high rates of acquiring rebounds won with a probability of 88.8% and a 94.4% probability, particularly in defensive rebounds. They also found the relationship of $y=2.52x-15.9$ ($r=0.74$) between the difference of the rates of getting rebounds (x) and the difference of scores (y), of which the relationship was significant even after separately tallying them up by defensive ($r=0.74$) and offensive ($r=0.73$) rebounds. Moreover, they pointed out the relationship of $y=1.64x+7.80$($r=0.71$) between the total scores (y) and the number of rebounds obtained (x) and that of $y=0.65x-15.4$ ($r=0.75$) between the number of rebounds obtained (x) and the scores from successful rebounds obtained (x), from which successfully acquiring rebounds equates to achieving scores of 0.65 points. Oida and Shimada (1969) studied the relationship between rebounds and game outcomes in the West-Japan University Championship and reported that the rates of acquiring offensive and offensive rebounds were 49% and 63% in winning teams, and 37% and 51% in losing teams, indicating that winning teams were superior to losing teams in regard to rebounds and that acquiring rebounds greatly contributed to wins/losses. Again, Okamoto (1989) found the effectiveness of acquiring rebounds from the studies of wide-ranging finals for high schools, company teams, nationwide professional teams, and in international friendship games and cited the reason why acquiring rebounds enables even teams with low successful shooting rates to have opportunities to shoot again so that the teams can make more scores.

Other studies asserted the usefulness of fast breaks. Matsubara et al. (1973) studied the fast break in games of the All-Japan University Championship and recognized the effectiveness of it because the success rates of the formation of three-to-two that is advantageous in the final phase were very high, though it is not as significant as the established theory that the success rate of the fast break is high and the three-line fast break, in particular, is well-balanced and the preferable formation.

In addition, Okamoto (1989) concluded that fouls/violations are an important factor for wins/losses of games from the fact that many violations or fouls were found to be committed by the losing teams in a variety of games involving players ranging from unskilled to skilled.

In short, we reviewed studies investigating the association between individual plays or fouls/violations and game outcomes to date. Although it is natural that the number of successful 2-point and 3-point shots is directly related to the game outcomes, it can be considered meaningful to compare the ratios of both in shots attempted or both in successful shots. We realized that, as important factors influencing the win/loss of games, many researchers have listed effective assists and fast breaks as measures leading to a shot, getting rebounds as measures that increase the number of shots, and fouls/violations giving the opponents the opportunity to shoot.

However, since any of these can be examined individually with the game outcomes, nothing mentions how different these are from the others in contributing to wins/losses. Thus, in order to compare the contribution to wins/losses with other plays, they needed to be analyzed while simultaneously including plays that are thought to be related.

3. The relationship between plays and wins/losses from a comprehensive perspective

Miyazoe et al. (2007) conducted a comprehensive study using a variety of plays. They converted and subdivided the ordinal STATS of games in the Men's Kanto University Championship into 50 plays according to team and obtained correlation coefficients with final score differences between winning and losing teams. The converted and subdivided plays were subtotaled into the number of plays in the first and second halves, as well as the total number of plays in an entire game, their ratios, and the number of scores according to plays leading to successful shots (e.g., successful

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shots from turnovers and successful shots from 3-point shots). They reported that significant correlations were found in “Score;” “Successful shot rates in field goals;” “Score/offensive times;” “Successful rebound rates;” and “DEF EFF ([the number of defensive rebounds acquired + opponents’ turnovers]/defensive times)” in greater than six teams. Based on these plays, they proposed that in order for one’s own team to win, the team needs to achieve greater than 80.3 points in “Score;” greater than 45.2% in “Successful shot rates in field goals;” greater than 0.85 in “Score/offensive times;” greater than 52.6% in “Successful rebound rates;” and greater than 45.9% in “DEF EFF,” as well as ensure the opponent’s team makes less than 74.1 points in “Score;” less than 43.5% in “Successful shot rates in field goals;” less than 0.77 in “Score/offensive times;” less 47.4% in “Successful rebound rates;” and less than 40.7% in “DEF EFF.”

This study implicitly suggests the need to pay attention to the association between plays. Namely, although they examined comprehensive plays from various points of view, their methodology is not considered to be a mutual association, but rather the examination of individual plays independently. It is reasonable to consider that the plays in basketball games are mutually related. For example, strategies aimed to steal the ball naturally cause fouls to increase; the frequent use of fast breaks forces a slow-paced offense because of reduced stamina; and frequent 3-point shooting makes layup shooting through the gap between the defenders effective because the defense line extends. Additionally, from the standpoint of statistical procedure, in order to statistically examine the substantial relationship among plays after keeping the influence of the other plays constant, multivariate analysis that simultaneously deals with two or more variables can be proposed as a measure as will be described in the next section.

4. The relationship between plays and wins/losses using multivariate analysis

Karipidis et al. (2001) examined the association between the following 14 plays and game outcomes in the European Championship using canonical discriminant analysis (Dillon and Goldstein, 1984): Successful 2-point shots; Unsuccessful 2-point shots; Successful 3-point shots; Unsuccessful 3-point shots; Successful free throws; Unsuccessful free throws; Defensive rebounds; Offensive rebounds; Turnovers; Steals; Ball-possession times; Fast breaks; Fouls; and Assists. As a result, the discriminant function consisting of Defensive rebounds (Partial regression coefficient of discriminant function = 0.541); Unsuccessful 3-point shots (-0.335); Unsuccessful 2-point shots (-0.288); Successful 3-point shots (0.270); Steals (0.057); Fast breaks (0.043); Turnovers (-0.040); and Offensive rebounds (0.031) out of 14 items had a significant canonical correlation coefficient with 0.704 (chi-square =68.49, df=8, $p<0.0001$) of which the correct discriminant ratio was 84.9%, indicating that these eight items were effective in determining wins/losses.

Pojskic et al.(2009) tallied the following 22 items in 37 games performed in the Olympic Games by winning and losing teams: 2-point shots made; 2-point shots attempted; Successful 2-point rates; 3-point shots made; 3-point shots attempted; Successful 3-point-shot rates; Free throws made; Free throws attempted; Successful free-throw rates; Offensive rebounds; Defensive rebounds; Total rebounds; Assists; Fouls; Turnovers; Steals; Block shots; Total number of members participating; Fouls received; Scores made by non-starters; Scores made by starters; and Total scores. Then, they conducted a canonical discriminant analysis using game outcomes as a dependent variable and these 22 STATS as independent variables. They then reported that the canonical correlation coefficient was 0.809 (chi-square =64.926, df=11, $p<0.0001$), which was extremely significant, sensitivity (the rate that correctly determines winning teams) was 91.9%, and specificity (the rate that correctly determines losing teams) was 89.2%, indicating a high correct determination rate. Also, they claimed that since the obtained structure coefficients (correlation coefficients between independent variables and discriminant scores) of a discriminant function were Assists (0.505); Successful 2-point rate (0.481); 2-point shots made (0.410); Defensive rebounds (0.370); Scores made by non-starters (0.317); Steals (0.284); Successful 3-point-shot rate (0.274); Block shots (0.274); Total rebounds (0.268); 3-point shots made (0.212); The total number of members participating (0.197); Scores made by starters (0.179); Total scores (0.178); 2-point shots attempted (0.139); Free throws attempted (0.121); Free throws made (0.102); Fouls received(0.053); Successful free-throw rate (0.043); and Offensive rebounds (0.029) in descending order, Assists, 2-point shots made, and Defensive rebounds are extremely vital for game outcomes.

Using the 15 items of 2-point shots made; Successful 2-point rates; 3-point shots made; Successful 3-point-shot rates; Free throws made; Successful free-throw rates; Defensive rebounds; Offensive rebounds; Assists; Steals; Turnovers; Block shots; Block shots received; Fouls; and Fouls received, Garcis et al.(2007) also analyzed 183 games in the EBA (a Spanish basketball championship that is the fourth tier level in the Spanish basketball league system) and obtained a discriminant function differentiating winning and losing teams. As a result, significant structure coefficients were found in Fouls (structure coefficient = 0.38); Assists (0.34); and Defensive rebounds (0.30), and they pointed out that these plays were indisputable plays to predict game outcomes.

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In summary, the common method of these studies is that they all use discriminant analysis. The overall fit is determined by the correct discriminant rate, and the strength of the association of each play with wins/losses is determined by partial regression coefficients and structural coefficients.

5. The relationship between plays and wins/losses under various game conditions

Taking into account the fact that consistent results have not necessarily been obtained in comprehensive studies, some studies attempting to obtain general results under various game conditions can be found.

First of all, as studies categorizing game conditions from a score difference perspective, we can find Ibanez et al. (2003). After categorizing games in the Junior World Championship into the three groups of "Blowout," "Close," and "Very close," Ibanez et al. (2003) analyzed them using discriminant analysis. Utilizing independent variables were Assists; Fouls; Fouls received; Turnovers; Defensive rebounds; Offensive rebounds; Steals; Block shots; 2-point shots made; 2-point shots failed; 3-point shots made; 3-point shots failed; Free throws made; and Free throws failed. In the study, the association between plays and game outcomes under various game conditions was examined using the significance of structure canonical coefficients (SCC) of the discriminant function obtained. As a result, the following plays were significant: Defensive rebounds (SCC = 0.50); 2-point shots made (SCC=0.36); and Free throws made (SCC=0.31) in blowouts, and Defensive rebounds (SCC=0.31) in Close, but no plays in Very close.

Lorenzo et al. (2010) examined 132 games in the Junior European Championship according to score differences, i.e., the three categories of "Close," "Slightly close," and "Large margin," using discriminant analysis. For this, game outcomes were a dependent variable and independent variables were the 13 items of 2-point shots made; 2-point shots failed; 3-point shots made; 3-point-shots failed; Free throws made; Free throws failed; Defensive rebounds; Offensive rebounds; Assists; Steals; Turnovers; Block shots; and Fouls. As it turned out, the canonical correlations in the three groups of "Close," "Slightly close," and "Large margin" were 0.52(chi-square = 31.7; $p<0.05$); 0.84(chi-square =139.3, $p<0.01$); and 0.97 (chi-square =52.2, $p<0.05$), respectively. Significant structure coefficients (SC) were found in Assists (SC=0.33) and Turnovers (SC=0.47) in close games; 2-point shots made (SC = 0.34); and Defensive rebounds (SC = -0.36) in slightly-close games, and 2-point shots made (SC = 0.37) in large-margin games, in which plays affecting wins/losses were different depending on game patterns.

Some studies examined the relationship between plays and rankings that put entire games in a league together, but not individual game outcomes, because each game outcome is influenced by various factors other than ability.

Ibanez et al. (2008) also obtained a discriminant function to distinguish between higher- and lower-ranking teams that were obtained from game outcomes through all of the seasons of the Spain Professional League, Division 1. The plays used were 2-point shots made; 2-point shots failed; 3-point shots made; 3-point-shots failed; Free throws made; Free throws failed; Defensive rebounds; Offensive rebounds; Assists; Steals, Turnovers; Block shots; Block shots received; Fouls; and Fouls received. Consequently, a function significant at the 1% level was able to be obtained and it could correctly predict both groups with an 82.4% probability. Then, the structure coefficients (SC) that are the correlation coefficients between each item and discriminant scores were Assists (SC=0.47); Steals (SC=0.34); Block shots (SC=0.30); Fouls (SC=-0.24); Free throws made (SC=0.22); Defensive rebounds (SC=0.20); 3-point shots made (SC=0.16); Offensive rebounds (SC=0.16); 2-point shots made (SC=0.08); 2-point shots failed (SC=-0.08); Fouls received (SC=0.07); Block shots received (SC=-0.06); Turnovers (SC=-0.05); 3-point-shots failed (SC=-0.04); and Free throws failed (SC=0.02). They asserted that among them, Assists, Steals, and Block shots -- the top three plays -- were effective in differentiating between higher- and lower-ranking teams.

Sampaio et al. (2003) conducted a more comprehensive analysis, combining the three factors of "Regular seasons and play-off;" "Home and Away;" and "Game-score difference." Targeted games were 409 games (353 games in regular seasons and 56 in play-off) held in the Portugal Professional League, which were categorized into Very close games (less than 8-point difference), Close games (greater than a 9- and less than an 18-point difference), and Blowout games (greater than 19 points) according to Home and Away games. After checking the 13 items of Assists; Block shots; Fouls; 2-point shots made; 2-point shots failed; 3-point shots made; 3-point-shots failed; Free throws made; Free throws failed; Turnovers; Defensive rebounds; Offensive rebounds; and Steals, they conducted a canonical discriminant analysis on them. The results indicated that all the functions were significant at the 5% level because all the Wilks' lambdas were less than 0.6. Significant structure coefficients were detected in 2-point shots made in Blowouts and Home games during the regular season; Free throws made and Defensive rebounds in the Close and Away games in regular seasons; Fouls; 2-point shots failed and Free throws made in Blowouts and Home games during the regular season; Free throws made, 3-point shots made and Defensive rebounds in Blowouts and Away games during the regular season; Fouls and Offensive rebounds in Blowouts and Home games in the play-off; and

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Free throws made, Offensive rebounds, and Free throws failed in Blowouts and Away games during the play-off. That is to say, whereas only a small number of plays showed a significant relationship with the wins/losses of games in Close and Blowout games, many various kinds of plays did so in Very close games.
As has been noted, an overview of the results of these studies shows that they have not succeeded in obtaining common findings, because the findings obtained are diverse, depending on the situation, even among studies that attempt to obtain more general findings under detailed conditions.

6. Games of unskilled junior players
We have reviewed studies of games in which international or national skilled players performed. Since skilled players have the most desirable characteristics for basketball players, many studies have used the games they played. However, some researchers studied the games in which junior players performed, who were still unskilled and did not display desirable physical fitness or other basketball characteristics.

Focusing on Offensive time, The number of players participating; The number of passes; Group skills; Offensive strategies; and Efficacy, Ortega et al. (2006) analyzed 34 games in the Andalusia-Region Championship in which 16 teams, composed of 184 boys aged 15 to 16 years old, competed. The results of this analysis pointed out that the characteristics of the winning teams usually showed less dribbling and fast breaks with only two players.

Koh et al. (2011) examined the association between that were performed by 80 male players aged from 16 to 17 years of age in 20 countries in the FIBA 33 (irregular 3-on-3 games) games of the Junior Olympic Games as independent variables and wins/losses using discriminant analysis. The plays/fouls were the Successful rates of the 3-point shots; Team fouls; Successful rates of field goals; Successful rates of 2-point shots; Mean standing height according to team; Team personal fouls; Assists; The number of free throws granted; and The number of rebounds acquired. As a result, the canonical correlation coefficient was significant at the 5% level with 0.86, and significant structure coefficients (SC) were found, in descending order, in the Successful rate of the 3-point shot (SC=0.53); Team personal fouls (SC=0.53); Successful rate of field goals (SC=0.49); Successful rate of 2-point shots (SC=0.43); Mean standing height according to team (SC=0.39); and Team personal fouls (SC=0.34). Based on these facts, they focused on aggressive offensive play styles as well as high standing height and high rates of successful shots and pointed out that junior players received many fouls from opponents because of their high aggressiveness and they themselves committed many fouls.
Summing up, in the case of junior players, characteristics not seen in skilled players were found, specifically dribbling less, fast breaks involving only two players, and fouls. This fact allows us to suggest the need to conduct further research because when the subjects are less skilled players, it is easily assumed that different results are likely to be obtained.

7. Structure of plays/factors
Studying comprehensive plays/factors allows researchers to handle many plays/factors, but sometimes makes it hard for them to concisely summarize the findings obtained. For instance, if a certain type of play shows a strong relationship with another play, which also shows a strong relationship with wins/losses, it is expected that the first play would also show a strong relationship with wins/losses. In a situation like this, it is reasonable to examine the association with wins/losses after factoring in plays/factors with high correlations to each other in advance. For this reason, some studies examined the structure of plays/factors in advance before examining the association with game outcomes.

Sakai et al. (1998) examined the structure of plays in the games between two specific teams in the Kanto-University League. The plays used were 2-point shots made; 3-point shots made; Free throws made; Defensive rebounds; Offensive rebounds; Assists; Steals; Successful acquisition of lost balls; and Successful acquisition of held balls as plays contributing to a win; as well as 2-point shots failed; 3-point-shots failed; Free throws failed; Failed acquisitions of held balls; The number of missed plays; Defensive fouls; and Offensive fouls as not contributing to a win. Moreover, they conducted a principal component analysis on 19 items adding the three composite scores such as “Contribution to scoring” (obtained by weighing the frequency of plays contributing to scoring); “Contribution without scoring” that is plays without scoring; and “General contribution,” and extracted three components. The first component seemed to be a factor directly related to scoring because “Contribution to scoring” and “General contribution” were included. The second principal component did not contribute to scoring because only “Contribution without scoring” was loaded. The third principal component was not used in the analysis because it comprised only Defensive fouls and Offensive rebounds and no obvious interpretation could be given. Then, they examined the individual characteristics of each player using the first principal component and the second principal component that directly and indirectly contributed to scoring, respectively.

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Oga et al. (1990) applied factor analysis to the following 17 items: 3-point shots made; 3-point shots attempted; 2-point shots made; 2-point shots attempted; Free throws made; Free throws attempted; Total scores; Personal fouls; Offensive rebounds; Defensive rebounds; Recovery; Assists; Steals; Violations; Lost balls; Block shots; and Good defense in games in men's competitions at the Olympic Games. Then, they extracted the four factors of "2-point shots," "3-point shots," "Defensive rebounds," and "Free throws."

Using the 17 items of 3-point shots made; 3-point shots attempted; 2-point shots made; 2-point shots attempted; Free throws made; Free throws attempted; Total scores; Personal fouls; Offensive rebounds; Defensive rebounds; Recoveries; Assists; Steals; Violations; Lost balls; Block shots; and Good defense, Kodama (1989) factored games in men's competitions at the Olympic Games and derived "Free throw by receiving fouls;" "2-point shots;" "3-point shots;" and "Aggressiveness of defense." Then, he concluded that the offensive system is built upon centering on the two factors of "2-point shots" and "3-point shots" and that consistent competency to acquire the ball, represented by "Aggressiveness of defense," is related to game outcomes.

Again, there are other studies employing non-metric multidimensional scaling as a technique to extract structure. Kodama and Suzuki (1990) applied TORSCA, one method of non-metric multidimensional scaling, into the male competitions at the Universiade Games (World University Games) and extracted a three-dimensional space, interpreted as "Under-basket shooting after the competition in inside plays;" "Short- and middle-range shooting;" and "Aggressive passing and 3-point shooting." The items used were the following 17 items: 3-point shots attempted; 3-point shots made; 2-point shots attempted; 2-point shots made; Free throws attempted; Free throws made; Total scores; Offensive rebounds; Defensive rebounds; Turnovers; Assists; Steals; Personal fouls; and Block shots. In the same way, Suzuki and Kodama (1988) applied TORSCA to 14 plays (3-point shots attempted; 3-point shots made; 2-point shots attempted; 2-point shots made; Free throws attempted; Free throws made; Total scores; Offensive rebounds; Defensive rebounds; Turnovers; Assists; Steals; Personal fouls; and Block shots) in the Universiade Games and extracted the following three axes: "Basic offensive power through tug-of-war under the basket;" which relates to the score-getting pattern by 2-point shots; "3-point shots" which leads to the score-getting pattern by 3-point shots; and "Opponents' fouls and free throws" which is the score-getting pattern by free throws resulting from the opponents' fouls.

Again, Kodama (2009) applied ALSCAL, non-metric multidimensional scaling, to 16 items performed in the World Championship, i.e., Playing times by player; 2-point shots attempted; 2-point shots made; 3-point shots attempted; 3-point shots made; Free throws attempted; Free throws made; Offensive rebounds; Defensive rebounds; Assists; Turnovers; Steals; Block shots; Personal fouls; Fouls received; and Total scores, and extracted a three-dimensional space composed of "Inside/outside plays involved with scoring;" "Accuracy of plays and athletic ability;" and "The length of participating games." He discussed the association between these axes and game outcomes.
By applying ALSCAL to the games played by the top eight teams in the World Championship, Kodama et al. (2010) and Kodama (2009) derived a three-dimensional space, which comprised "Inside/outside plays involved with scoring;" "Accuracy of plays and athletic ability;" and "Air superiority (Seiku-ken in Japanese)." From the results, they reported that 2-point shots, 3-point shots, and Free throws, which are measures used to score, were involved with the first, third, and second dimensions, respectively.

To sum up, in terms of methodology, these studies mainly used multidimensional scaling or principal component analysis to clarify the factors that explain the relationship among the various plays based on the interpretation of the axes. Although factor analysis usually involves the rotation of axes (factors) to make them easier to interpret, these were not commonly used in these studies.

8. Discussion

8.1 Findings of studies of plays/factors involved with game outcomes using multivariate analysis

Up till now, we have reviewed the research findings of studies examining the association between plays/factors and wins/losses mainly using discriminant analysis. Research findings based on studying skilled players playing in the Olympic Games, European Championship, and Nationwide Top Leagues, in particular, pointed out that Defensive rebounds; 2-point shots made; Free throws made; Fouls; Assists; and others are important plays determining game outcomes. However, consistent agreement is not necessarily seen with regard to what plays/factors among them are the most decisive ones. With junior players, in particular, the unique characteristics that winning teams display -- fewer dribbling plays, only two-men fast breaks, and frequent fouls -- were seen. This fact enables us to actually

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attempt to study various levels of players, because different plays/factors were found as crucial factors depending on the player's skill/physical fitness level when studying less skillful players.

8.2 Findings of studies of the structure of plays/factors using multivariate analysis

We have reviewed the findings of the studies about the structure of plays/factors in order to examine the relationship between plays/factors and game outcomes while considering the mutual relationships among them. Studies using factor analysis or non-metric multidimensional scaling yielded a relatively small number of dimensions, e.g., three or four factors/axes. Especially when limiting the targeted games to the Olympic Games or equivalent international games, common factors/axes, such as 2-point-shot related plays, 2-point-shot related plays, and free-throw related plays from fouls, were commonly derived. That is to say, a series of plays leading to final shooting was structured. However, in university-level games, no structure that was differentiated by shooting method could be obtained. Only undifferentiated structure, categorized into the two groups of plays common to all shooting methods and plays not leading scoring, was able to be derived. This fact allows us to assume that the same undifferentiated structure will be extracted in games with junior players play because the players are also unskillful.

8.3 Statistical methods

From the viewpoint of analyzing procedures using multivariate analysis, (canonical) discriminant analysis has been commonly used in studies examining the association between plays/factors and game outcomes. The reason that t-tests according to items individually was not used, but discriminant analysis was used instead, can be explained by examining the relationship between plays/factors and game outcomes while statistically keeping the influence of other variables constant. Furthermore, structure coefficients were utilized to find the effective independent variables. Since plays/factors are not performed nor occur independently through the run of the games, but mutually relate to each other, a certain relationship will be found. Thus, since a relationship like this is worth considering, discriminant analysis can be said to be one of the preferable methods used for analysis. Incidentally, discriminant analysis is used not only to differentiate only two groups but can also be used to differentiate two or more groups. However, in all the studies reviewed, it was used only for the categorization of two wins and losses. When limiting game outcomes to only two wins and losses, the application of logistic regression analysis based on binomial distribution can be considered. Although the normality and homoscedasticity of independent variables in each group are required as assumptions to their application, no assumptions like this can be made in logistic regression analysis (Hair et al., 2010).

Again, the studies reviewed used mainly factor analysis (principal component analysis) and non-metric multidimensional scaling, in which the factors obtained or dimensions were not so many, with only three to four factors/axes. Additionally, the considerable variance was explained by the first and second dimensions/axes, and almost all of the plays/factors that were included in the two dimensions/axes and the successive third and/or fourth were less convincing. This prevented researchers at times from clearly interpreting factors (in particular, principal components) and axes. This is thought to have been caused by not rotating principal components or axes. Doing so would make the variances of principal components or axes even and enables their interpretation. In order to understand the structure obtained more deeply, rotating the principal components or axes, such as in Varimax rotation (Harman, 1976), is recommended.

9. Conclusion: our new proposals

We reviewed and summarized the findings from the perspectives of a) the relationship between individual kinds of plays and wins/losses; b) the comprehensive association between plays/factors and wins/losses; c) the relationship between plays/factors and wins/losses using multivariate analysis; d) the association between plays/factors and wins/losses in various situations; e) games involving junior basketball players; and f) the structure of plays/factors. This allowed us to realize that no consistent findings can be obtained in terms of what plays/factors contribute most to wins/losses, the sequence of plays leading to scoring (e.g., two-point shooting, three-point shooting, and free throwing) by skilled players, and that discriminant analysis is commonly used in the studies. Based on these findings, we devised the following new proposals:

1) No consistent findings about the relationship between plays/factors and wins/losses were able to be obtained and that was dependent upon the games. This is because conditions are not able to be controlled such as experiments or measurements, and the plays themselves will change depending on the opponents. For this reason, researchers need to exert more effort to analyze various kinds of games in the future.

2) The feature of an alternative to a win or loss in games allows us to eliminate the need to use only discrimination analysis because it can discriminate three or more. Additionally, the normality and homoscedasticity of independent variables are assumed for discriminant analysis, but not for logistic regression analysis. For this reason, we can also recommend logistic regression analysis.

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3) When investigating the structure of plays/factors, a rotation that easily interprets axes in MDS or principal components has not been applied to the derived structure, which has made the research outcome ineffective. To make the research findings useful, the rotation of axes or principal components should be actively utilized.

Notes

Note.1) Although different expressions/words are used depending on the researchers, the discriminant function and canonical discriminant function were the same. Similarly, the canonical correlation and multiple correlation ratios were also identical.

Note.2) Whereas canonical correlation indicates the goodness-of-fit, Wilks' lambda indicates the badness-of-fit (Hair et al., 2010).

Note.3) TORSCA (TORgerson's SCAling) is one of the programs used in computing non-metric multidimensional scaling and was developed by Young and Torgeson (1967) at an early stage. With it, configuration is obtained while optimization and monotonic regression are repeated mutually.

Note.4) ALSCAL (Alternating Least Squares SCALing) is one of the programs used in computing both metric and non-metric multidimensional scaling and was developed by Takane, Young, and de Leeuw (1977). Its solution is obtained so that the squared sum of the difference between the squared dissimilarities and distances in the space becomes the least. Its computation is conducted using the alternating least square method.

Author Contributions

Conceptualization, K.N.,O.A; methodology, K.N., O.A; validation, K.N.,A.O.; investigation, K.N, A.O; writing—original draft preparation, K.N.,A.O; writing—review and editing, K.N.,A.O; visualization, A.O.; supervision, K.N., A.O.; project administration, A.O.; funding acquisition, A.O;
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