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796.323.2.011
Original scientific paper

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STRUCTURAL ANALYSIS OF KNOWLEDGE BASED ON PRINCIPAL ATTRIBUTES OF THE GAME OF BASKETBALL

Abstract

From the point of view of expert coaches and players, basketball can be observed as a team sports game, which can be presented as an ordered sequence of actions that each player has to perform according to the position and the role within the certain model of the game's tactics.

The aim of this survey was to determine the structure of latent factors, to identify and analyze a group of actions in the game, in the set of basic attributes and variables, to classify actions into relatively homogenous groups and to determine differences between the obtained groups of actions. In order to achieve the above mentioned, it was necessary to construct a measuring instrument (questionnaire) for knowledge registration in the game of basketball.

15 primary attributes were chosen for the characterization of entities (tasks in the game) and 10 competent experts performed the assessment according to them. Factor analysis under component model was used in the research process, with the use of Guttmann-Kaiser criterion and OBLIMIN rotation. That way we isolated four latent dimensions in the space of primary attributes, and they are named as: inside players, flow of the game, outside players and subspace C.

Beside the factor analysis, hierarchy method of classification was used, where the tasks in the space of primary game attributes were classified into four relatively homogenous groups of tasks, interpreted as groups A, B, C and D.

- Group A – tasks performed by inside players (power forward and centre) in A and B zone, thus in transition offence and set offence.
- Group B – tasks performed by inside players in A and B zone, in back court, thus in transition defence and set defence.
- Group C – tasks performed by outside players in the whole court, in front court and back court, thus in transition defence and set defence.
- Group D - tasks performed by outside players in the whole court, in front court and back court, thus in transition offence and set offence.

The acquired knowledge can directly influence the development of learning plans and basketball players' exercises, the development of new means for game monitoring, the analysis of the game of basketball, the evaluation of players' stats, and they make the foundation for the realization of further researches in the field of team sports games analysis.

Key words: THE GAME OF BASKETBALL / TASKS / EXPERTS / FACTOR ANALYSIS / CLUSTER ANALYSIS / DISCRIMINANT ANALYSIS

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INTRODUCTION

The knowledge in the game of basketball makes one of the areas of the game as a complex sports activity. The knowledge corpus in the game of basketball is analysed, as every structural approach requires, as a group that has its qualities of totality and order (internal organization). Knowledge analysis in the game of basketball is based on the information obtained from past scientific researches and the experience of basketball practice (Trninic, 1995, 1996). The subject of this research was the analysis of knowledge in the game of basketball, so the procedure for the gathering of knowledge of basketball experts was determined according to this goal. The assumption was that the knowledge in the game of basketball was most intensely depicted directly by the concept of tasks. That is why the information about actions in the game was used as a primary holder of knowledge in the game of basketball. For the purpose of scientific research it is necessary to classify the structures of entities (tasks) into groups in a way that the structures of tasks according to some of their features (relation and closeness) make relatively homogenous wholes (Trninic, 1995; Jelicic, 2006, Trninic, Trninic, & Jelaska, 2010). We limited ourselves to the systematized structures of tasks in subspaces based on the basic categories of the game of basketball. As a necessary first step we made a thorough analysis of two supposed subspaces defined by the representative sample of basic categories of tasks of the game of basketball. For the shaping of the plan of knowledge analysis in the game of basketball we used categories *basic attributes of the game* and *entities* (tasks in the game). The goal was, by using scientific methodology, to determine and analyse the content of the corpus of basketball knowledge according to the mastery of top-grade and selected basketball experts – players and coaches. The research procedure for the fulfilment of the first important goal had two phases. In the first phase, two steps were obtained. In the first step, we set *hypothetic model* of individual and collective tasks based on two attributes: position in the team ant phase of the course of a game. In the second step, based on that model, we made a list of *'bare'* or *unattributed tasks* in the game. In the second phase, for the purpose of objective and precise description of the tasks in the game, each task was joined the same attributes that describe it most thoroughly and that are based on the analyses of primary categories of the game of basketball. The expected results of the research are: analysis of the reliability of the attributes, determining the latent structure of the attributes, the list of precisely described tasks in the game, the structure of their internal grouping, hierarchical grouping of entities and interpretation of differences between the groups established in the space of primary attributes of the game. The second important goal of the research was the construction and validation of a measuring instrument (questionnaire) for gathering and registration of expert basketball knowledge. For the realization of that goal, we shaped a questioning procedure by which we registered the experts' knowledge.

The analysis of past researches about the area of knowledge in the game of basketball is based on the available theoretical annexes and scientific researches. The concept of tasks or tasks in the game, as one of the holders of basketball knowledge, comes in different forms (*job, task, assignment, duty*) at some authors (Harris, 1993; Walker, & Donohue, 1988). These authors, however, use the named words for pragmatic purposes for the marking of tasks that are supposed to be done in the context of some game tactics model, while the system theoretical analysis of tasks in the game, that would treat the area as a structure and organization of specific kinesiology knowledge in the game of basketball, does not exist in the published and available literature.

Until now, theoretic researches have dealt mainly with the examination of the following categories: court, positions and roles in the game, basic principles of the game and structural analysis of tasks in different phases of the flow of the game. Beside the previous, there are opinions (Javier, 1992) that 'determine the evaluation of the importance of basic principles of the game (technical and tactical skills) over other activities in the game'. In connection with it, this kind of thinking is considered to have magnified the real value of the principles of the game, because the technique as an instrument has the value only if it serves to strategic decision making, as Hernandez (1987) remarkably described it. Technique is not value by itself, but only if implemented in a strategic concept.

Wooden and Sharman (1974) divide the essentials of the game to: dribbling, receiving pass, pivoting, shooting, defensive rebound and offensive rebound. They also state the division of the game

essentials of the technique elements into those with or without the ball. Additionally, Wooden (1977) divides individual basics of the game on the control and balance of the body, offence techniques (passing, receiving the ball, pivoting, shooting, carrying, blocking, turns, actions with the ball and without the ball, offensive rebound) and defence techniques (defence before receiving the ball, defence after receiving the ball, defensive rebound). Also, he described the game of basketball as a precise science that demands successful performance of certain skills. Bird and Bischoff (1985) claim that teaching the young players fundamental principles of shooting, passing, ball carrying, defensive rebound, offensive rebound, are the basic assumptions to the development of the game of basketball.

Arnold (1981) classifies the basics of the game into: stance, movement, moving in stance, starting movements, changes of the direction and speed of movement, shooting, skills of passing, catching the ball, dribbling the ball, stopping, pivoting, cut, blocking, performing fakes and dribble penetration. According to him, fast and accurate performance of different basic skills in the game of basketball is the 'secret' of successful individual and team game.

Knight (1983) distinguishes three sectors of game areas: offence, connection between defence and offence which he calls conversion and defence. Further, he divides the basics of the offence into: manipulation with the ball, movement without the ball, block and cut, shot from the mechanic view and contested shot and passing and shooting while dribbling. He divides the basics of the defence into the defence on the ball and pressure (in receiving, dribbling, passing and shooting), he also thinks that the basic defence stance is the foundation of every defence and its most important basic element. The whole basketball technique comes from the stance. Bird and Bischoff (1985) observe the game of basketball through the following basics of the offensive play: dribbling, dribbling penetrations, stopping, pivoting, passing and receiving the ball, shooting, triple threat position, running, blocking and offensive rebound. And also, they make distinctions in defence: defensive stance, moving in stance (lateral sliding half steps, forward half steps and reverse half steps, keeping the position between the opponent and the basket, pressure on the player who lifts the ball, reaction in a basic defensive stance on the offensive threats,: shoot, pass and first step, way blocking, basket closing and defensive rebound.

Knight and Newell (1986, 1988) divide the basics of defence into: legs work, use of arms, adjustment of the position according to the position of the ball, guarding the access to the basket, defensive rebound (the culmination of the whole defensive game). Besides, they identified five basic areas that they think should be exercised on a daily basis: pressure on the ball, pressure on the passing line, helping and returning to the direct offence player, guarding the access to the basket and post-defence (the heart of a defensive game). Furthermore, they defined six basic principles of the offensive game: manipulation with the ball: passing, receiving, dribbling, shooting, space between players, cut, blocking and post-game.

Knight (1994) claims that the individual work on the basic principles in every training process is essential to the development of offensive or defensive system.

Hernandez (1987) claims that technique is an important part of the game on which the system is built, allowing thus a connected action that we call tactics. Starting from the dichotomy technique-tactics, the author develops systems and models of the game. The following groups of system elements of the game of basketball emerged out of such a consideration: individual offensive technique, individual offensive tactics, individual defensive technique, individual defensive tactics, collective offensive technique, collective offensive tactics, collective defensive technique and collective defensive tactics. Furthermore, he states that each of these separate unities consists of series of elements. *Individual offensive technique:* manipulation with the ball, basic offensive pose, moving with the changes in rhythm and direction, moving for the reception of the ball, backdoor running, two-step stop, pivots, dribble penetration, forward carrying and protection of the ball, pivots and penetrations with arms shift, ball reception, passing (from the chest height, baseball passing, hand off), shots (static and dynamic – frontal with the delay in the air, lay up shots, slam dunks), feints (while penetrating, shooting, passing and dribbling) and offensive rebound. *Individual defensive technique:* basic defensive stance, moving in the basic defensive stance, stopping the passing and shooting line, cutting the passed ball (in rebound, passing, blocking the shot or parring), guarding the access to the basket, defensive rebound and individual man-on-man defence. On the other hand, the collective offensive technique consists of: blocks, passing, ball

reception and passing and running towards the basket while collective defence technique consists of defence from blocks and various help systems.

If we analyze the game tasks, we can notice that basketball is the game of continuous tasks, which means that at the same moment when one intensive activity ends, the other structure of game tasks begins.

Basic tasks in transitional and set defence are directed to the elimination or minimizing the number of 'easy' points and on the forcing the opponent to play 5 on 5 against regrouped defence. For such an approach the team has to achieve, according to Harris (1993), the following goals: fast transition to defence, control of opponent's transition attack, prevention from achieving a point from the breakthrough with or without the ball, control of individual transition offence, attack on the rebounded or 'loose' ball, control of second shot, rotation in covering i.e. guarding the open player, control of open shots, forcing the opponent to make 'a move more'. Furthermore, in the important characteristics of the defence he includes: speech in defence, help in defence, and defence against all breakthroughs. Besides the previous, Harris (1993) deals with the basic tasks in transitional defence. Those tasks are: slowing down the first pass, securing or protecting the basket, pressure on the ball with the purpose of preventing the progress of the ball, preventing the pass toward side lines, preventing the penetration through the middle. The listed given tasks, that enable stopping of the opponent team in a way that they stop the actions that result in 'easy' points, are of a special importance for the control of intensity and result in a game.

METHOD

The knowledge of basketball is accumulated in the literature, scientific articles, coaches, scientists, players and others who study the game of basketball. Within that group of people with the knowledge about the game, it is possible, on the basis of the previously given criteria, to determine the ones we call **basketball experts**. The person considered to be an expert had to be basketball **coach** or **player**. **Criteria** according to which the experts are determined in the research were the following:

- Expert – **player** had to be a member of a team that won the first place on some European club contest (Euroligue, Eurocup), the member of the representation that won one of medals on European championship, World championship or the Olympic Games,
- Expert – **coach** had to have the status of the coach of a team that won the first place on some European club contest (Euroligue, Eurocup), the coach or member of the representation that won one of the medals on European championship, World championship or the Olympic Games.

Expert opinion is taken to be one of the most relevant ways of analysis and evaluation of the events in the basketball game and of the game quality of an individual – player, so it was used in scientific researches as a reliable criterion. (Brooks, Boleach, & Mayhew, 1987; Swaglin, 1993; Jakovljevic, 1995; Karalejic, 1996; Erculj, 1999; Trninic, Dizdar, & Dezman, 2002; Jakovljevic, Karalejic, & Radovanovic, 2007). Ten experts participated in this research, five of which were coaches, and five were players.

Sample of entities

In this research, entities are tasks in the game. The sample of tasks was determined by the following criteria: former theoretical annexes that contain some divisions of tasks in the game, former playing systems that classify tasks and one's own experience in high-grade basketball practice.

According to these criteria, we reached a large number of tasks (159), what was a practical obstacle for carrying out the research of experts' opinions. By additional procedure, by structural interview with experts, we made secondary selection out of which resulted in the list of 79 tasks. According to the research space, they cover all important aspects of the game of basketball. Considering the fact that the totality of the knowledge in the game of basketball in all its structure is most markedly depicted on the level of tasks in the game, they are taken as entities by which the corpus of basketball knowledge could be best analysed. For that reason, the analysis of the basic attributes of the game was made.

Basic attributes and variables

Basic attributes and variables in the research were derived from the following categories:

space and subspaces of the court, positions in the game and phases of the flow of the game.

All these categories consist of parts with relatively well defined correlations. Let us state basic divisions in order to explain the way the task attributes and variables are generated.

Connected to that, there is a unique division for the category **space and subspace of the court**. In order to assure the complete covering of the whole court and, on the other hand, greater precision in the division of the court into certain subspaces that are more interesting for the estimation of tasks in the game of basketball in this research we accepted the division into the whole court (C), front (F) and back (B) court, and also zones division : A (the zone of attempts to score point in the paint and directly under the basket), B (the zone of attempts to score point in the paint from the end of zone A to the pole of circle for free throw) and C (the zone for the attempts of scoring points that goes above and on the sides of zone B in the shape of letter Y) in the area of offence and the area of defence. An expert chooses maximum three answers out of the given possibilities. By the analysis of the category of the **game position**, it can be determined that their structure can be described by the game positions like: point guard (B1), shooting guard (B2), small forward (F), power forward or power wing (PF) and centre (C). Beside these positions there are also marks for outside players (O), inside players (I) and all positions (A). The expert chooses maximum two answers out of given possibilities, but in such a way that along with every answer he gives an opinion whether he considers the task to be obligatory for the related position, or it is the result of unique outstanding players' qualities. The **course** of the game is also an important category of a game and all authors emphasize the importance of continuous course of the game. In today's basketball almost all experts, maybe sometimes using different terminology, distinguish between four phases of flow of the game: set defence (D), transition offence (Con), set offence (O) and transition defence (Cno). The expert chooses maximum four answers out of given possibilities.

In the process of questioning experts, we used a specially designed questionnaire where the scale and the direction for data entry in the answer list were precisely defined for every attribute. In the attributes considering court zones, game positions and phases of flow of the game (1-11), the expert's opinions about game tasks are registered on nominal scales. The meaning and the description of every modality of nominal scale in these attributes are given with the definition of every attribute.

The process of experts' answers quantification

Within the field of basic attributes, the process of quantification was done in such way that the modalities of proposed answers to the questions were converted to numeric values. If, for the performance of a certain task the modality of proposed answer was not selected, we allocated it the value 1, and when it was selected, we allocated the value 2. The exceptions were the questions regarding the game positions.

Modalities of answers marked as group (O, I, A), are considered to be appropriate group selectors.

Besides, with game positions we had to pay attention whether the expert assessed the task as obligatory (O) or individual (I). In accordance with that, the answers were transferred to ordinal scale with values 2 for the modality obligatory task (O), and 3 for the modality individual or specific task (I) for a certain position.

Analysis of measuring instrument

In the construction of measuring instrument, the attributes are structured within one unit. We can mark them as **basic attributes**. Basic attributes are based on basic categories of the game of basketball, like: game space, phases of flow of the game, positions and roles in the team. Those units are treated in the results analysis in such way that equal plan of the analysis was made. After that it could be determined what way the suggested hypothetical structure of knowledge in the game was grounded. The work plan determined for every unit the application of analysis of measuring instrument (which includes analysis of reliability of measuring instrument of the variables and factor analysis) and analysis of grouping (which includes hierarchical grouping of entities – tasks and canonical discriminant analysis of the sample of groups obtained by previous analysis).

Data analysis

In connection with the work goals, data analysis was planned to enable the identification of the structure of basketball knowledge corpus and the control of measuring instrument for the collecting and registration of expert basketball knowledge. The analysed corpus of data matrix, contains the data carriers – entities (tasks in the game of basketball). In the matrix columns each task is described by the sequence of attributes. The attributes or variables of objects are usually displayed as coordinate axes in multidimensional space. In that space, entities are points. The measurement of experts' opinions agreement (match or consensus) about a unique subject of measurement was determined using reliability coefficient alpha. All the attributes which were shown not to achieve the satisfactory agreement in experts' opinion were eliminated from further analysis. In the work, we applied analyses used to determine basic indicators of validity and reliability and also internal consistence of the variables: RMS – the estimation of the amount of common variance, Cronbach's alpha – reliability measurement, MSA – measurement of sample adequacy, MACOV – minimum amount of common covariance.

Within the explorative strategy, we applied factor analysis under the component model with the aim to achieve condensation and description of intercorrelations of greater number of variables in lower number of factors (hypothetical or latent dimensions). Considerable number of factors was determined on the basis of GK criteria (Guttmann-Kaiser) of the matrix of correlation of the observed variables. Final factor solution was obtained using the OBLIMIN inclined rotation. Factor analysis was applied as a help method for verification of theoretical, or factor validity of the measuring instrument. The result of group of experts' opinion for all the attributes in the analysis was determined as a Z-score on the first main component of the attribute, or variable.

After the measuring characteristics of the proposed instrument were analysed and determined, by using those processes, we addressed the main goal of the research – the analysis of internal tasks structure. The practice of rational and empirical classification of objects, in accordance with the determined similarities, is the foundation of researches in most scientific fields. Cluster analysis is formal study of algorithms and methods for the grouping and classification of objects. The aim of grouping is (by using some of the algorithms for grouping analysis) to find appropriate and valid way of data organization. Grouping is a type of classification that is applied to the final group of objects. The objects are shown as points in d-dimensional metric space, and the closeness of the pairs of objects is shown in Minkowski metric as Euclidean distance (Jain, & Dubes, 1988). For the grouping method, we chose classification into non-overlapping subsets of intrinsic hierarchical type- exclusive intrinsic hierarchical grouping. The algorithm used for the classifications is of agglomerative type. The act of putting the objects into groups and gradual collecting of the atoms forms greater groups, until all the objects belong to one group (cluster). Out of different approaches and algorithms that deal with the problem, we chose the algorithm for hierarchical grouping that is based on Ward method in serves for rational and empirical classification and analysis which tends to identify and analyse clusters in a certain group of variables (Jain, & Dubes, 1988).

For the purpose of clearly defining the differences between the set groups in the space of attributes, we used canonical discriminant analysis. Within the canonical discriminant analysis we calculated: coefficient of canonical correlation (Rc), Wilks' lambda ($W\lambda$), the testing of statistic importance of discriminant functions was determined by Bullet χ^2-test, matrix of correlation with the discriminant functions (structure matrix), the position of group centroids in the space of discriminant functions and the matrix of entities classification based on discriminant functions.

RESULTS AND DISCUSSION

Metrical characteristics

Basic indicators for the determination of metrical characteristics of attributes or variables are presented in table 1. By the insight into the degree of reliability of variables we determined that all the attributes reached satisfactory reliability. The values of reliability coefficients go in the range from .86 to .98 (where the values greater than .90 prevail). It can be concluded that the degree of the agreement of experts' opinions about the real subject of measuring is extremely high at all he attributes, which means that the further analyses are based on the information that describe game tasks well. Besides, table 1 shows indicators MSA – measurement of sample adequacy, where all the measurements are in the category of excellent adequacy, RMS – the estimation of common variance and MACOV – measurement of the amount of common covariance expressed in percentage. So, we can conclude that all the attributes reached extremely high reliability values, and consequently were used in further analyses.

Table 1. Metrical characteristics of basic attributes

VARIABLE	RMS	ALPHA	MACOV%	MSA
ZONAT	.575	.929	56.442	.867
ZONAP	.468	.890	62.429	.795
ZONAZ	.532	.914	70.062	.809
ZONAA	.608	.938	67.221	.881
ZONAB	.462	.890	58.078	.812
ZONAC	.396	.858	50.082	.780
POZB1	.715	.961	78.096	.909
POZB2	.633	.944	68.470	.896
POZK	.559	.925	61.963	.882
POZKC	.682	.955	72.578	.923
POZC	.700	.958	75.129	.918
FAZAO	.885	.983	90.718	.931
FAZAKON	.636	.944	76.361	.867
FAZAN	.879	.975	89.533	.874
FAZAKNO	.640	.945	72.525	.896

Factor analysis

In table 2 central and dispersive values of basic attributes are shown, as well as the indicators of normal distribution.

Table 2. Descriptive characteristics of basic attributes

VARIABLE	$\bar{X}$	MIN	MAX	Σ	KURTOSIS	SKEWNES
ZONAT	.00	-.79	2.09	1.00	-.57	.99
ZONAP	.00	-.80	2.33	1.00	-.19	1.10
ZONAZ	.00	-.64	2.87	1.00	1.72	1.67
ZONAA	.00	-.99	1.59	1.00	-1.55	.42
ZONAB	.00	-1.19	1.72	1.00	-1.61	.04
ZONAC	.00	-.89	2.09	1.00	-.89	.80
POZB1	.00	-1.49	.98	1.00	-1.64	-.37
POZB2	.00	-1.49	1.31	1.00	-1.42	-.19
POZK	.00	-1.54	1.45	1.00	-1.29	-.04
POZKC	.00	-1.48	1.07	1.00	-1.59	-.37
POZC	.00	-1.42	1.11	1.00	-1.63	-.23
FAZAO	.00	-.78	1.40	1.00	-1.63	.59
FAZAKON	.00	-.97	1.61	1.00	-1.48	.44
FAZAN	.00	-1.06	1.04	1.00	-1.97	-.02
FAZAKNO	.00	-.63	2.38	1.00	.13	1.32

With the gathered data, basic statistical parameters were calculated: arithmetic mean (x), minimum result (min), maximum result (max), standard deviation (σ), degree of peakedness (kurtosis) and the degree of asymmetry (skewnes).

Table 3. Correlation matrix of basic attributes or variables

	ZONA T	ZONA P	ZONA Z	ZONA A	ZONA B	ZONA C	POZ B1	POZ B2	POZ K	POZ KC	POZ C	FAZA O	FAZA KON	FAZA N	FAZA KNO
ZONAT	1.00														
ZONAP	.01	1.00													
ZONAZ	.30	-.44	1.00												
ZONAA	-.58	-.34	-.28	1.00											
ZONAB	-.64	-.22	-.36	.55	1.00										
ZONAC	-.28	.31	-.12	-.29	.13	1.00									
POZB1	.33	.38	.24	-.50	-.36	.24	1.00								
POZB2	.26	.17	.33	-.36	-.27	.27	.85	1.00							
POZK	.07	.08	.19	-.18	-.04	.20	.59	.78	1.00						
POZKC	-.55	-.33	-.17	.53	.60	-.12	-.60	-.43	-.10	1.00					
POZC	-.57	-.34	-.10	.58	.55	-.11	-.57	-.41	-.15	.92	1.00				
FAZAO	.08	-.53	.59	.06	-.02	-.08	.09	.17	.06	.05	.15	1.00			
FAZAKON	.30	.34	-.32	-.12	-.15	-0.06	.11	.00	-.01	-.30	-.32	-0.63	1.00		
FAZAN	-.23	.42	-.60	.17	.22	.16	-.05	-.12	-.02	.13	.02	-.68	.33	1.00	
FAZAKNO	.37	-.19	.64	-.29	-.37	-.12	.26	.33	.21	-.18	-.13	.60	-.49	-.55	1.00

By the analysis of basic central and dispersive parameters, and the indicators of normality of distribution, we determined that at the majority of variables values do not diverse considerably from the approximate normal classification and that within the given range they well enough discriminate the chosen structures of game tasks. In the correlation matrix (table 3) a relatively high number of significant, bun not highly correlated analysed attributes, can be observed. From the total of 105 correlation coefficients, 51 of them are significant at the level of significance .01, which is 48.57%, and at the level of significance .05 totally there are 68 of them that are significant, or 58.09%. According to size, the biggest connection is in the correlation matrix between: position power forward and centre (.92), position point guard and shooting guard (.85), position shooting guard and small forward (.78), conversion/transition offence/defence with back court (.64), position power forward and zone B (.60), position small forward and point guard (.59) etc.

It is obvious that there are a lot of common tasks among players at inside positions and also among players at outside positions. The given correlations point to the understandable positive connection between certain positions, court zones and phases of flow of the game. Therefore, the analysed group of attributes is convenient for the determination of latent structure of the game of basketball. It is noticeable that there is a large number of negative and low correlations, for example between: court zones, more explicitly zone B and T (-64), positions power forward and point guard (60) and positions centre and point guard (-57). These negative correlations point to the negative connection between tasks performed in zone B and tasks that take place throughout the entire court, and also between tasks performed by inside and outside players. Communalities are relatively high values and they go within the interval from .66 to .93 (table 4), which indicates very high common variances of manifested attributes or variables with one or more extracted factors.

Table 4. Main components and communalities

VARIABLE	K1	K2	K3	K4	h^2
ZONAT	.69158	.00286	-.51851	.20101	.78755
ZONAP	.24078	-.72700	.14070	-.27483	.68183
ZONAZ	.48734	.69065	-.04318	.05058	.71893
ZONAA	-.74415	.15993	.09363	.34273	.70556
ZONAB	-.71404	.03217	.42859	.06102	.69830
ZONAC	.12134	-.27031	.58949	-.60316	.79909
POZB1	.79610	-.17012	.41423	.12562	.85008
POZB2	.72447	-.00014	.57564	.27109	.92970
POZK	.44142	.00115	.68300	.44861	.86260
POZKC	-.79902	.28937	.21599	.11364	.78174
POZC	-.77654	.36363	.20828	.08331	.78556
FAZAO	.18280	.86466	.11171	-.10132	.80380
FAZAKON	.10585	-.70613	-.30644	.38370	.75095
FAZAN	-.32183	-.72571	.16153	.09223	.66483
FAZAKNO	.52159	.65763	-.00007	-.10937	.71649

Table 5. Typical values of extracted components

COMPONENT	λ	λ%	λcum%
1	4.86727	32.4	32.4
2	3.55551	23.7	56.2
3	2.02240	13.5	69.6
4	1.09182	7.3	76.9

By factor analysis of the attributes we factorised correlation matrix within the explorative strategy. By the application of GK-criterion we extracted four factors that use 76.9% of total manifest space variance. Thereof the first factor uses 32.4%, the second 23.7%, the third 13.5% and the fourth 7.3% of total variance (table 5).

Table 6. Matrix of parallel projections of variables with oblimin factors

VARIABLE	INSIDE PLAYERS	FLOW OF THE GAMEE	OUTSIDE PLAYERS	SUBSPACE C
ZONAT	**.76364**	.08015	.02339	**.40805**
ZONAP	.37690	**-.53177**	.05262	**-.43708**
ZONAZ	.19814	**.74234**	.17193	.16174
ZONAA	**-.77425**	-.12824	-.01566	.30910
ZONAB	**-.82456**	-.13865	.06916	-.12488
ZONAC	.01113	-.01111	.10900	**-.86888**
POZB1	.35092	.00408	**.72200**	-.13991
POZB2	.10665	.10713	**.90177**	-.05857
POZK	-.23178	-.00928	**.98251**	.05686
POZKC	**-.84455**	.05699	-.10030	.06850
POZC	**-.83176**	.14094	.11952	.05642
FAZAO	-.11741	**.88797**	.05865	-.01083
FAZAKON	.31512	**-.76886**	.09033	.37283
FAZAN	**-.77659**	**.07818**	-.10234	-.17743
FAZAKNO	-.18436	**.77147**	.11540	-.00794

Table 7. Matrix of correlations of variables with oblimin factors (structure matrix)

VARIABLE	INSIDE PLAYERS	FLOW OF THE GAME	OUTSIDE PLAYERS	SUBSPACE C
ZONAT	.77987	.15196	.20263	.42909
ZONAP	.37468	-.57865	.19208	-.50975
ZONAZ	.26876	.78227	.26982	.23850
ZONAA	-.77598	-.10331	-.31281	.28021
ZONAB	-.80823	-.16593	-.17741	-.16917
ZONAC	.02872	-.11849	.24558	-.88699
POZB1	.57113	.05226	.85215	-.24438
POZB2	.38583	.17637	.95261	-.18138
POZK	.07210	.07550	.90148	-.10020
POZKC	-.87312	.04119	-.36661	.07626
POZC	-.86482	.12217	-.37304	.07866
FAZAO	-.08200	.88908	.09796	.09722
FAZAKON	.33460	-.70506	.06606	.26139
FAZAN	-.78747	-.02748	-.22204	-.22204
FAZAKNO	.31154	.78515	.26125	.08260

First latent dimension – **INSIDE PLAYERS** (tables 6 and 7) is determined by negative projections of the attributes: power forward, centre, zone A, zone B and offence phase and by positive projection of attribute zone T. The presence of attribute T with opposite sign can be explained by the fact that inside players are more 'inert' (more immovable) considering the extensity of moving lines in comparison to the outside players, because their movement is basically exhausted in A and B zone. The obtained solution is in relation with the traditional concept of understanding roles in the game of basketball (outside and inside players).

Second latent dimension – **FLOW OF THE GAME** is determined largely by positive projections of the attributes: set defence, conversion/transition offence/defence and back court and negative projections: conversion/transition defence/offence and front court (tables 6 and 7). That latent dimension makes clear distinction between the offensive and defensive tasks over the attributes of court zones and phases of flow of the game. Besides, the attributes of phases of set defence and phases of conversion offence/defence have positive unary operator, according to the direction of transformation, while the attributes of phase of conversion defence/offence and zone back court have negative unary operator, because transformation takes place in different direction. It is interesting how that latent dimension depicts two basic conditions of the game – position and transition.

Third latent dimension – **OUTSIDE PLAYERS** is determined primarily by positive projections of the attributes: point guard, shooting guard and small forward (tables 6 and 7). That latent dimension is, according to the usual roles in the game, characteristic for outside players. By the inspection of the given tables, it becomes obvious that the projections of all other attributes are low, as different from the first factor, where, with inside players, the zones of their primary field of action joined. It is obvious that the players are the least sensitive to court zones, and the flow of the game. It comes from greater moving radius that their positions in the game demand.

Fourth latent dimension – **SUBSPACE C** is a single factor. It is determined primarily by high negative projection of attribute zone C, while less contribution to the determination of this latent dimension have zone T (that gives part of the variance to the first latent dimension) and front court. It is noticeable that the attributes that mark game phases as well as all the positions in the game, have very low projections. To that factor, the attribute zone C imposes with its higher projection, as well as other attributes that mark court zones, especially attributes zone P and zone T that have higher projection than other attributes on this latent dimension. It is symptomatic for this latent dimension that it is not significantly defined by the attributes point guard, shooting guard and small forward, whose positions are largely connected to zone

C. That is why the existence of this latent dimension just mentioned, but not well described by the existing group of variables, so its sustainability is put under question.

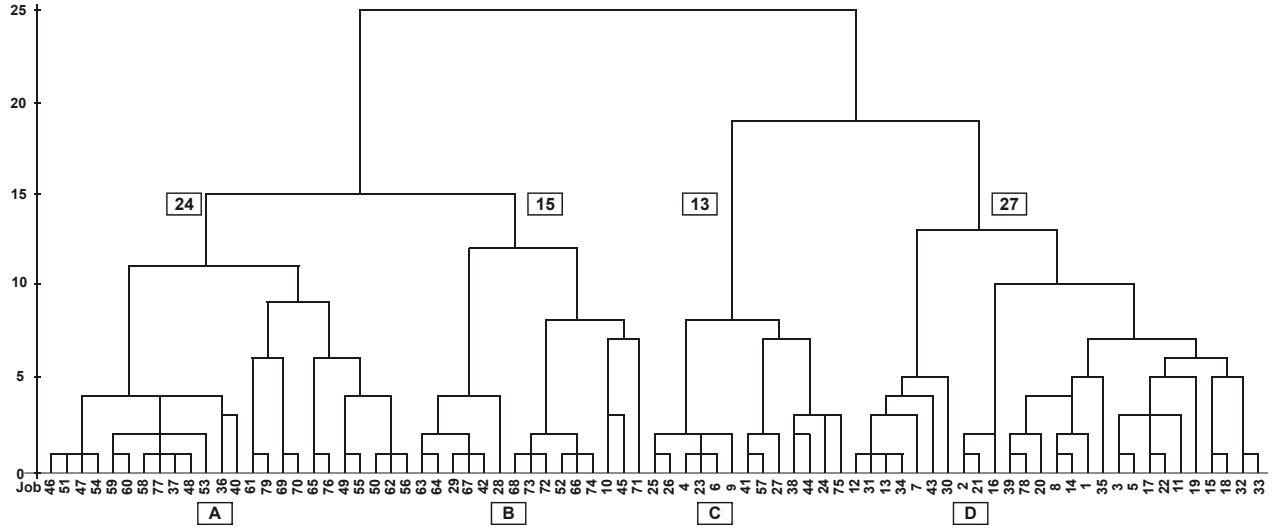
Table 8. Matrix of correlation between oblimin factors

	INSIDE PLAYERS	FLOW OF THE GAME	OUTSIDE PLAYERS	SUBSPACE C
INSIDE PLAYERS	1.00000			
FLOW OF THE GAME	.01973	1.00000		
OUTSIDE PLAYERS	**.30842**	.08317	1.00000	
SUBSPACE C	.01819	.13428	-.15429	1.00000

From the perspective of understanding the game of basketball, it is recognizable that this latent dimension could be in connection with the space of primary action of outside players. In the matrix of correlation between oblimin factors (table 8), we can notice medium correlation (.31) between first (inside players and belonging zones) and third factor (outside players). We can conclude that in the space, covered by these four latent dimensions, the ones related to the team structure, positions and roles in the game as well as to the flow of the game phases were very clearly identified. The attributes of the space of the court act in a different way. At the first factor, which at the same time carries higher described variances, inside players are connected to the zones of their actions (zone A and zone B). As opposed to that, with outside players that phenomenon was not recorded, but their primary zone of action to some extent was identified as a single factor (subspace C). These results, in the context of observing basketball, can be explained by significantly different game roles of inside and outside players. This probably comes from the fact that in classic roles distribution the inside players, compared to the outside, have greater movement limitations and smaller scope of actions in the game. The obtained factor solutions show that the questioned experts understand the game of basketball in the connection with traditional tactics theories. We think that the distribution of the positions and the role of players is the point of view that divides present and future trend of understanding the game of basketball. In future, the classification of players into inside and outside will probably slowly be erased, as well as standard divisions to the positions from number 1 to number 5. Consequently, the procedure of transformation processes must be directed to the creation of players with polyvalent technique and polyvalent play.

Hierarchical Cluster analysis

Figure 1. Dendrogram for the classification of tasks using Ward method



By the hierarchical cluster analysis at level 15 (Figure 1) we identified four groups: A – tasks performed by the inside players in transition offence and set offence; B – tasks performed by the inside players in transition defence and set defence; C – tasks performed by outside players in transition defence and set defence; D – tasks performed by outside players in transition attack and set attack. 24 tasks are classified in the first group. By the analysis of joining hierarchy in that group, at the distance 10, we identified two subgroups (A1 and A2 – Figure 2). Subgroup A1 is markedly characterised by the tasks that are performed by inside players in the phase of set offence. Subgroup A2 is characterised by the tasks that are performed by outside players in all four phases of flow of the game. By the inspection of tasks it becomes clear that the group of tasks, that makes group A, is performed by inside players primarily in the phases of transition and set offence.

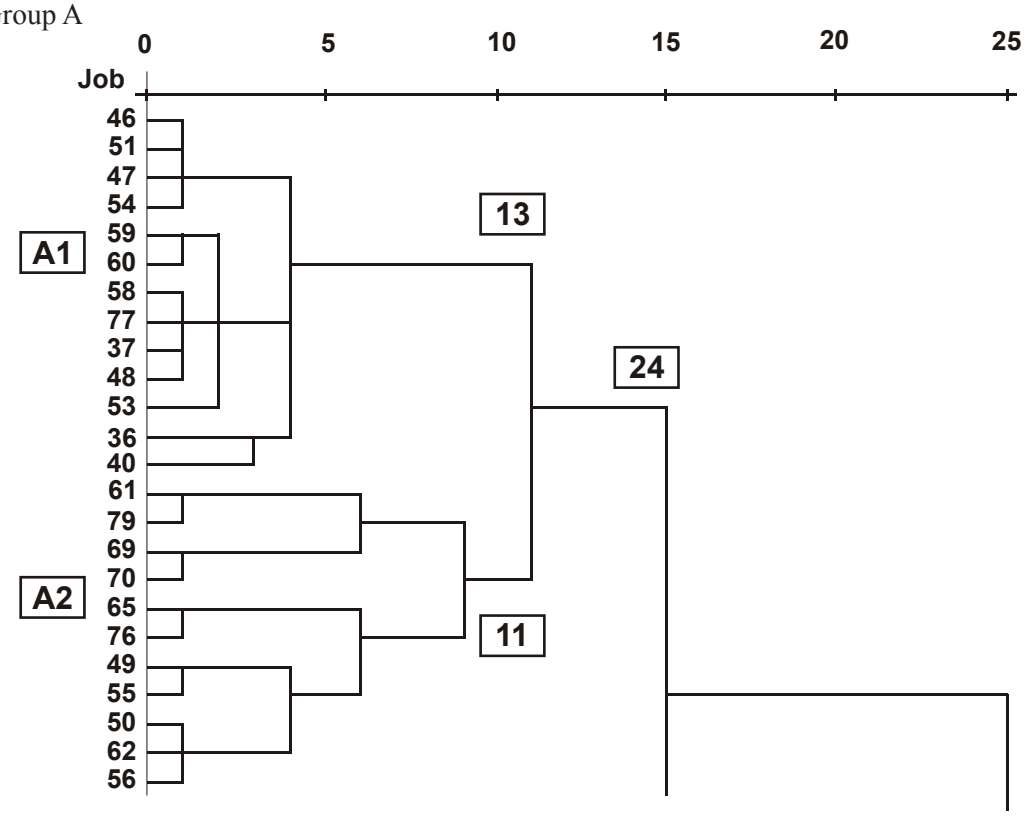
GROUP A1 – Task list

36. Playing at a low post position when the offence player is held by a shorter defence player
37. Usage of inside cuts with the purpose of playing 1:1 in zone A or positioning for offence rebound (selection of inside position)
40. Solving offensive rebound as a second or third rebounder in a team
46. Inside threat or the threat beneath the basket
47. Solving offensive rebound as a first rebounder
48. Frequent position making by playing without the ball for inside game.
51. Scoring or forcing of personal fault in the inside game in 1:1 situation, playing back to basket
53. Scoring beneath the basket and from half distance
54. Solving double team or threat teaming in back-to-basket play by passing to a 'free' player on the loaded or weak side of offence
58. Activity after block with the purpose of opening pass line for the reception of the ball or offensive rebound
59. Positioning for inside position for offensive rebound
60. Offensive rebound covering in the moment when the ball leaves shooter's hand
77. Making strong and aggressive blocks

GROUP A2 – Task list

49. One on one face-to-basket playing on free throw line
50. Taking the high player out of the paint for the releasing or opening the paint
55. Mediation (relay) for offence rotation from loaded to weak side of offence
56. Making successful blocks for shorter players and deblocking for reception of the ball or offensive rebound
61. Helping in the game against aggressive defence
62. Helping in releasing shooting guard from directing him towards the corner by making block on defence player who holds player with the ball
65. Helping small forward, shooting guard or possible second centre in defence
69. Overrunning of opponent defence as a fourth player and positioning in A or B zone for ball reception before the defence regroups
70. Overrunning of opponent defence as a fifth player and positioning in the role of security player on the free throw line in transition from defence to offence and mediator for attack rotation
76. Defences from pick & roll by braking block line and vertical run out to dribbling line
79. Enabling ball transition in play against pressing defence – safety player

Figure 2. Group A



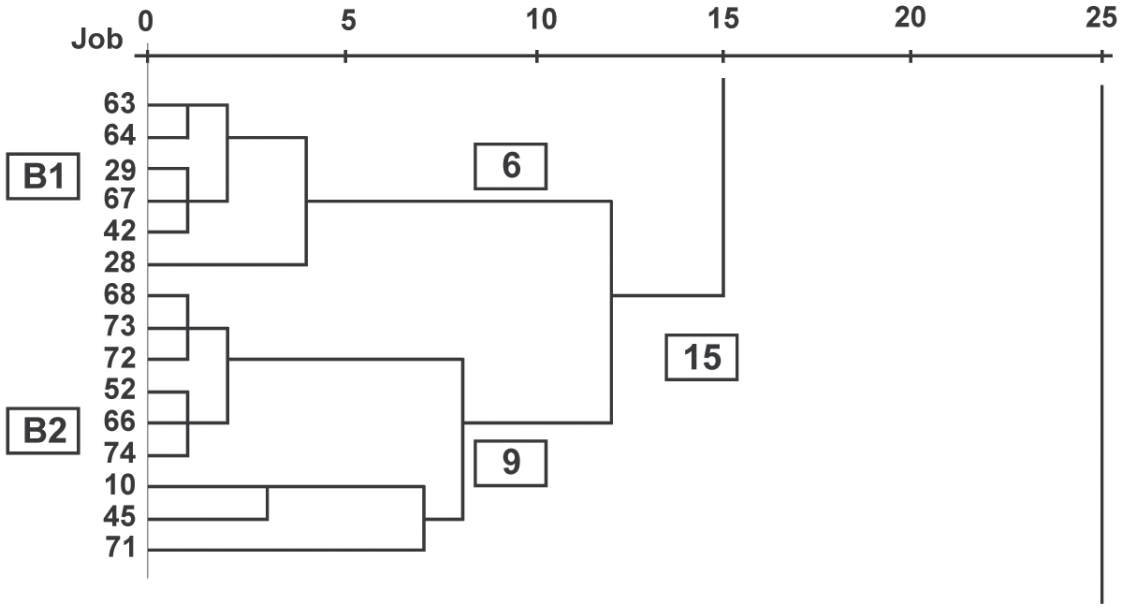
GROUP B1 – Task list

28. High closing of access to the basket and step in the 'holes' of defensive rebound triangle for long bounced balls
29. Participating in the organization of defensive rebound
42. High guard of access to the basket
63. Preventing or obscuring moving and passing line towards the 'heart' of the paint
64. Positioning for offence fault at the rotation of helping side vertically or horizontally
67. Positioning for the selection of inside position for defensive rebound or of positions in front of opponent player, i.e. between the opponent and the basket

GROUP B2 – Task list

10. Communication from the position of specific situation where the 'director' is last line of defence
45. Outside quick firs pass towards number 1 after score or missed shot or shot from free throw 52. Control of the middle of the paint and control of the board_
66. Blocking the shot with bouncing the ball in the direction of number 1 or number 2 or catching the blocked ball before it hits the floor
68. Solving defensive rebound with the protection and pressure on the ball before first pass
71. Preventing or slowing down of first outside pass of a rebounder or interfering the angle of first outside pass
72. Closing the back of the defence front line by sprinting below the ball line in the paint
73. Breaking the centre's blocking line and shooting guard's movements
74. Defensive positioning in front of or beside on the position of small post (on the side of the ball) and/or rotation to the second centre from the position on the help side

Figure 3. Group B

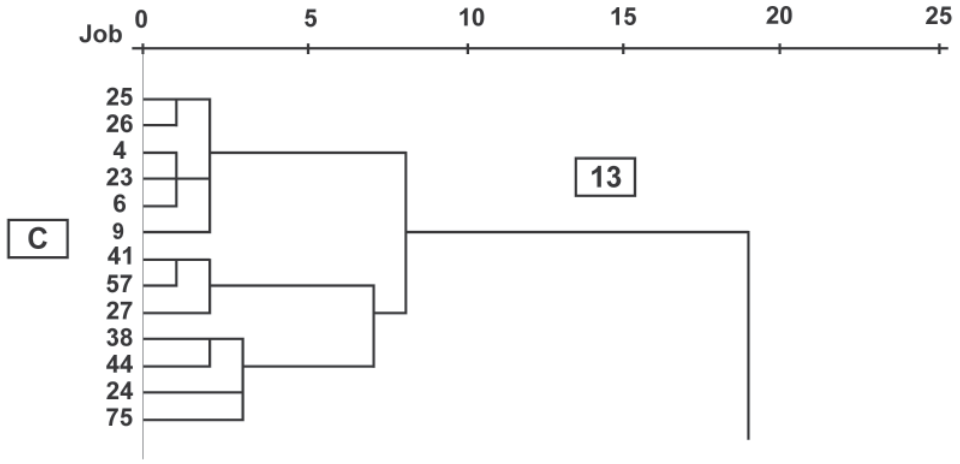


In group B 15 tasks are classified into two subgroups (B1 and B2 – Figure 3). Subgroup B1 is marked with the tasks performed by inside players (and partly outside ones) in set defence. Subgroup B2 is marked with the tasks of outside players in the phase of set defence in conversion/transition offence/defence. Group of tasks, that makes B group, is performed by inside players in transition and set defence. Group of 13 tasks, which makes group C, is performed by outside players in transition and set defence (Figure 4).

GROUP C – Task list

4. Pressure in front defence line with the prevention of penetrating first defence line
6. Setting and determining pressure intensity in front defence line
9. Communication from the position of defence leader with the command (verbal or non verbal) about defence change
23. Slowing the opponents' actions by stopping, withholding or directing offence
24. Preventing vertical or in-depth dribbling
25. Isolation (removing) an opponent player from the game after pass
26. Helping on relation shooting guard-shooting guard, shooting guard-small forward and shooting guard-centre
27. Participating in ball takeover: ball interception, 'steal', 'loose' ball, shot blocking
38. Slowing opponents actions by closing pass line at side positions
41. Blocks avoiding
44. Defence of counter attack by preventing pass at side or wing positions
57. Maintaining relation ball – defence player – offence player in defence, on a player without the ball
75. Making double team in the court corners according to the game situation

Figure 4. Group C



Group D consists of 27 tasks, classified into two subgroups (D1 and D2 – Figure 5). Subgroup D1 is marked by the tasks of outside players in the phase of conversion/transition defence/offence. Subgroup D2 is marked by the tasks of outside players in the phase of set attack. The insight into task list reveals that the group of tasks, which makes group D, is performed by outside players (primarily first and shooting guard) in transition and set offence.

GROUP D1 – Task list

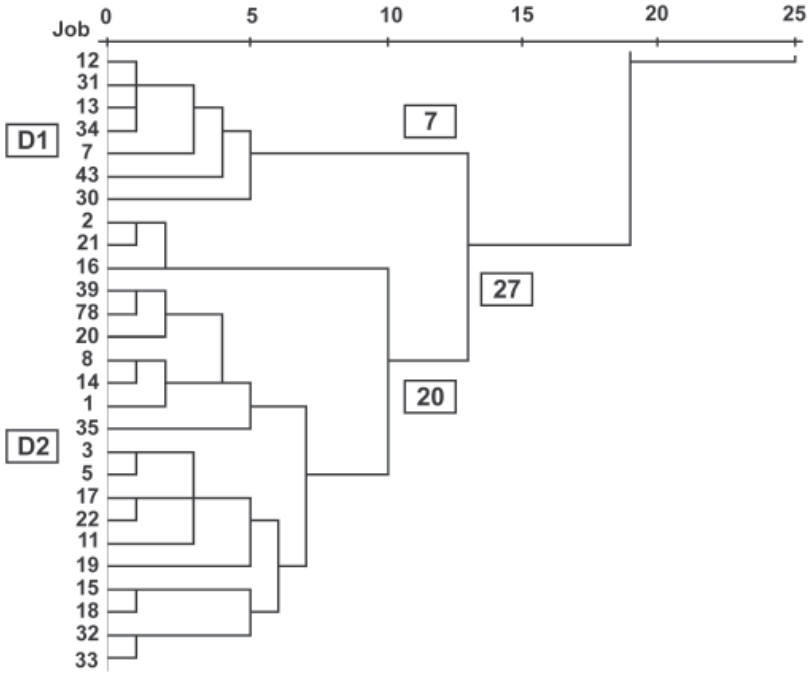
7. Determining the moment of changing speed and aggressiveness of the game during the game
12. Quick transfer of the ball in the front court of the court
13. Penetrating front line of pressing defence
30. Opening for the reception of first pass or second pass in the starting phase of counter attack
31. Quick and safe transfer of the ball against pressing defence
34. Penetrating first line of defence of counter attack and creating power in numbers and space
43. First runs into counter attack by sprinting in opponent's 'back' and thus covering side line

GROUP D2 – Task list

1. Organization and control of offensive game
2. Ball control until desired open shot
3. Feeding the team by offence assists
5. Selection and in-time pass to best positioned player
8. Using co-player depending on the game situation, i.e. depending on the quality and rhythm of players during the game
11. Scoring when needed in the situations with time pressure and game results pressure
14. Signalizing game organization during offence setting
15. Changing direction and speed of offence by dribbling from loaded to weak side
16. Quick offence rotations by passing from loaded to weak side
17. Braking through the crowd (two, three, four players) and finding 'holes' in defence
18. Forcing defence to make double team (doubling), threat teaming (tripling) and thus opening outside shot for number two or three or inside players
19. Cooperation with power forward and centre

20. Readiness and patience in waiting for ball reception throughout attack continuity without the ball
21. Two on two play with different types of cooperation and communication in offence: pass and go, backdoor cut, feint or dribbling guidance of defensive player who holds offence player with the ball on the block, emptying the side of offence.
22. Making blocks without the ball on relation short-high player for obtaining situations high-short
32. Determining counter attack closure from middle court position
33. Organized counter attack closure
35. Closing start counter attack phase or preventing reception of first pass in preparation for or beginning of counter attack
39. Scoring open shots
78. Continuous moving and cuts in 'holes'

Figure 5. Group D



Positions in the court and phases of flow of the game are important attributes of the game of basketball, while court zones, as opposed to the positions and phases of flow of the game, act partially non-homogenously and inconsistently with regard to the previous two game attributes. Thus, the tasks in the game are not significantly sensitive to court zones, which is probably in accordance with modern interpretation of the game of basketball (universal quality, polyvalence and total game). Therefore, because 'smooth' transition between certain phases of flow of the game majority of game tasks is invariant to court zones. After the analysis of hierarchical grouping, good structure and inside coherency of four task groups can be determined. These tasks, considering the flow of the game variables, show familiarity of groups A and D, because both refer to the phases of set and transition attack and familiarity of groups B and C, because both refer to the phases of transition and set defence. On the other hand, familiarity between groups A and B can also be seen because they both refer to inside players and groups C and D refer to tasks of outside players.

Discriminant analysis

By canonical discriminant analysis in the space of basic attributes on the sample of four acquired groups of entities, the existence of three discriminant functions was determined, statistically considerably making distinctions between groups of entities obtained by cluster analysis (table 9).

Table 9. Typical value (λ), variance percentage (λ%), Wilks' lambda (Wλ), canonical correlation (Rc), test for testing the importance of canonical correlation (χ^2), number of degrees of freedom (DF) and level of importance (Q)

	λ	λ%	Wλ	Rc	χ^2	DF	Q
1*	7.6633	54.06	.0079	.9405	331.447	45	.0001
2*	5.1353	36.23	.0686	.9149	183.549	28	.0001
3*	1.3762	9.71	.4208	.7610	59.286	13	.0001

From table 9 it is visible that there is a statistically important difference between the given groups of entities – tasks in the game at the importance level considerably lower than, with extremely high canonical correlations (Rc_1 =.94, Rc_2 =.91 i Rc_3 =.76).

Table 10. Correlations of variables with discriminant functions (structure matrix)

VARIABLE	F1	F2	F3
FAZAKNO	**57856**	.14158	.23493
FAZAO	**.54091**	-.15003	-.29638
ZONAZ	**.40289**	.05647	.06866
FAZAN	**-.37412**	.05519	.36451
FAZAKON	**-.29527**	.20378	-.00493
POZB1	.12732	**.57593**	-.16619
POZKC	-.02769	**-.47591**	.09462
POZC	.00854	**-.43408**	-.05037
POZB2	.16518	**.42379**	-.07476
ZONAA	-.07282	-.35262	-.13396
ZONAP	-.21875	.34493	-.24718
ZONAB	-.12147	-.27760	-.03700
ZONAT	.10409	.24777	.21943
POZK	.10061	**.21833**	.06093
ZONAC	-.04606	.15352	.05540

Table 11. Position of group centroids in the space of discriminant factors

	F1	F2	F3
A	-1.93630	-2.03120	1.10232
B	1.92187	-2.48319	-1.80517
C	5.11973	1.47585	1.15853
D	-1.81161	2.47446	-.53478

Figure 6. Position of tasks in coordinate system of first and second discriminative function

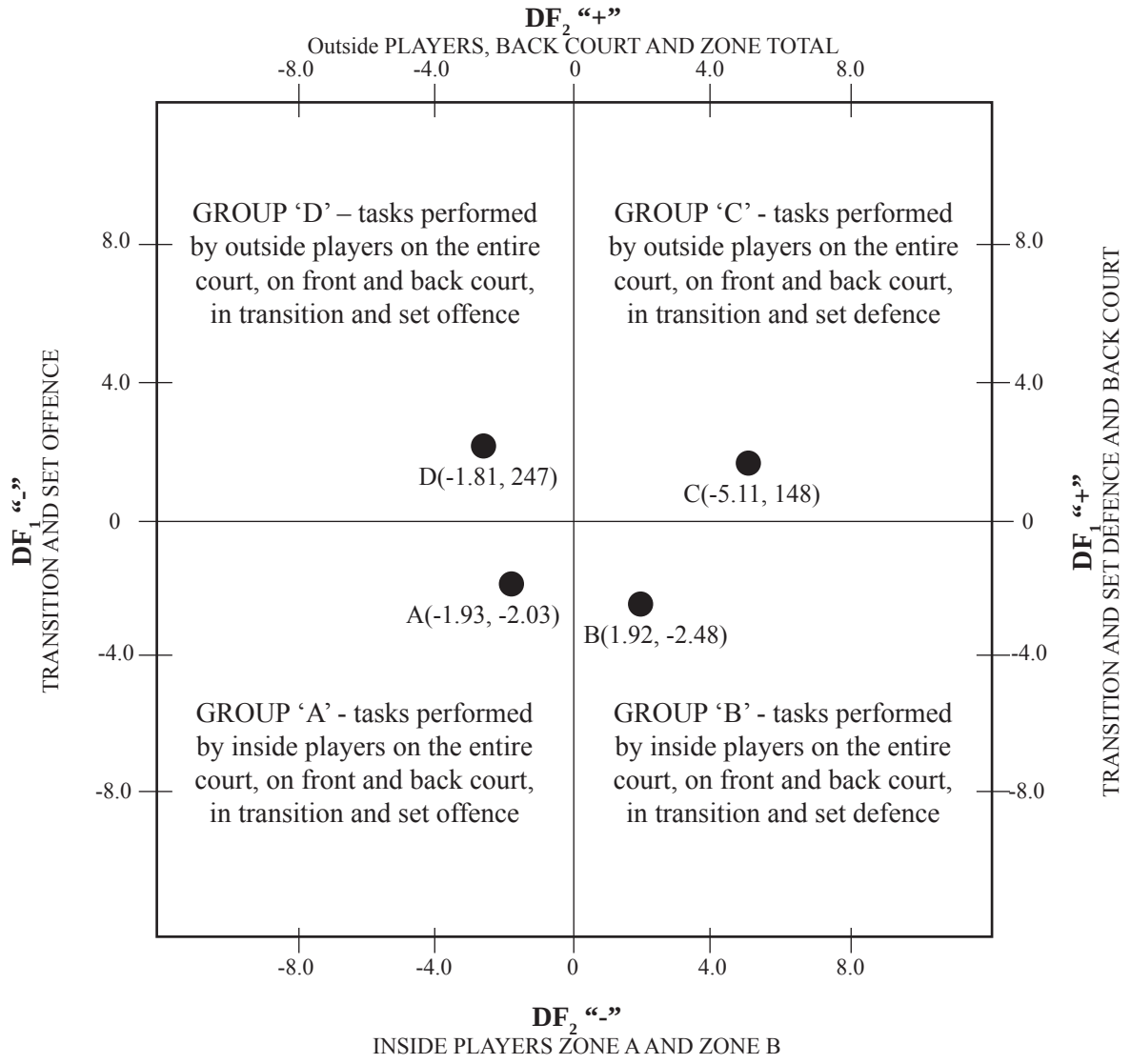


Table 12: The matrix of entity classification on the basis of discriminant functions

GROUP	ENTITIES	A	B	C	D
A	24	22	2	0	0
		91.7%	8.3%	.0%	.0%
B	15	0	15	0	0
		.0%	100.0%	.0%	0%
C	13	0	0	13	0
		.0%	.0%	100.0%	.0%
D	27	0	0	0	27
		.0%	.0%	.0%	100.0%
Classification of groups: 97.47%					

The three obtained discriminant functions make significant difference in entity groups resulted from cluster analysis (table 10). The first discriminant function is dominantly defined by the game phase course attributes. It should be seen that the phases related to *transition and set defence* are of the opposite unitary operator compared to those related to the phase of transition and set offence. Besides these, in this discriminant function we can find back court variable. The second discriminant function with the greatest discriminant "power" is determined with positive unary operator by outside players' positions on the one hand and with negative unary operator by inside players' position on the other. Apart from these, the positive pole of this discriminant function is significantly determined by *front court* variable and *zone T*, whereas the negative pole is determined by *zone A and zone B* variable*s.* The third discriminant function, though statistically significant, is of weak discriminant power (verified by 9.7% of total variance) and it is not dominantly determined by any variable.

Table 11 and Figure 6 show that group D centroid is placed in the first quadrant of the first and second discriminant function coordinate system, group C centroid is placed in the second quadrant, group A centroid is in the third and group B centroid is placed in the fourth quadrant, which makes description of the determined entity groups and their characteristics possible with regards to the first and second discriminant function: group A- tasks performed by inside players (power forward and centre) in zone A and zone B as well as in transition and set offence; group B- tasks performed by inside players in zone A and zone B, in back court as well as in transition and set defence; group C- tasks performed by outside players in the entire court, in back and front court as well as in transition and set offence.

We conclude that group D and group A positions almost coincide with each other, with regard to the first discriminant function (they are placed on the side determined by transition and set offence), whereas group B and, further, group C are positioned towards the side determined by variables of transition and set defence (Figure 6). With regard to the second discriminant function, certain analogy can be stated on positive side between groups D and C and between groups B and A on negative one. The second discriminant function is dominantly determined by team positions: on positive side by outside players and on negative side by inside players. Table 12 shows that the entity classification into groups B, C and D is 100% whereas for group A is 91.7%. Therefore, the total of correctly classified entities is 94.47%, which sustains very high group differentiation according to the basic attributes. The only deviation is found in group A from which two tasks are moved into group B. The results of discriminant analysis indicate the justification of task grouping into groups A, B, C and D resulting from hierarchical cluster analysis.

CONCLUSION

The survey of classifying tasks into relatively homogenous groups and the task inside structure analysis are the first of its kind based on the exact scientific proceedings. The game tasks as entities have functioned as well as "entrance tickets" for the basketball tree in enlightening "knowledge in the game of basketball" through the basic attributes. From the results of the survey it is seen that the game tasks having been evaluated according to the basic attributes embraced the upper part of the tree (strategy, tactics, and game conditions).

It has been shown that the basketball game tasks represent the category which has given enough information for analysis and hypothetical model - tree verification. On the basis of the all above it has become possible to confirm the model of knowledge structure in the game of basketball. The given entity grouping according to the game phase course corresponds with the category of game conditions.

According to the criteria of game positions and game roles, the given entity grouping corresponds to the category of game tactics. This survey should give contribution to the wholeness of the existing specific kinesiology knowledge, in the first place by scientifically based description of kinesiology content segments referring to the game of basketball. In order to accomplish that, the measuring instrument for the registration of knowledge in the game of basketball has been constructed. The instrument can be applied in the areas of other team sports games as well. Practical task significance could be determined according to possible contribution to various parts of sport practice. The survey results could be applied in schooling area (its direct impact on curriculum and syllabus of basketball players education, the process

of coach education, curriculum and syllabus for basketball experts training), training area (basis for creating modern tools which would enable the extension of learning possibilities and improving basketball knowledge in training process, analysis of precisely described game tasks and its inside grouping structure as methodological hypothesis for professional orientation and selection as well as the starting point in planning the everyday training and practice contents), basketball matches (planning of creating the new means for matches monitoring, analysis of flow of the game, evaluation of players stats and game strategy and tactics selection). Furthermore, the results can be used in the work field of basketball association (coach academies) and basketball camps that are directed towards player training in certain positions and game roles.

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Received 1.10.2010.
Accepted 27.10.2010.