



THE COMPETITIVE ACTIVITY STRUCTURE OF HIGHLY SKILLED BASKETBALL PLAYERS ON THE BASIS OF FACTOR ANALYSIS METHODS

original paper

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ABSTRACT

Purpose. To analyse and generalize the competitive activity structure on the basis of the hierarchy of technical and tactical indicators of qualified basketball players in won and lost games by using the factor analysis methods.

Methods. The study involved 96 professional basketball players who were national team players of countries that took 1–8 places in the final tournament of the European Basketball Championship 2017. Technical and tactical indicators of their competitive activity were analysed for revealing and interpreting the results with the factor analysis methods.

Results. The grouping of elements of the competitive activity structure of highly skilled basketball players was analysed. Groups with the highest value of factor capacity depending on the results of the game were determined. A significant difference in the structure of technical and tactical activity in the won and lost games was presented.

Conclusions. The data obtained in the course of the study on the basis of factor analysis allowed us to present updated information on the competitive activity structure of highly skilled basketball players and to partially confirm the existing data.

Key words: basketball, structure, technical and tactical activity, methods of factor analysis

Introduction

The general theory of sport and modern athletes training systems consider the cycle of the most important problems for the further improvement of the training process. Most authoritative researchers in the field of physical education and sports agree that the issues of improving the training process and competitive activities are of highest importance. One of the topical problems is the study of the competitive activities structure in a specific kind of sport with the application of complex nonlinear methods of mathematical processing of the studied indicators [1]. The methods allow to integrate the knowledge of mathematical sciences for the further development of the general theory of sport and improving the athletes training system in a specific kind of sport [2–4]. Such approaches are not completely new, but have high practical and theoretical signifi-

cance and involve a number of problems that do not have a final conclusion, as well as common points of view among both scientists and practitioners in the field of team sports games that are very popular and have a spectator interest. Significant scientific studies in this area include the work of Kozina [5], Kozina et al. [6], Okazaki and Rodacki [7], Kabaciński et al. [8]. These studies, using the material of team sports games (volleyball, handball) and applying factor analysis methods, investigated the athletes' physical preparedness structure and determined the factor models of game activity. One of the first studies of the competitive activity structure in qualified athletes in basketball with the use of factor analysis methods is the research by Kyrychenko and Doroshenko [9], performed on the basis of the indicators of the competitive activity of qualified basketball players who participated in European cup tournaments in 2003 and 2005. These

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authors attempted to use the method of principal components with the Kaiser normalization and varimax orthogonal rotation of the matrix to study the competitive activity structure.

In modern sports science, the issues connected with the use of factor analysis methods for studying the various aspects of preparedness and competitive activity of highly skilled basketball players remain relevant. Non-linear methods of multidimensional mathematical analysis were applied in studies of competitive activity indicators in the Spanish professional basketball league [10], at the final tournament of the European Championship 2015 [11], in elite women basketball teams while preparing for youth Olympic tournaments [12].

The problems with using factor analysis methods to reveal the consistent patterns of team, group, and individual dynamics of the competitive activity effectiveness in basketball were described in the studies by Bazanov et al. [13], Kozina et al. [14], Villa and Lozano [15]. An analysis of factor variables that determine the parameters of teamwork of qualified basketball players in conditions of increasing competitive activity is presented in a study by Gruber and Gray [16]. A similar methodological principle was employed by Kozina et al. [14], who made an attempt to determine the individual characteristics of the complex athletes' preparedness with the help of mathematical modelling and multivariate statistical analysis methods. Hopkins [17] and Koryahin et al. [18] proposed an algorithm for selecting the most optimal test tasks for determining the level of various aspects of preparedness of qualified basketball players [8] with the use of multidimensional statistical analysis methods, which is based on the hierarchy of both indicators of athletic preparedness and their significance from the point of view of test theory. A similar study was conducted by Karpowicz and Karpowicz [19] among young Polish basketball players aged 15–16 years observed for a long time.

Further development of research approaches based on the use of multidimensional mathematical analysis methods in the system of training qualified basketball players can be observed in studies by Sampaio et al. [20] or Sporiš et al. [21]. Also, Scanlan et al. [22], on the basis of the comparative characteristics of the requirements to actions of highly skilled basketball players of Australian basketball leagues, showed the possibilities of studying the hidden structure of standard indicators of game efficiency in basketball. Research has used the multivariate statistical analysis methods to determine the technical and physical preparation of highly qualified basketball players, as well as the level of development of their aerobic and anaerobic

functions [18]. Discriminant analysis of highly skilled basketball players' game efficiency is shown as an adequate method of research in the field of competitive activity.

The methods of factor analysis are suitable in the study of theoretical [23] and practical [24] problems of qualified basketball players training system. In the presented study, an attempt was made to investigate the indicators of the competitive activity structure in qualified basketball players on the materials of the European Basketball Championship 2017 by using the methods of factor analysis.

The study of the technical and tactical activity of qualified basketball players and the results interpretation with the help of the factor analysis methods will make possible the understanding of modern trends in the development of modern basketball.

It was hypothesized that the grouping of the competitive activity structure elements of qualified basketball players with the factor analysis methods presented significant differences in technical and tactical indicators in won and lost games. Therefore, it requires studying in order to increase efficiency through professional correction of the training process.

The purpose of the study was to analyse and generalize the competitive activity structure on the basis of the technical and tactical indicators hierarchy in qualified basketball players in won and lost games by using the factor analysis methods.

Material and methods

Participants

The study involved 96 professional basketball players who were national team players of 8 countries (Slovenia, Serbia, Spain, Russia, Latvia, Germany, Italy, Greece) that took 1–8 places in the final tournament of the European Basketball Championship 2017. Factor analysis methods were applied to study the competitive activity structure indicators in order to determine their hierarchy and interpret the obtained results depending of the differences in the won and lost games. In the process of factor analysis, we used 11 024 indicators of competitive activity of qualified basketball players in 64 games: 7936 indicators in 46 won games and 3088 indicators in 18 lost games.

Procedure

Between August 31 and September 17, 2017, the final tournament of European Basketball Championship

Table 1. Final results of the top 8 teams in the final tournament of the European Basketball Championship 2017

Place	Team	Number of games	Won	Lost	Ratio
1	Slovenia	9	9	–	–
2	Serbia	9	7	2	3.5
3	Spain	9	8	1	8
4	Russia	9	6	3	2
5	Latvia	7	5	2	2.5
6	Germany	7	4	3	1.33
7	Italy	7	4	3	1.33
8	Greece	7	3	4	0.75
Total		64	46	18	2.56

2017 was held in 4 countries (Finland, Israel, Romania, Turkey). It was attended by 24 national teams. The results of the performance of the top 8 teams (the total number of games, the number of wins and losses) are presented in Table 1.

Statistical analysis

With the use of the factor analysis methods, the elements of the structure of competitive activity were grouped according to individual indicators of qualified basketball players. To process the results, the specialists of the Department of Physical Rehabilitation, Sports Medicine, Physical Education and Health of the Zaporizhzhia State Medical University used the SPSS-12 computer software. To study the competitive activity structure of qualified basketball players at the final tournament games of the European Basketball Championship 2017, the principal component analysis with Kaiser normalization and varimax orthogonal rotation of the primary R matrix were applied. The principal component analysis differs from other factor analysis methods in that the diagonal elements of the primary R matrix used in the component analysis equal one (i.e. 1 or -1) in each case [9]. The differences between factor analysis and component analysis are related to the specificity of problems that are solved with the help of these methods of analysis.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Human Ethics committee of the University of León, León, Spain.

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

Tables 2–4 show the grouping of indicators that form the competitive activity structure of qualified basketball players. The competitive activity structure of qualified basketball players in the games of the final tournament of European Basketball Championship 2017 (Table 2, number of games: 64) was studied by the factor analysis methods with respect to the specifics of the tasks that were being solved in this study.

To determine the specifics of the competitive activity structure of qualified basketball players in won and lost games by using the factor analysis, the corresponding athletes' indicators were analysed (Table 3, number of games won: 46; Table 4, number of games lost: 18).

According to an American study [25], a significant degree of reliability of the obtained indicators characterizing the competitive activity structure is achieved if the percentage of sampling its elements is at least 60%. As applied to this research, in order to group elements of the overall competitive activity structure of the qualified basketball players in accordance with the most significant indicators of factor loading, the percentage of the sample elements that are significantly interrelated (correlated) is 67.59% (Table 2). The value equals 67.42% for the won games (Table 3) and 69.5% for the lost games (Table 4). The obtained data indicate a sufficiently high degree of reliability of the results.

Also significant is the distribution of indicators in the factor groups by the absolute value: values > 0.7 indicate the presence of statistically significant differences; those between > 0.5 and < 0.7 indicate a trend towards statistically significant differences.

It is worth to notice the coincidence of groups of elements in the overall structure and the structure of competitive activity in the won matches. At the same time, there are significant differences between these 2 groups and the structure of competitive activity in highly skilled basketball players in the matches played.

In the won games, the first group of factors includes offensive rebounds, defensive rebounds, and, as a result, the total number of rebounds. In the lost games, the first group of factors involves quantitative and qualitative indicators of 3-point shots and scored points.

The second group of factors comprises quantitative and qualitative indicators of 3-point shots in the

Table 2. Grouping of competitive activity general structure elements in qualified basketball players in accordance with the factor loading values, $n = 11\ 024$

Indicators of competitive activity	Values of factor loading			
	Group 1 of factors	Group 2 of factors	Group 3 of factors	Group 4 of factors
Time (min)	0.444	0.573*	0.353	0.383
2-point shots (n)	0.325	0.069	0.663*	0.436
2-point shots (%)	0.383	0.086	0.639*	0.432
3-point shots (n)	0.009	0.859	0.182	-0.052
3-point shots (%)	0.045	0.878	0.224	0.044
Free throws (n)	0.110	0.172	0.894	-0.034
Free throws (%)	0.176	0.143	0.894	-0.0123
Offensive rebound (n)	0.699	-0.245	0.144	0.082
Defensive rebound (n)	0.799	0.241	0.220	0.061
Total rebounds (n)	0.929	0.0995	0.221	0.059
Assists (n)	0.0568	0.5839	0.129	0.365
Fouls (n)	0.0865	-0.061	-0.006	0.646*
Turnovers (n)	0.034	0.209	0.265	0.631*
Steals (n)	0.133	0.377	0.005	0.387
Blocks (n)	0.451	-0.228	0.241	0.016
Points (n)	0.221	0.525	0.744	0.207
General dispersion	2.764	2.881	3.465	1.681
% dispersion	0.173	0.181	0.217	0.106

* trend towards statistically significant differences at a factor value between > 0.5 and < 0.7

Table 3. Grouping of competitive activity structure elements in highly skilled basketball players in the won games in accordance with the factor loading values, $n = 7936$

Indicators of competitive activity	Values of factor loading			
	Group 1 of factors	Group 2 of factors	Group 3 of factors	Group 4 of factors
Time (min)	0.447	0.595*	0.356	0.332
2-point shots (n)	0.404	0.067	0.624*	0.407
2-point shots (%)	0.455	0.087	0.610*	0.398
3-point shots (n)	0.014	0.866	0.145	-0.061
3-point shots (%)	0.060	0.893	0.187	0.021
Free throws (n)	0.082	0.169	0.914	-0.0194
Free throws (%)	0.166	0.138	0.907	-0.004
Offensive rebound (n)	0.718	-0.223	0.109	0.101
Defensive rebound (n)	0.770	0.269	0.218	0.047
Total rebounds (n)	0.916	0.131	0.204	0.046
Assists (n)	0.0129	0.584*	0.195	0.305
Fouls (n)	0.131	-0.046	-0.088	0.682*
Turnovers (n)	0.009	0.174	0.303	0.658*
Steals (n)	0.111	0.404	0.078	0.277
Blocks (n)	0.463	-0.218	0.265	-0.089
Points (n)	0.257	0.538	0.717	0.187
General dispersion	2.862	2.969	3.426	1.561
% dispersion	0.179	0.186	0.215	0.098

* trend towards statistically significant differences at a factor value between > 0.5 and < 0.7

Table 4. Grouping of competitive activity structure elements in highly skilled basketball players in the lost games in accordance with the factor loading values, $n = 3088$

Indicators of competitive activity	Values of factor loading			
	Group 1 of factors	Group 2 of factors	Group 3 of factors	Group 4 of factors
Time (min)	0.564	0.426	0.47	0.312
2-point shots (n)	0.491	0.402	0.014	0.548
2-point shots (%)	0.491	0.458	0.4	0.510
3-point shots (n)	0.871	-0.114	0.061	0.079
3-point shots (%)	0.837	-0.099	0.195	0.198
Free throws (n)	0.133	0.134	0.089	0.927
Free throws (%)	0.153	0.166	0.072	0.926
Offensive rebound (n)	-0.135	0.716	-0.113	0.159
Defensive rebound (n)	0.057	0.693*	0.321	0.331
Total rebounds (n)	-0.009	0.839	0.213	0.328
Assists (n)	0.387	0.029	0.706	0.095
Fouls (n)	0.168	0.302	0.276	0.002
Turnovers (n)	0.482	0.267	0.409	0.021
Steals (n)	0.046	0.076	0.762	0.108
Blocks (n)	0.131	0.655*	-0.265	-0.026
Points (n)	0.721	0.221	0.065	0.634
General dispersion	3.269	2.959	1.825	3.070
% dispersion	0.205	0.185	0.115	0.192

* trend towards statistically significant differences at a factor value between > 0.5 and < 0.7

Table 5. Generalized data of grouping the competitive activity structure elements in qualified basketball players in accordance with the factor loading values, $n = 11\ 024$

Grouping elements of the competitive activity structure	Factor group number			
	1	2	3	4
Won games	-	Time	-	-
	-	-	2-point shots	-
	-	-	% 2-point shots	-
	-	3-point shots	-	-
	-	% 3-point shots	-	-
	-	-	Free throws	-
	-	-	% Free throws	-
	Offensive rebound	-	-	-
	Defensive rebound	-	-	-
	Rebounds	-	-	-
	-	Assists*	-	-
	-	-	-	Fouls*
	-	-	-	Turnovers*
	-	-	Points	-
	Lost games	3-point shots	-	-
% 3-point shots		-	-	-
-		-	-	Free throws
-		-	-	% Free throws
-		Offensive rebound	-	-
-		Defensive rebound*	-	-
-		Turnovers	-	-
-		-	Assists	-
-		-	Steals	-
Points		Blocks	-	-

* trend towards statistically significant differences at a factor value between > 0.5 and < 0.7

won games; and offensive rebounds, the total number of rebounds, and blocks in the lost games.

The third group of factors includes quantitative and qualitative indicators of 2-point shots, free throws, and scored points in the won games; and quantitative indicators of assists and steals in the lost games.

The fourth group of factors involves only 2 indicators (quantitative and qualitative indicators of free throws, Table 4).

Consequently, the grouping of the competitive activity structure elements in qualified basketball players by the factor analysis methods allows us to determine the presence or absence of significant differences in the won and lost games (Table 5).

As a result of experimental studies, the newest data were obtained on the grouping of competitive activity elements of the technical and tactical indicators in highly qualified basketball players: participants of the final tournament of the European Basketball Championship 2017. The opinion of specialists was also confirmed [6, 24] on the importance of studying the competitive activity indicators with factor analysis methods in won and lost games, as it allows to develop scientific and methodological actions for improving the educational and training process.

Discussion

According to the authors who studied the competitive activity structure of qualified basketball players using factor analysis [6, 8], these methods are quite effective. Problematic questions for the researchers are the rather high complexity of the selection of competitive activity indicators and the interpretation of the results obtained by using methods of factor analysis. The main difficulty in selecting elements of the competitive activity structure of qualified basketball players is that researchers need to select indicators that do not duplicate the factor loading of one another. In the competitive activity structure, as a rule, the indicators are analysed that are used in assessing the effectiveness of technical and tactical actions [18, 26], including free throws, 2-point shots, and 3-point shots. On the one hand, different types of shots in the process of studying the competitive activity structure in some way duplicate the corresponding factor values, on the other – these elements present significant differences, which is also significant [24] for adequate procedures of factor analysis. In our opinion, it is preferable to use some duplication of indicators of the competitive activity structure (analysis of the parameters of free throws, 2-point shots, and 3-point shots) in the

factor analysis process, since the changes in the primary R matrix will not be significant.

Strong restrictions on the selection of indicators for studying the competitive activity structure of qualified basketball players with the help of factor analysis methods are necessary for optimal mathematical and statistical processing of the obtained results. Therefore, with regard to the logic of research in the field of Olympic and professional sports, the most important is the selection of elements that most fully characterize the competitive activity structure, even taking into account some duplication of indicators, e.g. free throws, 2-point shots, and 3-point shots.

In addition, the discussed issues include the problems of interpretation of indicators that are obtained as a result of applying a factor analysis variety – principal component analysis with Kaiser normalization and varimax orthogonal rotation of the primary R matrix. In particular, the indicator of played time is interpreted by researchers [26] as a value for calculating the individual (relative) competitive activity efficiency of qualified basketball players. In the study by Kyrychenko and Doroshenko [9], the value of the played time indicators is used as a separate component of the competitive activity structure, which indicates its efficiency or inefficiency. In our opinion, both methodical approaches can be applied in the process of competitive activity structure factor analysis of highly skilled basketball players with expert advice of highly qualified specialists for each specific case.

Also significant, in terms of scientific discussion, are the problems of forming a certain factor analysis algorithm for studying the competitive activity structure of qualified basketball players. In our opinion, this algorithm should contain the following components: selection of elements of the competitive activity structure on the basis of mathematical and statistical approaches; isolating the main components by using Kaiser normalization and varimax orthogonal rotation of the primary R matrix; interpretation of competitive activity structure indicators and development of methodological recommendations for improving the training process. Despite the existence of controversial positions, the factor analysis methods are adequate for studying the competitive activity structure.

Conclusions

1. The study of the competitive activity structure of qualified basketball players by using the factor analysis methods shows significant differences in the won and lost matches, with the 4 most significant in-

dicators of factor loading and the correlating elements selection of 67.42% for the won games and 69.5% for the lost games, which allows to state a high degree of reliability of the obtained experimental results. Differences in the competitive activity structure of qualified basketball players in the won and lost matches were determined in 4 groups of factors. Differences in the overall competitive activity structure or the competitive activity structure of qualified basketball players in won games were not established.

2. Factor analysis is quite effective and informative for studying the competitive activity structure of qualified basketball players. In the process of investigating the competitive activity structure in basketball by using factor analysis, selection of indicators and expert interpretation of the results are most difficult.

3. Prospects for further research in this area are based on the refinement of the factor analysis algorithm of the competitive activity structure in qualified basketball players.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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