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**Original Article**

# Modeling of the athletic training process in team sports during an annual macrocycle

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**Abstract.**
In the article we substantiate the concept of the athletes' training process in team sports in the macrocycle based on the methods of modeling, which involves developing methodological aspects of making model characteristics of athletes' training and competitive activities, models of structural formations in the training process.

The analysis of players' competitive activity need to be made taking into account quantitative and qualitative indicators of technical-tactical actions and the conditions under which they are performed. Implementing technical-tactical actions are fixed in the three regimes of coordination complexity (RCC): on-site or at a convenient speed of movement (1st RCC); in motion limiting space and time (2nd RCC); under the condition of active obstruction on the opponent's side (3rd RCC) .

Passing the ball should be seen as tactical moves in the game and are devided to retaining, developing, and aggravating. It is proved that the analysis of competitive activity is necessary to carry out depending on players' responsibilities during the match.

The study has been involved 46 elite athletes – the representatives of the core team of Ukraine on field hockey "Dynamo – ShVSM" (Vinnytsa), "Olimpia – Kolos – Sequoia" (Vinnytsa); players' sports qualification – Masters of Sport of Ukraine. The study was conducted from 2007 to 2017 at the bases of the Sports Complex of the Athletes' Olympic Preparation in the city of Vinnytsa, the Vinnytsa State Pedagogical University named after Mykhailo Kotsiubynsky and the scientific research laboratories of the National University of Ukraine on Physical Education and Sport.

In the process of research, such methods were used: theoretical analysis and generalization of literary data and the Internet; pedagogical observation; video shooting of competitive activities; pedagogical testing; methods of functional diagnostics; pedagogical experiment.

Four tactical models of the game of football teams and field hockey teams have been developed: "A", "B", "C", "D", where the structure and content of each of them determine the quantitative indicators of passess (blockng, acceleration, 'sharpening') and pressings (high, middle and low). Tactical models allow:

purposefully make a program of the team technical and tactical training; increase the effectiveness of managing the team competitive activities; optimally vary the team tactics both during the competition itself and during a separate match.

**Keywords:** tactical competitive, technical-tactical actions, theoretical analysis

## Introduction.

At the present stage, it is important to find ways to optimize constructing the athletes' training process in team sports. Modeling is one of the most rational approaches that can increase the efficiency of the training process (O.V. Borysova, 2011; V. Kostiukevich, 2014; V. Platonov, 2013; B.N. Shustin 1995; O. Shynkaruk, 2017).

The problem of modeling the athletes' training process in different years was studied by L. Matvieiev (2000) V. Platonov (2013, 2015), O. Shynkaruk (2013), B. Shustin (1995), E. Anders (1999), Ye. Imas (2017) M. Stech,J. Skrobecki, K. Wnorowski (2012), I. Zapartidis (2009). In team sports the problem of constructing the athketes' training process on the basis of modeling was considered in the works of J. Kozina (2009), V. Kostiukevych (2014), S. Tiulenkov (2007), O. Fedotova (2007), S. Chernov (2006).

In recent years, two main directions have emerged in using modeling. This leads to developing models of two groups. The first of these covers models that characterize the structure of competitive activities; models that characterize the main aspects of the athlete's preparedness; morphofunctional models that reflect the morphological features of the organism and the possibilities of individual systems and their parts (E. Yu. Doroshenko, 2013; V. Platonov, 2015; Ko Byoung–Goo Ko, Kim Ju–Hak, 2005; M. Lames, 2006; Y. Imas., O.


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Borysova, O. Shlonska, I. Kogut., V. Marynych, V. Kostiukevych, 2017). The second group includes models of large structural units of the training process – stages of multi-year training, macro cycles and training periods; models of training stages, meso- and microcycles; models of individual training exercises and their complexes (V. Kostiukevich, 2014; 2016; V. Platonov, 2015).

In team sports in managing the training process they use models as the first (E. Yu. Doroshenko, 2013; O. Mitova, 2016; M. Dopsaj, G. Nešić, N. Ćopić, 2010; M. Lames, 2006; O. Shynkaruk, 2017), and the second (V. M. Kostiukievich, N. Yu Schiepotina, 2016; V. Kostiukevych V., V. Stasiuk, 2016; S. Yu Tiulienkov, 2007; Te. V. Fiedotova, 2007) groups. The special place is occupied by methods of modeling macro cycles, which, especially for team sports clubs, have a completed character, due to the current system of conducting competitions (E. Yu. Doroshenko, 2013; V. Kostiukevych V., V. Stasiuk, 2016; O. Mitova, 2016). Therefore, it is relevant, on the one hand, to develop theoretical foundations of modeling in relation to team sports, and on the other hand, the practical realization of modeling methods based on the scientific substantiation of the club and national teams training process.

**Hypothesis.** Using modeling methods will reorient the training process in team sports from an empirically intuitive to a manageable process with predictable results.

**The purpose of the research** is to substantiate theoretical and methodological foundations and the concept of modeling the training process of athletes playing team sports in the annual macro cycles.

**Materials and methods.**

**Contingent.** 46 elite athletes participated in the study – the representatives of the main command structure of the Ukrainian field hockey teams "Dynamo - ShVSM" (Vinnytsia), "Olympias - Kolos - Sequoia" (Vinnytsia); sports qualification of players – Masters of Sports of Ukraine. The average age of field players (n = 40) – 24,3±4,54 роки ($\bar{x} \pm S$), goalkeepers (n = 6) – 24,4±4,95 years.

**Organization of research.** The research was conducted from 2007 to 2017 at the bases of the Sports Complex of Athletes' Olympic Training in the city of Vinnytsa, the Vinnytsia State Pedagogical University named after Mykhailo Kotsiubynsky; the research scientific laboratories of the National University of Ukraine on Physical Education and Sport (Kyiv).

In the process of research, the following methods were used: theoretical analysis and generalization of literary data and the Internet; pedagogical observation; video shooting of competitive activities; pedagogical testing; methods of functional diagnostics; pedagogical experiment.

Theoretical analysis of literature and data of the Internet was aimed at broadening the knowledge of the basics of the theory and methodology of athletes' training, generalizing the data of special literature on the topic of the research.

The structure and content of the training process, players and teams' competitive activities were defined as the object of pedagogical observation.

Video shooting of competitive activities was conducted to obtain urgent information and voluminous information on the parameters of the elite athletes' competitive activity in field hockey.

Pedagogical testing was used to determine the capabilities of hockey players, such as starting speed, speed-strength qualities, fast endurance and overall endurance. Start speed was estimated using the test – running 30 m from a high start, speed-power quality – a jump in length from the place, fast endurance – shutter running 180 m, overall endurance – the Cooper test. To measure the speed of the run in the tests – running 30 m from the high start and shutter running 180 m, the Microgate system was used for automatic speed measurement.

Athletes' functional diagnostics was determined using the instrumental method "Cardiolab + Bicycle". The following indicators were determined: dynamics of heart rate and blood pressure in the process of work and recovery; characteristic of the cardiogram in the process of incremental increase in load; load capacity; maximum and relative oxygen consumption, athletes' physical performance.

The pedagogical experiment consisted of two stages – the recording and forming. In the process of determining the experiment stage, modeling warm-up complexes, training programs and model training tasks were developed. At the stage of the formulating the experiment, micro-and mesocycles, stages and periods of the annual macrocycle were developed and introduced into the training process of the model.

In this study, we used methods of mathematical statistics that are recommended for studying and analyzing the research results in the field of physical culture and sport:

1. Definition of data characterizing the sample of objects: *S; m; V.*

2. The reliability of the difference between the values of two sample populations according to Student's t-criterion. For the confirmation of the hypothesis of the normal distribution of the study results, the criteria for the consent of W Shapiro-Wilkie and Mann-Whitney were used.

3. In order to construct and forecast the model characteristics of athletes' preparedness and competitive activity, the regression analysis (simple linear regression equation) was used.

4. To determine the relationship between athletes' special abilities and morphological characteristics, the correlation analysis of the normalized Pearson correlation coefficient was used.

5. In order to identify the most significant indicators of athletes' special abilities and hidden links between them, the factor analysis was used. The factor analysis was carried out using the system for integrated statistical analysis "Windows" - "Statistic" (used the main component method).

6. To determine the degree of consistency of experts opinion who assessed the level of athletes' technical and tactical skills, the methods of qualimetry, including the coefficient of concordation of Candela, were used. The study of data processing was carried out using the computer program "EXEL", "Statistica".

**Research results.** Our research was based on the systematic approach to constructing an athletes' training process in team sports. The study solved complex problems concerning improving players' special abilities at different stages of the annual macrocycle in accordance with the theoretical and methodological foundations of theperidization theory.

The working hypothesis of the study was to develop an integrated assessment of elite athletes' competitive activity in field hockey. The integral assessment of competitive activities was developed on the basis of the following methodological approaches:

1. Implementing technical and tactical actions was recorded in three modes of coordination complexity and gaming tension. The first coordination complexity mode (CCM) included technical and tactical actions that were carried out in place or at a convenient speed of movement. The technical and tactical actions performed in motion with restrictions in space and time, were assigned to the second CCM. The third CCM included technical and tactical actions that were carried out in the face of an active hindrance by the opponent.

2. Registration of ball passes was carried out taking into account the objective of their performance by the player. As a technical and tactical move it may be: holding the ball, developing the attack, exacerbating the game situation. Accordingly, passes were classified as blocking, acceleration and 'sharpening'.

3. The integral assessment should reflect the quantitative and qualitative indicators of players' technical and tactical activities. For this purpose, six specific indicators of competitive activity were developed – quantitative (intensity coefficient, mobility factor, coefficient of aggressiveness), qualitative (efficiency coefficient, coefficient of martial arts effectiveness, creativity coefficient).

Coefficient of intensity (CI) (points):

$$CI = \frac{TTA_з}{t},$$

Where TTA – the total amount of technical and tactical actions performed by the player:

$$TTA_з = TTA_{1st\ CCM} + TTA_{2nd\ CCM} + TTA_{3rd\ CCM};$$

*TTA1st CCM* – technical and tactical actions performed in the 1-st mode of coordination complexity;
*TTA2nd CCM* – technical and tactical actions performed in the 2-nd mode of coordination complexity;
*TTA3rd CCM* – technical and tactical actions performed in the 3rd mode of coordination complexity;
t - time played by the player in the match.

Mobility coefficient (MC):

$$MC = \frac{TTA_{2nd\ CCM} + TTA_{3rd\ CCM}}{t} \times 2,$$

where 2 is the corresponding coefficient.

Coefficient of Aggressiveness (CA):

$$CA = \frac{TTA_{3rd\ CCM}}{t} \times 3,$$

where 3 is the corresponding coefficient.

Coefficient of Efficiency (CE):

$$CE = \frac{TTA_r}{TTA_з},$$

where TTDr – the sum of realized technical and tactical actions.

Coefficient of Combat Efficiency (CCE):

$$CCE = \frac{TTAr_{\ 3rd\ CCM}}{TTA_{з\ \ 3rd\ CCM}},$$

where TTAr 3rd CCM – implemented technical and tactical actions in the 3rd mode of coordination complexity;

TTAs of the 3rd CCM – the sum of technical and tactical actions performed in the 3rd mode of coordination complexity.

Coefficient of Creativity (CC):

$$CC = \frac{(EP \times 1) + (SP \times 2) + (SG \times 5) + (G \times 10)}{t},$$

where EP – number of acceleration passes;

SP – number of 'sharpening' passes;
SG – number of shots on goal;
G – number of goals;
1,2,5,10 - corresponding coefficients.
The values of specific indicators of competitive activity on a special scale are converted into points.
The Integral Assesment (IA) of the field player was determined in points by the formula:
*IA = CI + MC + CA + CE + CCE + CC.*
*(7)*

The integral assessment of the players' technical and tactical activities in field hockey was determined based on the survey of the competitive activity of the club and national teams of the division "A", division "B", division "C", as well as leading club teams of Ukraine.

Determining the performance of the main game techniques in the game – stopage, dribbling, pass, interceptions, controlling and shots on goal – has allowed developing the technical and tactical activities structure of teams of different qualifications (Fig. 2).

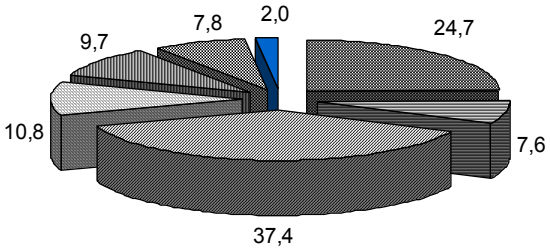



Fig. 2. The structure of technical and tactical activity of club teams of the "A" division in hockey on the grass, %:

– stopage, – dribbling, – passes, – dribbling, – interception, – tackling, – shots on goal

Based on this training programs of technical and tactical preparedness of club players as well as teams of field hockey were developed.

Model specific value indicators integrated evaluation of technical and tactical activities of club teams of varying qualifications listed in Table. 1

The highest integral score is recorded in the club teams of the "A" division. Integral evaluation of technical and tactical activities of club teams Division "A" is 6,42±0,48, Division "B» - 5,83±0,39, Division "C" – 5,17±0,48 points. So, the higher is the team, the higher the integral score is. The integral estimation of the leading club teams of Ukraine is 5.70±0.74; it is almost the same as the model indicator of the club teams of the "B" division.

Table 1

**Model values of specific indicators of integrated evaluation of technical and tactical activity of club teams of different qualifications in field hockey**

| Teams | statistical indicators | Specific indicators of technical and tactical activity, points | | | | | | Integral evaluztion, points |
|---|---|---|---|---|---|---|---|---|
| | | Iitensitive coefficient | mobility coefficient | aggresiveness coefficient агресивності | effectivenesscoefficient | effectivess coefficient | creative coefficienti | |
| Division «A» (n=13) | $\bar{x}$ | 1,30 | 2,12 | 1,15 | 0,81 | 0,63 | 0,42 | 6,42 |
| | S | 0,04 | 0,21 | 0,16 | 0,03 | 0,06 | 0,07 | 0,48 |
| Division «B» (n=22) | $\bar{x}$ | 1,08 | 1,88 | 1,12 | 0,78 | 0,62 | 0,35 | 5,83 |
| | S | 0,12 | 0,19 | 0,14 | 0,05 | 0,07 | 0,05 | 0,39 |
| Division «C» (n=18) | $\bar{x}$ | 0,98 | 1,59 | 0,99 | 0,74 | 0,59 | 0,28 | 5,17 |
| | S | 0,11 | 0,18 | 0,16 | 0,04 | 0,08 | 0,06 | 0,48 |
| Leding club teams of Ukraine (n=13) | $\bar{x}$ | 1,04 | 1,81 | 1,07 | 0,79 | 0,63 | 0,36 | 5,70 |
| | S | 0,12 | 0,14 | 0,19 | 0,03 | 0,04 | 0,07 | 0,74 |

Integral evaluation of technical and tactical activity allows to determine the result of the team in those competitions in parallel with the sporting result. In some cases, the value of an integral evaluation may be more

objective than a sports result, which is not always adequate to the level of skill of the teams participating in the competition.

Based on the analysis of competitive activities, four tactical models of the game of hockey teams have been developed (Table 2). Model "A" is characterized by the predominant use of accelaration passes (50-70%), 'Sharpening' and blocking passes make up 10-20%. At the tackling stage, the team basically (about 60%) uses high pressing. For Model "B", compared to "A", the use of a slightly larger number of blocking (15-20%) and smaller – 'sharpening' passes (5-15%) is typical, the use of middle pressing is also prevalent (about 65%). The characteristic features of the "C" Model are much more frequent than in the two previous models, the use of blocking passes (20-30%), while basically (about 70%) is used middle pressing. The Model "D", as a rule, uses a team that chooses a game style based on fast reverse attacks, using at the same time mostly middle (about 55%) and low (about 40%) pressings.

Table 2

**Tactical models of football and hockey teams**

| Types of tactical model | Indicators of competitive activity | | | | | |
|---|---|---|---|---|---|---|
| | amount of ball passes, % | | | kind of pressing, % | | |
| | blocking | acceleration | sharpening | high | middle | low |
| Model «A» | 10-20 | 50-70 | 10-20 | 60 | 30 | 10 |
| Model «B» | 15-25 | 50-75 | 5-15 | 20 | 65 | 15 |
| Model «C» | 20-30 | 60-80 | 5-10 | 10 | 70 | 20 |
| Model «D» | 5-15 | 65-85 | 5-10 | 5 | 55 | 40 |

The main task of the research at the stage of establishing the experiment was to scientifically substantiate the construction of the footballers and hockey players' training process at different stages of the annual training cycle. In this case, characteristics of the construction of training sessions, microcycles, mesocycles, stages and periods of hockey teams training in the annual macro cycles were determined. It was assumed that the definition of the structure and content of training cycles and stages of preparation would, on the one hand, optimize the construction of the hockey teams' training process, and on the other hand, to experimentally substantiate, at the stage of the forming experiment, the use of modeling methods in the training process of athletes playing sports.

On the basis of the theory of periodization of sports training (L.P. Matvieiev, 2000; V. Platonov, 2013; 2015), the study used a dual cycle of constructing the training process of field hockey players throughout the year (Fig. 3). Distribution of training loads of different orientations in the annual cycle of training field hockey players is given in Fig. 4: 51.8% loads performed mainly in aerobic mode; 42.5% are mixed (aerobic-anaerobic) and 5.7% anaerobic stresses, including: 3.6% alactatious and 2.1% glycolytic.

The means of hockey players training in the annual training cycle are distributed as follows: non-specific (general preparatory) exercises - 49.0%, specific - 51.0%, including: special preparation – 2,3%, auxiliaries - 26.1%, competitive exercises - 22.0%.

The annual training cycle for the national team is based on, on the one hand, the achievement of the goal in the current year, and on the other – training and participation in the main competitions of the four year - the Olympic Games and World Championships.

The planning of the training process of the Ukrainian field hockey teams in the annual training cycle is carried out in parallel with the planning of the players' training in the clubs. For direct players' training in the national team, 95-115 days are spent, during which there are 133-155 training sessions. In addition to them, in the annual cycle of team training, 5-7 preparatory, 9-13 control, 1-2 lead-in (model) and 5-8 calendar games are conducted.

In the course of the study, indicators of elite athletes' functional preparedness in field hockey at various stages of the annual macro cycles were determined.

The largest absolute values of $VO_{2abs}$ in male hockey team players were observed during the competition period: 3,99±0,29 $l \cdot min^{-1}$. The greatest relative values of $VO_{2rest}$ were observed, in the players of men's teams recorded in the pre-adventurous mesocycle (55,2±6,12 $ml \cdot min^{-1} \cdot kg^{-1}$).

In the process of the annual training cycle, the greatest increase in $VO_2$ occurred in the base mesocycles. So, in hockey elite players, the growth of the absolute value of $VO_{2abs}$ between the retractable and basic developing mesocycles amounted to 0,19 $l \cdot min^{-1}$– 4,82%, and the relative value is 1,7 $ml \cdot min^{-1} \cdot kg^{-1}$ – 3,18 %.

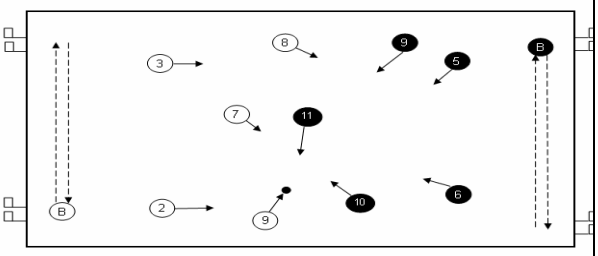
In the pre-competitive mesocycle and competitive period, the $VO_{2abs}$ were at the level of the base mesocycles. In this regard, we note that during the preparation of the team in the annual training cycle, it is very important to lay the foundation for the players' functional readiness in the base mesocycles. In general, the difference in the values of the functional readiness of players of male field hockey teams by the $VO_{2rest}$ indicators from the beginning of the preparation stage and to the stage of participation in the competition is 3,0 $ml \cdot min^{-1} \cdot kg^{-1}$ – 5,47 % ($p<0,05$). In other words, in the process of preparing a hockey team for the competition, it is necessary to plan an increase in the level of players' functional readiness by 5-6%.

For the purposeful managing the elite athletes' training process in field hockey in the annual cycle of training, it is necessary to focus on the basic model of the player of a certain role, which includes indicators of the morpho-functional state, physical and functional preparedness and competitive activity. The basic models of players of different roles allow us to determine the integral level of athletes' preparedness, which makes it possible to more effectively solve the issues of selection and acquisition of club and team teams in the game of sports. With the purpose of purposeful influence on the level of of hockey players' preparedness and competitive activity, model training tasks were developed and implemented in the training process (Table 3).

*Table 3*

**Model training task for improving the field hockey players' technical and tactical skills**

Title: Game Exercise: 6x6 for four goals.
Goal: Improving players' techno-tactical skills.
Place: Hockey field, sports hall.

| Code MTT | Durability | Direction | *CLS, points* | $CI_{t.l.}$ *point·min*$^{-1}$ |
|---|---|---|---|---|
| MTT: TTM: 6.65 | 17 min. – motor activity;<br>4 min. – OMI | Aerobic-anaerobic | 262 | 10,5 |
| Content and scheme of doing MTT | In the process of MTZ the tasks of improving the technology of the game, game thinking, rapid decision-making in gaming situations are solved.<br>The amount of load in the training session is 20-25 minutes. |  | | |

| Consistency of MTT | Contents of individual actions (steps) of the MTZ | Loadness components | | | | | |
|---|---|---|---|---|---|---|---|
| | | *t,хв* | *I* | *RCC* | *IO,хв* | *ЧСС, уд·хв*$^{-1}$ | *CLS, points* |
| 1st step | Game exercise 6 × 6 on four goals. The purpose of the exercise is to send the ball to one of the goals. The goalkeeper moves from one to the other goal | 4 | B | 2–3 | – | 150–162 | 43 |
| 2nd step | Passive rest (drink 100-150 ml water) | 1 | – | – | – | 126–132 | – |
| 3rd step | The same as Step 1, but the pass of the ball in two touches | 4 | B | 2–3 | – | 162–174 | 72 |
| 4th step | Passive rest (drink 100-150 ml water) | 2 | – | – | – | 114–120 | – |
| 5th step | The same as Step 1, but the pass of the ball in two touches with the personal care of the players | 4 | B | 2–3 | – | 168–180 | 99 |
| 6th step | Passive rest (drink 100-150 ml water) | 2 | – | – | – | 114–120 | – |

Notes: MTT – Model Training Task; CLS – Coefficient of Load Size; $CI_{t.l.}$ – Coefficient of Intensity of Training Load; RCC – Regime of Coordination Complexity; OMI – Organizational and Methodical Instructions

The simulation of training sessions became the basis for developing models of training micro-and mesocycles for the elite field hockey players' training in the annual macro cycles.

**Discussion.** The analysis of the literature and the synthesis of best practices in organizing the training process allowed to state that the rational construction of the annual macro cycles in the team sports is possible on the basis of: the definition of the structure of competitive activities; definition of factors that ensure the effectiveness of competitive activities; developing the structure and content of training and competition microcycles and mesocycles; establishing dynamics and content of training materials and training loads; defining a set of special abilities of athletes; development and introduction into the training process of modeling warm-up complexes, training programs and model training tasks; theoretical and methodological substantiation of the training process on the basis of modeling methods.

Our research confirmed the research of specialists who recommend to build a training process for athletes playing sports on the basis of the theory of periodization.

At the same time, our study on the basis of the systematic approach showed how to optimize the training process in team sports. First of all, it concerns targeted planning, taking into account the structure, content of not only stages and periods of annual training, but also mesocycles, microcycles and practically every training session.

The theoretical aspect of our research, first of all, is concluded in the experimental substantiation of increasing the efficiency of the athletes' training process based on simulation methods.

**Conclusions**

Analysis and synthesis of scientific sources on the research problem suggests that one of the most optimal ways to increase the efficiency of the team sports athletes' training process is the application of modeling methods.

It is determined that the concept of making the team sports athletes' training process on the basis of modeling methods should include the developing, on the one hand, methodological aspects of constructing model characteristics of athletes'preparadness and competitive activity, and on the other hand, models of structural units of the training process: microcycles, mesocycles, stages and periods.

The method of analysing the team sports athletes' competitive activity should be based on the following provisions:

• the analysis of players' competitive activity must be carried out taking into account not only quantitative and qualitative indicators of performance of technical-tactical actions, but also the conditions in which they are performed. In this regard, the implementation of technical and tactical actions should be fixed in three regimes of coordination complexity (RCC): on-site or convenient speed of movement (1st RCC); in motion with space and time constraints (2nd RCC); in conditions of an active obstкгсешщт by the rival (3rd RCC);

• ball passes should be considered as tactical motions in the process of the game and distributed to blocking, acceleration, 'sharpening';

• the analysis of competitive activities must be carried out depending on the functions performed by the players in the match process.

Four tactical models of the game of football teams and field hockey teams have been developed: "A", "B", "C", "D", where the structure and content of each tactical model determine quantitative indicators of blocking, acceleration, 'sharpening' passes and high , middle and low pressings.

Tactical models allow to purposefully design a program of the team's technical and tactical training; increase the effectiveness of managing team's competitive activities; optimally vary the tactics of team play both during the competition itself and during a separate match.

Developed conceptual approaches for making the team sports athletes' training process in the annual macro cycles are due to the theory of periodization of sports training, which is based on the methodological approach that allows planning and implementing the training process, taking into account the structure and content of stages and training periods, due to the calendar of competitions.

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