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On the Building of Shooting Load and Efficiency Evaluation Model of Competitive Basketball

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Abstract: Based on the diminishing marginal principle of shooting efficiency decreases along with shooting load, this paper combined the original basic indicators and used diagonal deviation principle, to build a more accurate shooting load and efficiency evaluation model with single index distribution algorithm. By the algorithm, applied research of shooting load and efficiency of all players in the CBA team is conducted. In this way, this paper provided theoretical value and significance for the scientization of competitive sport in China.

Keywords: Basketball, efficiency, load, match, model.

1. INTRODUCTION

As a key part of competitive basketball, the scientific distribution of shooting load is an important factor to adjust the practical direction in the competitive basketball. Combined analysis on the accumulated shooting statistics of a large number of basketball games can help explore the hidden important information behind the data. Competitive technical performance of the players on the field can be calculated in the form of model formula in a more accurate and direct way.

As is known from the diminishing marginal principle of shooting efficiency decreasing with shooting load, with the increasing of shooting loads, the offensive efficiency is in an upward trend. However, the upward trend must be slowly with the time, which will be reduced until the offensive load reaches a certain degree, or the offensive load is not match with the player ability. In general, offensive core players are able to keep certain efficiency under high offensive load. Non-offensive core players may keep higher shooting efficiency than offensive core players under relatively lower offensive load. However, once the offensive load on the player is increased, the offensive efficiency may decline significantly, which means that he or she cannot bear high offensive efficiency. All these phenomena show that adjusting the match between shooting load and shooting efficiency of the offensive players is very important. The author hopes to provide theoretical reference for the staffing, competition ability prediction, strategy personnel selection, and scientific development of basketball.

2. RESEARCH OBJECT

Related indicators to evaluate shooting load and shooting efficiency were selected as research objects, including shooting load, total shooting number, total playing time, shooting efficiency, number of two-point trails, number of three-point trails, number of free throws, total scores, and shooting conditions of players of Tianjin RongGang team in season 08-09.

3. RESEARCH METHOD

3.1. Documents

Related research data on shooting load and shooting efficiency were looked up to support this paper in theory.

3.2. Expert Interview

The relevant experts and scholars in basketball were interviewed for their constructive suggestions on this model.

3.3. Mathematical Statistics

This paper adopts SPSS for Windows11.0 statistical software for data processing.

3.4. Logical Reasoning

This paper combines the principle of basketball to reason related research topics based on logic principles.

4. RESULTS AND ANALYSIS

4.1. Review of Current Evaluation Methods and Theoretical Preparation of Newly Built Model

4.1.1. Review of Current Evaluation Methods

The author searched database websites such as China Journal Net with keywords, including "shooting load", "shooting efficiency", "basketball load", and "basketball efficiency". Sadly, the results basically have no support for this paper. In some related literature, there are two basic types in using indicator methods: First, use various basic indicators to compare and draw conclusions. For example, Wan Jiang [1], the scholar, directly compared the indicators including total shots, hit times, hit ratio, number of free throw, and free throw hit ratio to draw conclusions. Second, conduct weight assignment to various basic indicators with modeling, and draw conclusions after calculation and verification. But their use of indicators has the same features, namely using single indicator. The author thinks that there are multiple basic indicators for the research objects in this paper, while there are certain compensatory characteristics in between. Therefore, using single basic indicator to represent the match between shooting load and shooting efficiency is not delicate enough.

4.1.2. Theoretical Preparation of Evaluation Model of Shooting Load and Shooting Efficiency (Feasibility Analysis after the Construction of the Model)

With the continuous development of modern basketball games, basketball tactics design [2] shows the assimilation trend. Nowadays, the world professional basketball tactics are generally following the main design thoughts, including systemic design, balance principle, elasticity principle, and optimality principle. Optimality principle manifests the thinking process that coaches and players seeking for the best action plan under a variety of competition background. Different from natural selection, it features strong initiative in selection. The author conducted a thorough interview of Professor Zhou Xianjiang, a doctoral tutor in Wuhan Sports College, which hold the view that the main tactic design in modern basketball is providing offense opportunities for one or two players at the same time by various methods, including covering with or without ball, and shake off. More sophisticated tactics design may consider that the third player will be needed to obtain the offense opportunity under the circumstances that the foresaid two players cannot offend due to defense of competitors. Generally, based on logical relationship, the coach chooses team the first, second, and third offensive core players in the team to serve as the first, second, and third offense, which clearly makes higher success rate.

After observed the video, the author thinks that in CBA field, the whole team will focus on a specific tactic based on the actual condition. According to the result of video observation, the tactic implementation success rate of CBA teams ranges from 33% to 51%. So from that perspective, the using of offensive tactics is the objective reasons of the distribution of offense times of each player.

From the design and using principle of such tactics, the coach can adopt different tactics to adjust the shooting load that the players can handle, to achieve more reasonable shooting load distribution. This provides the practical basis for the model of this research.

4.2. Construction of Shooting Load and Efficiency Evaluation Model of Competitive Basketball

4.2.1. Basic Assumptions

To eliminate the abnormal events of small effect, so as to make the model simple and easy to use, without too many factors, the following abnormal events are eliminated.

4.2.1.1. Events during the game (emergencies, such as miscalculation of the referee and conflicts among players) have no effect on the emotion, psychology, and competitive ability of players.

4.2.1.2. There is no "waste time", or in another word, players spend every second in the game.

4.2.1.3. The games ends in the scheduled time (whole playing time of each teams are the same), and the indicators can reflect the real skills and levels of the players (i.e. the greater the strength difference of the two teams, the higher of the probability that the stronger team wins, with better indicators).

4.2.1.4. The players have no cases of injuries and suspensions, and play as usual.

4.2.1.5. The referee can enforce the rules correctly.

4.2.2. Definition and Description of the Symbols

Symbol	Symbols Description
Vi	Shooting load
Ei	Total number of shots
Ti	Total playing time
Ui	Shooting efficiency
Ai	Number of two-point trail
Bi	Number of three-point trail
Ci	Number of free throw trial
Di	Total score

4.2.3. Model Construction

4.2.3.1. Selection of Primary Indicators

Scoring ability is the important indicator of offensive capability. In high level competitions, the number of shooting opportunities of both teams is almost the same. In this case, the team that reasonably distribute and effectively use the shooting opportunities will get more scores and advantages for offense.

Scoring ability: Shooting ratio and shooting times in the process of competition.

If we consider the relationship between shooting and scores only from the practical significance, shooting ratio is clearly not enough. There is another important factor, shooting times. That is to say, the score a team obtains has direct relationship with shooting ratio and times. For example, if the shooting rate is 60% for both teams, the scores will differ due to the total shooting times of 100 and 80 respectively. However, as is seen from the technical data of various games, the total shooting time of a team against the opponent is relatively stable. The coefficient of variation of shooting times is lower than that of the shot time, which means the randomicity of shot is higher; while shooting time is relatively stable due to the stable exchange of offense and defense under deadlock. Cai Rui [3] thinks that the correlation between other factors and scoring ability is poor. In this way, other indicators are excludes in the construction scope of this model, which confirmed that the indicators in this paper are reasonable. Therefore, factors including shooting times, shot times, free throw times, free throw hit ratio, and playing times are selected and divided into two indicators: shooting load and shooting efficiency. Of course, scoring ability is not the only factor that reflects offensive capability. There are some other important indicators, such as offensive rebounds ability and collaboration (with their own effects on the scoring ability data). But offensive rebounding ability, collaboration, or assists ability will eventually to a part of offensive score. Based on the recognition method of understanding internal overall situation from outside results, the author tends to combine the simplified data to conduct further analysis on the offensive efficiency and offensive load of players in Tianjin team.

4.2.3.2. Definition of New Indicators

Shooting load

In fact, Vi = Ei/Ti does not represent the actual offensive load of the player. As is regulated in the basketball statistical rules, two or three free throws against foul will be accumulated in the free throw statistics, but not in the total shooting times. Therefore, free throws should be added into the total shooting times for more reasonable and complete statistics of the players. According to the PRE calculation formula of John Hollinger [4], the conversion coefficient between shooting times and free throws is about 0.44, which means that there will be one free throw for every 0.44 shooting, with the consideration of three shots. Therefore, the definition and formula of shooting load are as follows:

Definition: Offense or shooting times per minute during playing time.

Formula: Vi =(Ai + Bi + 0.44* Ci)/ Ti

As is known from the formula: in this paper: offensive load refers to the number of offense or shooting per minute, which is a standard data, with unit of times/minute. During the interview, Professor Zhou Xianjiang raised some questions about playing time. Therefore, there will be some limitations for the statistics of playing time to prevent the circumstance where offensive load is low but offensive efficiency is high due to the small number of shooting. What's more, the author and the expert has achieved consensus of the reasonable indicator selection.

Shooting efficiency

Usually, traditional offensive efficiency is measured by hit ratio, which includes two-point, three-point, and free throw. Either two-point or three-point will be reflected in the total score, plus that combined scoring efficiency is more simple and intuitive than single indicators of the three. Therefore, this paper tends to combine the three indicators to make a simpler and more reasonable combined indicator of offensive efficiency.

Definition: offense (shooting) scores of each player.

Formula: Ui =Di /(Ai + Bi + 0.44* Ci)

4.2.3.3. Statistical Line of Action

The line of action in this paper is playing time.

First, the high efficient of the player could be related to the small shooting rate during the playing time. Role players, who only shot when the best opportunity comes, have less offensive opportunities but higher efficiency than offensive players. Apparently, their shooting load and match are not that bad as the calculation result shows.

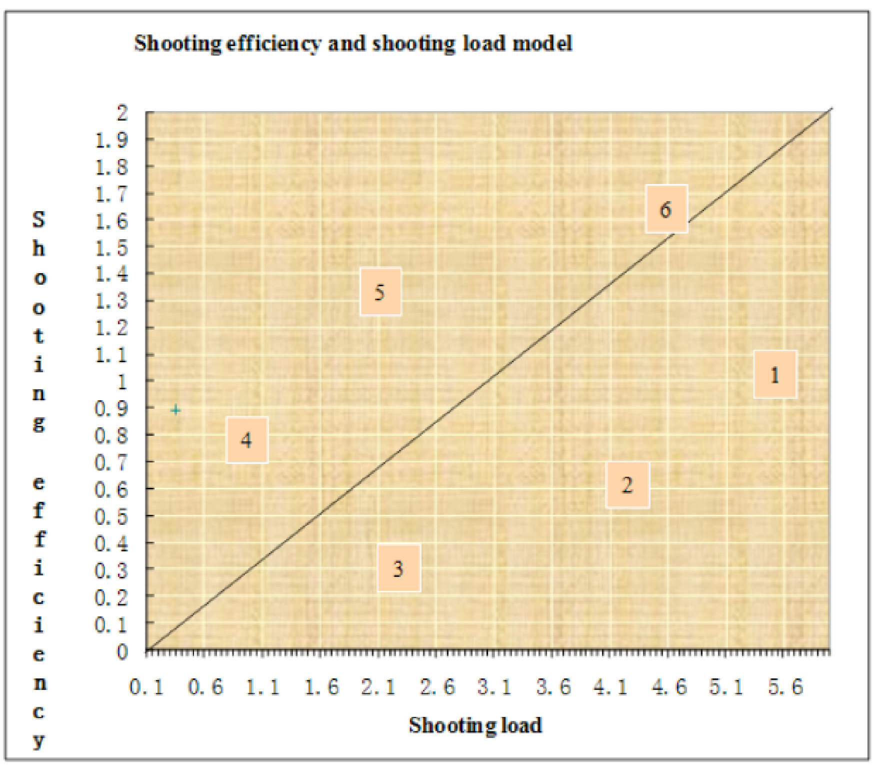

Fig. (1). Shots efficiency and shooting load model.

Second, it avoids the condition where some players have less shooting load in relatively long playing time because some other tactics are not accepted in the statistics.

4.2.3.4. Model Construction

Coordinate establishment: first quadrant of the coordinate is established, with Vi (shooting load) as the X axis, Ui (shooting efficiency) as the Y axis (shooting load and efficiency cannot be minus).

The diagonal description: The diagonal is a straight line. Assume its function is a linear function:

y=a*x+b

In terms of ideal condition, the player's shooting loads should fluctuate up and down around scoring efficiency. That is to say, the coordinate points of the players should distribute in the vicinity of the black diagonal, which is reasonable.

4.2.3.5. Interval Description

4.2.3.5.1. Interval 1 and 6: Main offense players in the team

The main feature in this interval is that the players owns offensive loads much higher than other players, normally the first or second scoring point in the tactic design. But the difference between interval 1 and 6 is that players in the interval 6 have higher offensive efficiency than players in the interval 1 under the same offensive loads, which indicates that players in the interval 6 have the ability to take more offensive loads. If the incensement degree of the offensive load is reasonable, the offensive efficiency of players in interval 6 can fall near the diagonal line, which indicates that players in interval 6 have better performance on the offensive end. It is worth noting that if the player in interval 1 deviates too far from the diagonal, then the play has a lot of shooting opportunities but low efficiency, which makes the point far from the diagonal. This type of players is controversial. They are mostly weaker striker, who is forced to undertake tasks beyond their loads.

4.2.3.5.2. Interval 2 and 5: Secondary offense players in the team

The main feature in this interval is that the offensive loads undertaken by the players are less than players in interval 1 and 6. Players in this interval are mostly weaker third scoring point or strong role players. The difference is the same as that between interval 1 and 6. It is worth noting that under appropriate load incensement, players in interval 5 have the potential to become main offensive players in the team.

4.2.3.5.3. Interval 3 and 4: They are relatively weaker offensive players, featuring the lowest offensive loads and the weakest offensive capabilities.

The further the X axis from the intersection point, the greater the offensive load is, while the further the Y axis from the intersection point, the higher the offensive efficiency is. Therefore, we can divide the coordinate into 6 intervals based on offensive load and efficiency. At the same time, in order to better explain the offensive end properties, we define the 6 intervals as the following:

Area 6 - strong core players (approximate: load > 0.43, efficiency > 1.213)

Area 1 - weak core players (approximate: load > 0.43, efficiency < 1.213)

Area 5 - strong role players (approximate: 0.26 < load < 0.43, efficiency > 0.43)

Area 2 - weak role players (approximate: 0.26 < load < 0.43, efficiency < 1.037)

Area 4 - strong offensive added players (approximate: 0.1 < load < 0.26, efficiency > 1.037)

Area 3 - weak offensive added players (approximate: 0.1 < load < 0.26, efficiency < 1.037)

4.3. Model Utilization (take Tianjin RongGang team for example)

Ten players are selected in the statistics, including: Zhou Xuefeng, Liu Hao, Li Gangfeng, Xu Lei, Wang Bin, Wang Hao, Xu Guijun, Zhang Ji, Smith, and Hawkins. This is actually the regular team of Tianjin RongGang team. This also shows the rationality of selecting playing time as the criteria, which further improves the rationality and logic relationship of the analysis in this paper.

The intersection coordinate is (0.1, 0.85), the far end coordinate is (0.6, 1.4). Substitute the two points into the equation, then: (a, b) = (1.1, 0.74), so the diagonal function equation is: y=1.1x+0.74

4.3.1. Statistical Line of Action of Tianjin Team

Data of Smith: total playing time 1940.2 minutes, two-point trials 596 times, three-point trials 238 times, free throw 243 times, total score 1077 points. Data of Xu Guijun: total playing time 1117.9 minutes, two-point trial 318 times, three-point trial 179 times, free throw 116 times, and total score 577 points; Data of Hawkins: total playing time 1846.3 minutes, two-point 712 times, three-point trial 25 times, free throw 244 times, and total score 947 points. Data of Liu Hao: total playing time 1246.5 minutes, two-point trial 343 times, three-point trial 184 times, free throw 148 times, and total score 648 points (Table **1**). According to the former formula, the offensive loads 0.48496031, 0.49024063, 0.45732546, and 0.47502607, are all greater than 0.43. The four players have one shooting opportunity almost every two minutes, accounting for most of the shooting opportunities, which makes them undisputed major offensive players in the team.

As in known from Fig. (**3**), the distributions of the four players are deviated near the right of the diagonal, which means that their shooting loads are higher. That is to say, their abilities are not enough to support the shooting loads. But the deviation degree of the foreign aid Smith and Hawkins is smaller than Liu Hao and Xu Guijun. The offensive efficiency of Smith and Hawkins reaches 1.144624 and 1.144624, which are higher than 1.094373 and 1.052843 of Liu Hao and Xu Guijun, which indicates that the unit score of Smith and Hawkins is higher by 0.4 to 0.9 point. We can draw the conclusion that, under the same shooting load, the scoring efficiency of Smith and Hawkins will be higher than Liu Hao and Xu Guijun. In other words, the shooting abilities of foreign aid players are better than domestic players.

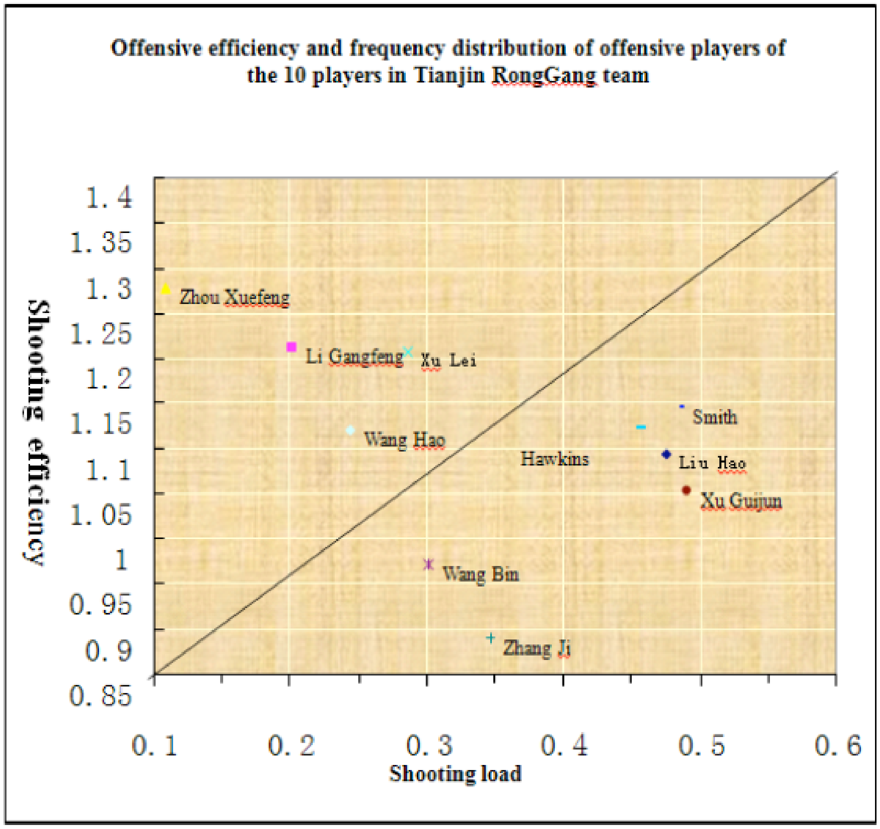

Fig. (2). Offensive Efficiency and Frequency Distribution of Offensive Players of the 10 players in Tianjin RongGang Team.

In this case, this paper holds the view that the abilities of Smith, Hawkins, Xu Guijun, and Liu Hao don't match their existing offensive loads. It is suggested that they should select shooting opportunities in the future to improve offensive efficiency. Or the team could configure strong aid players for these weak core players to share their shooting loads and get higher shooting efficiency.

4.3.2. Interval Distribution

As is known from Fig. (**2**), the 10 players in Tianjin RongGang team are distributed in interval 1, 2, and 4. Hawkins, Smith, Xu Guijun, and Liu Hao are in interval 2; Zhang Ji and Wang Bin are in interval 2; Li Gangfeng, Zhou Xuefeng, and Wang Hao are in interval 4; Xu Lei is in interval 5.Discussions about the players in these intervals are as follows:

4.3.2.1. Interval 1

4.3.2.2. Interval 5

Xu Lei is a strong role player (refer to Table **2**), with playing time 459.4 minutes, two-point trial 65 times, three-point trial 57 times, free throw 22 times, and total score 159 points. His shooting load is 0.28663474, which are significantly less than four players in interval 1. But his offensive efficiency is 1.207473, which is significantly higher than the above four players and the value of the diagonal. But because of his shooting load is significantly less than that of the weak core players, the author think Xu Lei's ability matches with existing offensive load. At the same time, he has the ability to support higher offensive load in a small range.

4.3.2.3. Interval 2

Zhang Ji and Wang Bin are weak role players (refer to Table **3**). As is known from Fig. (**1**), offensive loads of

Table 1. Part indicator statistics of part players in Tianjin RongGang team.

	Time	Two-point trail	Three-point trail	Free throw trial	Score	Shooting load	Shooting efficiency
Smith	1940.2	596	238	243	1077	0.48496031	1.144624
Hawkins	1846.3	712	25	244	947	0.45732546	1.12156
Xu Guijun	1117.9	318	179	116	577	0.49024063	1.052843
Liu Hao	1246.5	343	184	148	648	0.47502607	1.094373

Table 2. Part indicator statistics of part players in tianjin RongGang team.

	Time	Two-point trial	Three-point trail	Free throw trial	Score	Shooting load	Shooting efficiency
Xu Lei	459.4	65	57	22	159	0.28663474	1.207473

Table 3. Part indicator statistics of part players in tianjin RongGang team.

	Time	Two-point trial	Three-point trail	Free throw trial	Score	Shooting load	Shooting efficiency
Zhang Ji	239.9	62	4	39	74	0.34664444	0.889851
Wang Bin	780	108	103	54	228	0.30097436	0.971205

Table 4. Part indicator statistics of part players in tianjin RongGang team.

	Time	Two-point trial	Three-point trail	Free throw trial	Score	Shooting load	Shooting efficiency
Li Gangfeng	1680.8	111	183	102	411	0.20161	1.212
Zhou Xuefeng	375.2	24	7	22	52	0.10842	1.278
Wang Hao	1730.3	219	159	100	473	0.24388	1.120

Zhang Ji and Wang lei are 0.34664444 and 0.30097436, which are higher than Xu Lei of 0.28663474. But their offensive efficiencies are 0.889851 and 0.971205, which are smaller than Xu Lei of 1.207473, which means that the unit shooting score is 0.2 to 0.3 point higher than Xu Lei, with deviation from the diagonal. Therefore, the author thinks his ability cannot support the existing offensive load, and suggests enhancing training and improving offensive end skills and means, and reducing offensive load to achieve higher offensive efficiency.

4.3.2.4. Interval 4

Li Gangfeng, Zhou Xuefeng, and Wang Hao are offensive complement players (refer to Table **4**. As is known from Fig. (**1**), they are above the diagonal. Therefore, their potential for offensive load is low. Li Gangfeng undertakes offensive load of 1.212819 with offensive efficiency of 0.20161828, offensive efficiency, locating above the diagonal. At the same time, his playing time reaches 1680.8 minutes, which indicates that he has the ability to support higher offensive loads. It is suggested that offensive load should added.

5. CONCLUSIONS AND RECOMMENDATIONS

(1) This paper builds shooting load and efficiency evaluation model of competitive basketball based on various basic indicators, which is in line with the characteristics of basketball game. The combination of various factors contributes to the new indicator system and evaluation model with high practical guiding significance.

(2) In general, the distribution of shooting loads and efficiency of Tianjin team is not reasonable. Core players undertake high shooting loads and low shooting efficiency. Some role players undertake low shooting loads. The shooting loads of players in each position are not reasonable and need adjustment on tactic design and implementation for reasonable distribution of shooting loads and higher efficiency. The shooting ability of existing players is not enough to support shooting load. It is suggested to enhance training and improve their ability quickly.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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Declared none.

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