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Factor Analysis of Special Qualities of Elite Field Hockey Players

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Abstract

One of the methods to make an objective analysis of the use of adequate means and methods of the training process depending on the special qualities of athletes is factor analysis. The article describes a methodological approach to factor analysis of special qualities of elite field hockey players. The aim of the research is to determine the factor structure of special qualities of elite field hockey players based on experimental data. The study involved 40 elite male field players in field hockey. The average age of sportsmen was 24.7±4.27 years. Sports qualification – masters of sports of Ukraine. Research methodology: analysis and generalization of special literature and Internet data, lesson observation, pedagogical testing, methods of functional diagnostics, video recording of competitive activities, pedagogical expertise, methods of mathematical statistics. 28 specific qualities of elite male field players in field hockey were defined. The structure of special qualities of hockey players was determined by five orthogonal factors, and the sum of the contribution to the total sampling variance was 69.55%. Factor analysis of special qualities of elite field hockey players allowed to manage the training process more purposefully and adjust the managerial impact on the state of the players ' sports form in the training macrocycle.

Keywords: *field hockey, elite field players, special qualities, factor analysis*

Introduction

The construction of the training process of elite athletes is based on the development of criteria for monitoring various indicators, characterizing the level of readiness of sportsmen, and on defining the relationship between these indicators and their impact on the sports result. One of the methods to make an objective analysis is factor analysis (Yermolayev, 2002; Kozina et al., 2017; Doroshenko et al., 2019).

The factor analysis is used to systematize indicators into factors that reflecting the level of special training of athletes (Alekseeva, 2010). The problem is relevant for team game sports (Bukova, 2008; Kostiukevych, 2019, 2020). In particular, the factor structure of sportsmen's readiness was studied: in basketball by Koryagin (1997); Bezmylov and Shynkaruk (2010); in volleyball – Maslov and Nosko (2002); in football - Lisenchuk (2004), Bukova (2008), etc.

The basis of research is a methodological approach, which is based on taking into account the integrated level of skill of athletes as a structure. Factor analysis was carried out with the use of the system for comprehensive statistical analysis and data processing in the "Windows" - "Statistic" environment (Yermolayev, 2002). The methods of main components and axis rotation using the "non-normalized varimax" method were used (Zatsiorsky, 1969; Denisova et al., 2008). The objective of factor analysis in the processing of experimental data is to evaluate the importance of factor of weight, as well as the part of the influence of each factor on the general dispersion (sampling variance) of the sample (Babushkin, 1991;

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Vincent, 2005). The scheme of the results of factor analysis is characterized by such indicators as: the number of factors, the dispersion of factors, factor of weight, factor dispersions (Yermolayev, 2002; Nachinskaya, 2005). The number of K factors shows how many linearly dependent feature groups are characteristic of the complete set of initial features. The dispersion of factors indicates how important individual factors are for the entire feature system. Factor loads (weight) allow to judge the strength of the relationship between indicators and factors. Factor dispersions show which variables play a crucial role in shaping the set of factors that is defined (Zatsiorsky, 1969; Korenberg, 2004).

The aim of the research was to determine the factor structure of special qualities of elite male field hockey players based on experimental data.

Methods

The research involved 40 elite male athletes (field players) in field hockey. The average age of athletes was 24.7±4.27 years. Sports qualification - master of sports of Ukraine. The research was conducted in the competitive period of the macrocycle. All players agreed to participate in the research.

Video recording of competitive activity - definition of integral assessment of technical and tactical activities (IA TTA). The key points that were taken into account when developing of the integral assessment:

1. Registration of technical and tactical actions was carried out taking into account the complexity of coordination and the intensity of the game of their implementation.

2. The methodology of analysis of technical and tactical activities took into account the direction and importance of technical and tactical moves (transfers, dribbling, mannequin, etc.).

3. Quantitative indicators of technical and tactical activities were analyzed together with their qualitative characteristics.

4. A differentiated approach was needed to determine a comprehensive assessment of the technical and tactical activities of hockey players of different roles.

5. Comprehensive assessment objectively reflected the athlete's skills shown in the game, and was the basis for developing models of competitive activities.

The following methodological approaches were used to control and analyze the technical and tactical activities of hockey players:

1. Execution of technical and tactical actions was recorded in 3 modes of coordination complexity and game intensity. The first mode of coordination complexity (1st MCC) - technical and tactical actions (TTA) were performed on site or at a convenient speed (stops, transmissions, implementation of standard provisions, etc.). The second MCC - TTA was performed in the process of movement with restrictions in space and time (stops, dribbling, passing, holding, hitting the goal). The third MCC - TTA was performed in conditions of active intervention by the opponent (stops, mannequins, transfers, retention, shots on goal).

2. Execution of the ball was recorded in accordance with the goal. As a technical and tactical move, it could be: holding the ball, developing the attack, aggravating the game situation. On this basis, passes were classified into maintenance, development and sharpening.

3. Integral assessment reflected the quantitative and qualitative indicators of technical and tactical activities of hockey players. Six coefficients were developed: intensity, mobility, aggression; efficiency, effectiveness of martial arts, creativity (Kostiukevych et al., 2018).

1. The intensity coefficient (IC) determined the overall activity of the player in the game:

$$IC = \frac{\sum_{i=1}^{n} TTA}{t}, (1)$$

where: $\sum_{i=1}^{n} TTA$ - total amount of technical and tactical actions;

t - time played by a player in a match

2. The mobility coefficient (MC) characterized the general mobility of the player during the match, his desire to perform technical and tactical actions in motion in different parts of the field:

$$MC = \frac{\sum_{i=1}^{n} TTA(2nd\ MCC + 3rd\ MCC)}{t} \times 2, (2)$$

where: $\sum_{i=1}^{n} TTA(2ndMCC + 3rdMCC)$ - total amount of technical and tactical actions performed by the player in the second and third modes of coordination complexity;

t - time played by a player in a match;

2 – indicator of coordination complexity

3. The aggressiveness coefficient (AC) characterized the player's activity in single combats, in conditions of active intervention by the opponent:

$$MC = \frac{\sum_{i=1}^{n} TTA(2nd\ MCC + 3rd\ MCC)}{t} \times 2, (3)$$

where: $\sum_{i=1}^{n} TTA(3rdMCC)$ - total amount of technical and tactical actions performed by the player in the third mode of coordination complexity;

t - time played by a player in a match;

3 – indicator of coordination complexity

4. The efficiency coefficient (EC) reflected the value of the player for the team, the quality of performed by him technical and tactical actions:

$$EC = \frac{\sum_{i=1}^{n} preciseTTA}{\sum_{i=1}^{n} allTTA}, (4)$$

where: $\sum_{i=1}^{n} preciseTTA$ - total amount of precise technical and tactical actions performed by the player;

$\sum_{i=1}^{n} allTTA$ - total amount of all technical and tactical actions performed by the player in a match

5. The efficiency coefficient of martial arts (ECMA) characterized the quality of technical and tactical actions performed by the player in conditions of active intervention by the opponent:

$$ECMA = \frac{\sum_{i=1}^{n} preciseTTA(stops, holds, tackings, dummies, performed\ in\ 3rd\ MCC)}{\sum_{i=1}^{n} allTTA(stops, holds, tacklings, dummies, performed\ in\ 3rdMCC)}, (5)$$

where: $\sum_{i=1}^{n} preciseTTA(stops, holds, tackings, dummies, performedin3rdMCC)$ - total amount of precise technical and tactical actions performed by the player in the third mode of coordination complexity;

$\sum_{i=1}^{n} allTTA(stops, holds, tackings, dummies, performedin3rdMCC)$ - total amount of all technical and tactical actions performed by the player in the third mode of coordination complexity during the match

6. The creativity coefficient (CC) allowed us to integrally evaluate the player's game creativity in the confrontation with the opponent. Usually a player with a high creativity coefficient must be confident in his actions, have a wide arsenal of technical and tactical actions and be able to apply them in accordance with the situation:

$$CC = \frac{\sum_{i=1}^{n} preciseTTA(DP \times 1 + SP \times 2 + GP \times 5 + GK \times 5 + G \times 10)}{t}, \quad (6)$$

where: DP – developing passes; SP – sharpening passes; GP – goal passes; GK – goal kicks; G – goals.

7. The integral assessment (IA) of a field player was determined by the sum of six specific indicators and was one of the criteria for creating an athlete rating:

IA = IC + MC + AC + EC + ECMA + CC (7)

Educational testing. A 30 m run from a high start was used to estimate the starting speed. Photo sensors were installed on the start and finish lines. At the command "to start», the hockey players stood in front of the starting line in the high start position. At the signal of the coach, they had overcome the distance of 30 m with maximum intensity. The time to overcome the distance was fixed with accuracy to 0.01 s. The best result of two attempts was taken into account. Rest between attempts lasted from 3 to 5 minutes.

Speed and strength qualities were determined by a long standing jump. The hockey player got toes on the line, prepared to jump. First he waved his hands back, and then abruptly took them forward and pushing off with two legs jumped as far as possible. Two attempts were given. The length of the jump was measured from the line to the point where the athlete's back foot touched the ground of the field or floor. It was not allowed to take the feet off the field or floor before jumping.

To assess the speed endurance of hockey players, the test – Shuttle run of 180 m (Kostiukevych, 2011) is informative. In a straight line, three cones were placed at a distance of 15 m, one after the other. At the signal of the coach, the hockey player started running from the first cone, covering a distance of 15 m, ran around the second cone, went back to the first, then ran to the third cone, ran around it and returned to the start line, after which the exercise was repeated again without stopping (Figure 1). Immediately after the test, the heart rate was recorded for 10 seconds, and again at the end of the first, second and third minutes of recovery.

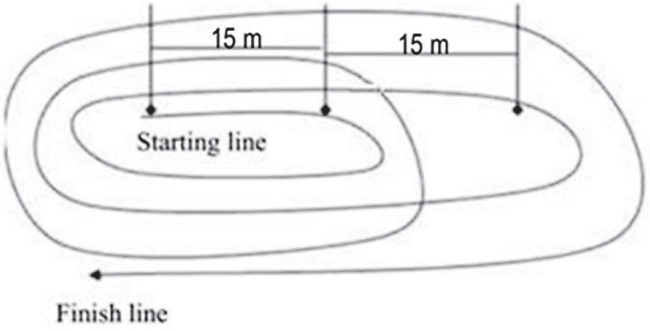

FIGURE 1. The scheme of performing the 180m Shuttle run test.

The Cooper test (continuous running for 12 minutes) was used to determine the overall endurance of the players. Before the test, a 15-minute warm – up was performed, followed by a 5-minute rest, and after the rest, a testing exercise was performed. The test result was evaluated by the number of meters that the hockey player overcame during 12 minutes of running.

The level of technical preparedness of elite hockey players was determined using the following tests:

1. Running 14.63 m from the stand with the knocking the ball out – assessment of the starting speed in connection with special agility. The duration of the entire exercise was evaluated from the start of running to hitting the ball with a stick. The best result was chosen from two attempts. The pause between attempts was 2-3 minutes.

2. Dribbling - running the cones around - a shot on goal – assessment of high-speed technique (Figure 2). The result was assessed by the duration of the entire exercise - from the beginning of the dribbling to the ball touching the back wall of the goal.

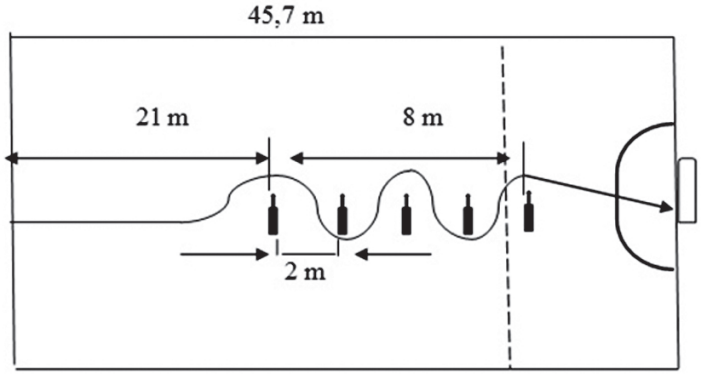

FIGURE 2. Scheme of the test "dribbling, running the cones around, shot in the goal"

3. Dribbling - the target passing (performed in the form of a shuttle run - 5 times) – assessment of high-speed technique in combination with special endurance (Figure 3). Were evaluated the duration of the entire exercise - from the start of the dribble of the first ball to the crossing by the hockey player the start line after the fifth pass of the ball and the total accuracy of five passes (when hitting the goal – 1 point, for a miss – 0 points).

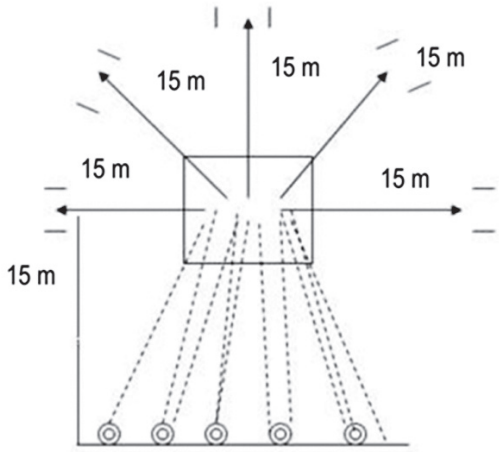

FIGURE 3. Scheme of the test: "dribble - shooting the goal"

4. Throwing the ball with a stick on the range – an assessment of technical preparedness and special strength. Conditions: The hockey player threw the ball with a stick in the corridor 10 m wide.

5. A series of shots on goal – an assessment of special speed-strength endurance (Figure 4). Were evaluated the duration of the entire exercise - from the start of the strike on the first ball and the touch of the goalkeeper or crossing the goal line of 31 goals and the total number of goals scored in the goal.

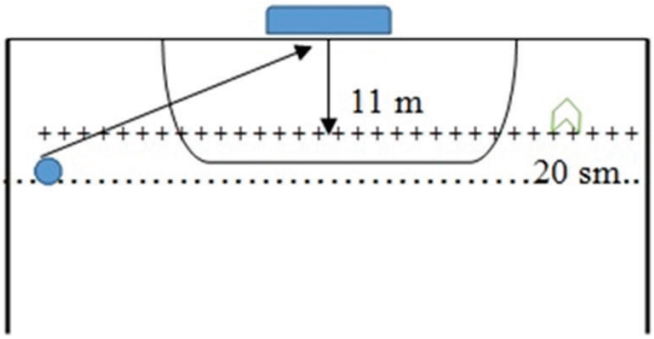

FIGURE 4. Scheme of the test "series of shots on goal"

Methods of functional diagnostics. The determination of the level of physical performance (PP) and maximum oxygen consumption (VO2max) using the running version of the PWC170 (V) test (Carpman et al., 1998).

Step 1. The player without warming-up performed the first running load. Distance 700-900 m. Running speed should be constant. The player's heart rate immediately after running was approximately – 110-130 bpm. The time taken to cover the distance was about 5 minutes. At the end of the first running load, the heart rate was recorded.

Step 2. The player rested for 5 minutes.

Step 3. The second running load was performed. Distance - 1100-1300 m.

Step 4. The running speed was calculated when overcoming the first (V_1) and second (V_2) distances.

$$V = \frac{S}{t}, (8)$$

where: V – speed of running while overcoming the distance ($m \cdot s^{-1}$);

S – length of the distance (m);

t – time to overcome the distance (s).

Step 5. The physical performance of PWC170 (V) was determined:

$$PWC_{170(V)} = V_1 + (V_2 - V_1)\frac{170 - f_1}{f_2 - f_1}, (9)$$

where: $PWC_{170(V)}$ – load power in $m \cdot s\text{-}1$, at which the heart rate reaches 170 bpm;

f1, f2 – heart rate during the first and second physical activity.

Step 6. For this purpose, the formula of Belotserkovsky (2005) was used:

$$PWC_{170} = 417 \cdot PWC_{170(V)} - 83 \quad (10)$$

Step 7. The absolute value of maximum oxygen consumption was calculated:

$$VO_{2max(abs)} = 1{,}7 \cdot PWC_{170} + 1240 \quad (11)$$

where: $VO_{2max(abs)}$ – the absolute value of maximum oxygen consumption

Step 8. The relative indicator was determined:

$$VO_2\,\max(rel) = \frac{VO_2\,\max(abs)}{MT} \quad (12)$$

where: $VO_{2max(rel)}$ – the relative value of the maximum oxygen consumption ($ml \cdot min^{-1} \cdot kg^{-1}$);

$VO_{2max(abs)}$ – the absolute value of the maximum oxygen consumption ($ml \cdot min^{-1}$);

MT – body weight of a hockey player (kg).

For an expert assessment of the level of technical and tactical skill (LTTS) of hockey players, a 10-point scale was used in which volume, mastery, and effectiveness of the technique were estimated from 1 to 10 points. The total amount of points scored by the player allowed determining the rating of his

technical and tactical skill.

Methods of mathematical statistics. The research determined the main characteristics of the variation series: mean ($\bar{x}$), dispersion (S^2), standard deviation (SD), coefficient of variation (CV). The samples for the normal distribution of the results were checked using the Shapiro-Wilky test. Factor analysis was performed using the method of main components. The consistency of experts in determining the level of technical and tactical skill of hockey players was determined by the Kendall's coefficient of concordance. Statistical processing of experimental material was carried out using computer programs of mathematical statistics such as "Microsoft Excel" and "Statistica -6".

Results

In this study, factor analysis revealed the most significant indicators of the special qualities of elite field hockey players (Table 1, Figure 5). The structure of special qualities of hockey players was determined by five orthogonal factors, and the contribution to the total dispersion of the sample was 69.55%.

Table 1. Factorial structure of special qualities of elite male field hockey players (field players, n=40)

Indicator	Factor				
	1	2	3	4	5
Age, years old	0,360	**0,494**	0,012	-0,335	0,290
Height, sm	-0,074	**0,591**	0,374	-0,176	**-0,452**
Body mass, kg	0,045	**0,933**	0,251	-0,112	-0,109
Quetelet index, g·см$^{-1}$	0,076	**0,914**	0,177	-0,069	0,026
VO_2max(abs), l·min^{-1}	0,163	0,148	**0,792**	0,150	0,104
VO_2max(rel), ml·min^{-1}·kg^{-1}	0,028	**-0,786**	0,309	0,170	0,189
PWC_{170}, кgm·min^{-1}·kg^{-1}	0,051	**-0,775**	0,407	0,168	0,195
$PWC_{170(V)}$, m·s^{-1}	0,145	0,016	**0,848**	0,070	0,176
Running 30 m from the high start, s	-0,097	0,017	-0,210	**-0,743**	-0,187
Standing long jump, m	0,152	0,167	0,391	**0,639**	-0,176
Shuttle run 180 m, s	-0,079	0,364	-0,366	**-0,523**	0,006
Cooper Test, m	0,150	-0,432	**0,561**	0,274	0,174
LTTS – 1 MCC, points	**0,866**	0,128	-0,046	0,163	0,206
LTTS – 2 MCC, points	**0,893**	0,021	-0,030	0,244	0,216
LTTS – 3 MCC, points	**0,849**	-0,105	0,001	0,284	0,207
LTTS – average value, points	**0,884**	0,041	-0,060	0,244	0,247
Running 14,63 m with knocking the ball out, s	-0,101	0,148	-0,068	**-0,858**	-0,046
Dribbling – running the cones around– shot on goal, s	-0,467	0,080	0,084	**-0,690**	-0,260
Dribbling– targeting, s	-0,117	0,280	-0,045	**-0,476**	-0,004
Throwing the ball with a hockey stick at a distance, m	**0,659**	0,347	0,152	0,025	0,003
Series of shots on goal, s	-0,293	0,207	0,075	-0,549	0,083
Intensity coefficient, points	**0,752**	-0,062	0,268	-0,004	-0,241
Mobility coefficient, points	**0,716**	-0,209	0,262	0,186	-0,287
Aggressiveness coefficient, points	0,192	-0,348	-0,060	**0,431**	-0,350
Efficiency coefficient, points	0,139	-0,103	0,242	-0,076	**0,758**
Efficiency coefficient of martial arts, points	0,125	-0,303	0,171	0,208	**0,686**
Creativity coefficient, points	**0,461**	0,028	0,284	0,001	0,030
Integral assessment, points	**0,734**	-0,346	0,273	0,328	-0,131
Total of operating variables	5,97	4,58	2,93	3,90	2,11
Input of the factor on total dispersion, %	21,31	16,35	10,45	13,93	7,53

The first factor - a factor of technical and tactical skill and competitive activity (21.31%). The high weight factors were noted here according to the level of expert assessment of technical and tactical skills in all three modes of coordination complexity (LTTS - 1 MCC, r=0.866; LTTS - 2 MCC, r=0.893; LTTS - 3 MCC, r=0.849), and also by the average value of LTTS, r=0.884.

High weight factors were also noted for such indicators of competitive activity of field hockey players as the throw of the ball with a stick at a distance (r=0.659), the intensity coefficient (r=0.752), the mobility coefficient (r=0.716), the creation coefficient (r=0.461), as well as the integral assessment (r=0.734).

In the second factor (16.35%), the system-forming indicators were those that primarily reflected the functional preparedness of hockey players. High weight factors were observed in Body mass index (r=0.933), Quetelet index

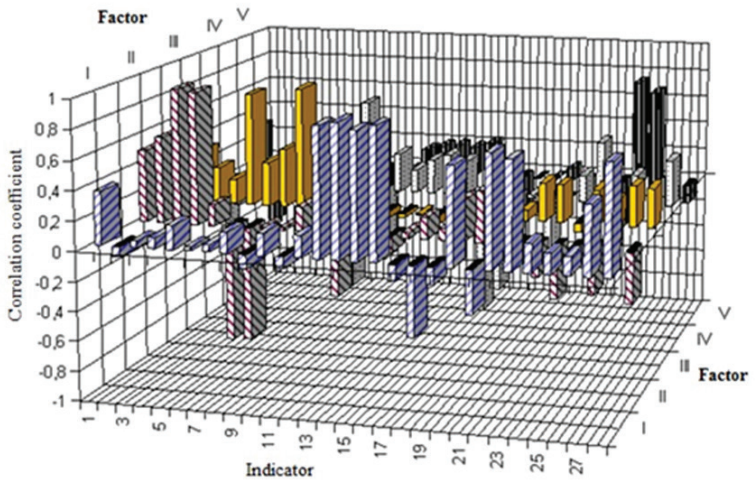

FIGURE 5. Factorial structure of special qualities of elite male field hockey players

(r=0.914), $VO_{2max(rel)}$ (r=-0.786), PWC_{170} (r=-0.775).

The third factor was interpreted as a factor of Physical Working Capacity (10.45%). High weight factors in the indicators of the $VO_{2max(abs)}$ (r=0.792), $PWC_{170(V)}$ (r=0.848) were highlighted here.

The interpretation of the importance of speed and speed-power indicators for competitive activity in field hockey was determined by the fourth factor (F4).

The most significant indicators in it were: running 30 m from the high start (r=–0.743), standing long jump (r=0.639), running 14.63 m with a ball knocked out (r=–0.858), dribbling – running the cones around - shot on goal (r=–0.690), series of shots on goal (r=–0.549), coefficient of aggressiveness (r=0.431).

The fifth factor, (7.53%) was designated as a factor in the effectiveness of competitive activity. The high weight factors in it fell on the indicators of the coefficient of effectiveness (r=0.758) and the coefficient of effectiveness of martial arts (r=0.686).

Discussion

Factor analysis is used when there are problems in determining the most important indicators of athletes' preparedness, which affect the sports result (Akhmetov, 2005; Kutek, 2019). The working hypothesis of our study involved a number of consistent logically conditioned actions.

Firstly, it was necessary to determine the special qualities (SQ) of elite field players in field hockey. Based on previous research of the features of managing the training of athletes in team sports and building the training process in field hockey (Kostiukevych et al., 2018, 2019), 6 components of special qualities of elite hockey players were determined:

1. The morphofunctional component (4 SQ): age, body length, Quetelet index (body mass ratio (g) to body length (sm)).

2. The component of physical fitness (4 SQ): the 30 m run from a high start.

3. The functional preparedness component (4 SQ): $VO_{2max-(abs)}$; $VO_{2max(rel)}$, PWC_{170}; $PWC_{170(V)}$.

4. The component of technical and tactical skill (4 SQ): LTTS in the 1st MCC, LTTS in the 2nd MCC; LTTS in the 3rd MCC; the average value of LTTS.

5. The technique related component of physical fitness (5 SQ): running 14.63 m with a ball knocked out; dribbling – running the cones around - shot on goal; dribbling – passing – targeting; throwing the ball with a hockey stick at a distance; series of shots on goal.

6. The component of the integral assessment of technical and tactical activities (7 SQ): intensity coefficient (IC); mobility coefficient (MC); aggressiveness coefficient (AC); efficiency coefficient (EC); efficiency coefficient of martial arts (ECMA); creativity coefficient (CC); integral assessment (IA).

Secondly, the results of measuring and testing the special qualities of elite male field hockey players in the competitive period of the macrocycle were determined.

Thirdly, a factor analysis scheme was chosen - the method of principal components.

Conclusions

Factor analysis (FA) in field hockey, is carried out in the following sequence: formation of FA goals; determination of the main indicators of training and competitive activity of athletes; mathematical data processing; choice of factor analysis method.

The structure of the special qualities of elite field hockey players was determined by five orthogonal factors: 1) factor of technical and tactical skill (21.31% of the total variance of the sample); 2) system indicators are indicators of functional readiness (16.35%). 3) factor of physical performance (10.45%); 4) the speed and speed-power abilities of hockey players (13.53%) 5) factor of competitive activity (7.53%).

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Conflict of Interest
The authors declare that there are no conflicts of interest.

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