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## The Construction of the Factor Model for Fitness Assessment in Ice Hockey Players

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## Keywords

factor structure, diagnostics, ice hockey

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## The Construction of The Factor Model for Fitness Assessment in Ice Hockey Players

### Authors' Contribution:

A – Study Design  
B – Data Collection  
C – Statistical Analysis  
D – Data Interpretation  
E – Manuscript Preparation  
F – Literature Search  
G – Funds Collection

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## Introduction

Sports diagnostics is irreplaceable with regard to qualified control of the training process providing information on the states and changes in all sports, whose primary aim is to enhance performance. Its interpretation enables coaches to actively engage in the training process and to predict the increase and decline in sports performance. On the basis of assessment of both the level and changes induced by sustained training, sports diagnostics serves to assess the predispositions necessary for the training process itself. The success in both individual and team sports lies in a scientifically justified system of training activity.

The selection of appropriate and verified methods in both specific and general conditions has to be performed on the basis of diagnostics, through which the indefinite character of exercises is eliminated. Athlete's training level may be defined as a specific form of organism's adaptation to a physical load. The adaptation is the result of genetic dispositions and the applied training. To differentiate between both effects in real conditions is practically impossible without unconventional methods used to uncover "weak" performance-determining links, which are used for the analysis and assessment of performance.

Diagnostics is based on a model physical load, which must mimic the competition conditions of identical intensity and duration. At the same time, it is necessary to assess the motor ability of the tested person and apply a dynamic load [1]. Both components depend on the motor competence that determines the performance of a particular motor task included in the assessment. The motor competence is characterized by two parameters: 1. skill – technique acquisition related to a motor task; 2. the condition of the muscular system.

Sports performance in ice hockey is alternate with regard to exercise intensity and falls into the category of the so-called 'multiple sprint sports' [2]. These types of sports performances are characterized by alternation of maximal-intensity short-duration exercise intervals and rest intervals.

The primary aim of the factor analysis is to derive hypothetical variables or factors out of a variety of observed variables. The factor analysis not only tests a particular hypothesis, but also looks for and proposes a new one [3].

The purpose of this study was to design a probability model whose application would refine the diagnostics of parameters of actual and continuous states in ice hockey players, using factor and analytical procedures.

## Material and Methods

The sample consisted of 22 U18 ice hockey players of the ice hockey team HC Košice, which ranks among the most successful ones in Slovakia. The systematic work of coaches includes expert assessment, but lacks requirements related to the prediction of the players' future performance level. This requires innovation of diagnostic tools for the assessment of somatic, functional and motor parameters while preserving sufficient information values of the used test items. Simultaneously, it is necessary to reduce the number of redundant subtests from the viewpoint of the expected results.

Tests and test-related norms in test battery 1 of the Methods Department of the Slovak Ice Hockey Federation (MD SIHF) include tests of both general and specific fitness for individual age categories. The test battery serves for performance assessment in U15, U18 and U20 categories and includes 10 subtests, which measure the running and skating speed, lower-body explosive strength, maximal strength of arm extensors and shoulder joint muscles. The score scale ranges from 1 to 80 points for the general tests and 1 to 90 points for the specific fitness tests (see Table 1).

Using the MD SIHF materials, test battery 2 was designed for the assessment of general and specific motor fitness. As shown in Table 1, battery 2 included field and laboratory tests measuring strength, lower-body flexibility, skating speed and agility. The test of the maximal skating speed [4] was applied together with the test of skating speed around the rink used especially at the exhibitions of the National hockey league or the Continental hockey league. Single-leg broad jump and agility test were performed according to the methods described by Brooks (Training center). The laboratory measurement of strength was conducted using a jump ergometer. On the basis of

previously conducted studies, 4 variables were selected: no. 15, 16, 17 and 18 (see Table 1). Test battery 2 included the test of lower-body strength and flexibility.

The results of the test batteries were processed by the procedures of correlation and factor analysis. In contrast to the correlational analysis, which provides information on the correlation structure among the observed variables [5], the factor and analytical procedures are oriented towards the quality of the correlation [6, 7]. The orthogonal rotation of factors into a simple structure was performed using the method Varimax [8].

## Results

Test batteries 1 and 2 represented relatively independent units with a certain degree of compactness in individual test items. Almost every test item was related to another variable, which is most probably a determining factor of skating speed.

Tab. 1. Arithmetic means and standard deviations in test batteries

	No	Variable	Ice hockey players U18 (N=22)	
			x	s
Specific motor fitness (Test battery 1)	1.	Forward skating 36m (s)	5.2	0.2
	2.	Backward skating 36m (s)	6.2	0.2
	3.	Forward skating 6x9m (s)	13.5	0.6
	4.	Forward skating 6x54m (s)	49.4	1.2
Specific motor fitness (Test battery 2)	5.	Test of maximal skating velocity (kph)	32.8	1.8
	6.	Test of skating speed – 1 lap around the rink (s)	15.3	0.5
General motor fitness (Test battery 1)	7.	60m run (s)	8.3	0.2
	8.	400m run (s)	65.1	2.0
	9.	1500m run (s)	381.9	28.7
	10.	6x9m run (s)	14.6	0.2
	11.	Standing broad jump (cm)	230.5	7.3
	12.	Bench press (kg)	68.7	8.4
General motor fitness (Test battery 2)	13.	Sit-and-reach (cm)	16.5	4.9
	14.	Agility - octagon (s)	5.0	0.6
	15.	J. ergometer <b>tc</b> time of contact (s)	0.2	0.1
	16.	J. ergometer <b>P</b> performance in the active push-off phase (W/kg)	39.2	5.4
	17.	J. ergometer <b>v</b> velocity in the final push-off phase (m/s)	2.4	0.1
	18.	J. ergometer <b>h</b> height of jump (cm)	30.4	3.1
	19.	Single-leg broad jump: left leg (cm)	192.7	14.4
	20.	Single-leg broad jump: right leg (cm)	194.3	11.2
	21.	10 single-leg squats: left leg (s)	6.6	0.5
	22.	10 single-leg squats: right leg (s)	6.7	0.6

Legend: J. ergometer – jump ergometer, N – number of players, x – arithmetic mean, s – standard deviation

Tab. 2. Factor analysis of test batteries

Test battery 1					Test battery 2					
No.	Factor 1	Factor 2	Factor 3	Factor 4	No.	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
1.	.508	.379	-.571	-.328	5.	.028	-.102	.502	-.280	.640
2.	.851	-.183	.035	.165	6.	-.153	.297	-.483	.682	.115
3.	.645	.151	-.131	.327	13.	.229	.125	-.207	.075	.797
4.	.095	.087	.039	.930	14.	-.071	-.154	.153	.896	-.078
7.	.358	.689	-.274	.208	15.	.013	-.137	-.940	-.036	.006
8.	.076	.870	.082	.067	16.	.671	.106	.680	.028	-.108
9.	-.194	.825	.037	-.041	17.	.944	-.116	-.044	-.087	.079
10.	.777	-.087	.059	-.202	18.	.941	-.102	-.002	-.054	.091
11.	-.715	-.325	.154	-.073	19.	.650	.171	.087	.030	.456
12.	.036	.089	.956	-.026	20.	.558	.266	.225	-.300	.144
					21.	.073	.900	.090	-.167	.075
					22.	-.062	.949	.026	.126	.025

Table 2 shows the results of the factor analysis of the variables included in test battery 1: 4 factors extracted and the results of battery 2: five factors extracted. It is necessary to take into consideration that battery 2 includes two test items more, which covers the examined motor aspect to a larger extent. This resulted in a different number of extracted factors indicating more detailed saturation of these factors. The significance of factor loading which is shown in bold letters was set at **<0.4** [9].

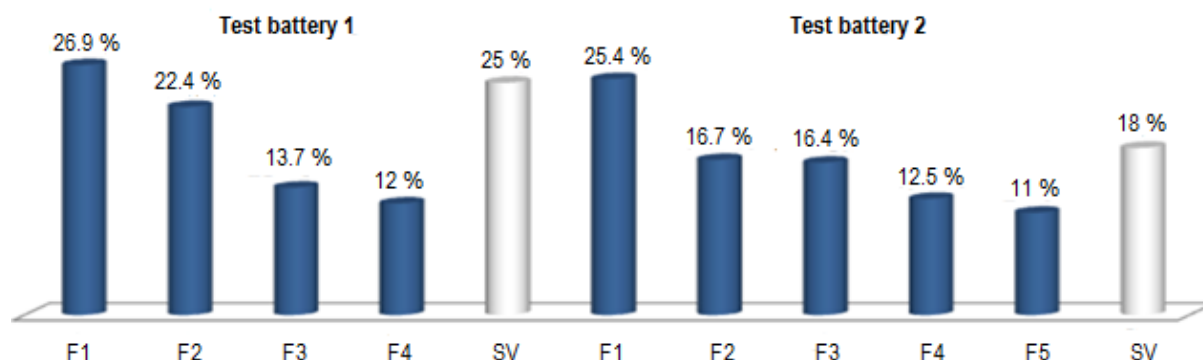


Fig. 1. Percentage of factor loading in test batteries 1 and 2

In test battery 1 of the MC SIHF four factors, indicators of conditioning abilities, were extracted. With regard to the conducted analysis, we may conclude partial incompleteness of the battery and the need to complement the battery with test items that would be more indicative of skating performance.

The saturation of five factors within test battery 2 has demonstrated a hierarchy of individual parameters, which are actually indicative of skating performance. With a certain degree of scientific skepticism, this battery may be regarded as a relevant indicator.

Tab. 3. Factor model 1

Variables	Factors				
	1	2	3	4	5
Maximal skating velocity (kph)	.122	-.034	-.254	.055	<b>.912</b>
Test of skating speed – 1 lap around the rink (s)	-.057	<b>.524</b>	<b>.600</b>	.060	-.230
60m run (s)	-.076	<b>.715</b>	.077	-.179	.290
400m run (s)	-.203	<b>.722</b>	-.031	-.067	-.359
1500m run (s)	-.294	<b>.782</b>	-.069	.294	.085
Agility – octagon (s)	.195	<b>.624</b>	-.100	<b>-.487</b>	-.273
Jump ergometer tc time of contact (s)	.098	-.170	<b>.911</b>	-.120	-.151
Jump ergometer P performance in the active push-off phase (W/kg)	<b>.577</b>	-.025	<b>-.714</b>	.228	.029
Jump ergometer v velocity in the final push-off phase (m/s)	<b>.941</b>	-.200	-.022	.154	.059
Jump ergometer h height of jump (cm)	<b>.944</b>	-.163	-.056	.153	.071
Single-leg broad jump: left leg (cm)	<b>.500</b>	.149	.031	<b>.736</b>	.234
Single-leg broad jump: right leg (cm)	.233	-.152	-.336	<b>.795</b>	-.135

Factor 1 covered 22% of the whole complex area. Its base was formed by abilities related to explosive strength. The share of factor 2 in the total variance equaled 20.4%. This factor may be considered as the factor of skating and running speed, speed endurance and agility, as it was saturated by variables of jump ergometry and the test of skating speed. Therefore, the factor could be regarded as the energetic factor of skating performance. The share of factor 4 in the total variance equaled 13.8% and was saturated by variables of agility and single-leg broad jumps. The factor represented frequency speed and explosive strength. Factor 6 seems to be highly specific being saturated by the variable of skating speed and representing the factor of maximal skating velocity. This is indicative of its specific position in terms of skating speed. Specific variance (SV – 17.5%) of factor model 1 was not directly associated with the content of the test items. It was

probably saturated by personal, psychological and other variables, which did not make part of motor parameters.

Tab. 4. Factor model 2

Variables	Factors		
	1	2	3
Forward skating 36 m (s)	<b>.520</b>	.008	<b>-.734</b>
Backward skating 36 m (s)	<b>.824</b>	-.205	.055
Forward skating 6x9m (s)	<b>.765</b>	.029	.037
Forward skating 6x54m (s)	.386	.273	<b>.649</b>
Run 6x9m (s)	<b>.648</b>	<b>-.406</b>	-.154
Standing broad jump (cm)	<b>-.717</b>	-.194	.164
Bench press (kg)	-.088	-.309	<b>.648</b>
Ten single-leg squats: left leg(s)	-.092	<b>.925</b>	-.038
Ten single-leg squats: right leg (s)	-.001	<b>.919</b>	-.082

Within factor model 2, three factors were extracted with a higher rate of specific variance compared to factor model 1. Factor 1, which may be termed the skating-related factor of lower-body explosive strength, covered 29.9% of the total variance. Factor 2 was saturated by variables sensitively assessing the level of lower-body strength in terms of dominance and preference. The factor covered 23.5% of the total variance. Factor 3 represented the factor of skating speed endurance and maximal strength of arm extensors and shoulder joint muscles. Its saturation equaled 16.1%. The value of the specific variance of factor model 2 equaled 31.2%. Almost one third of the covered motor area indicated that the content validity increased relatively significantly.

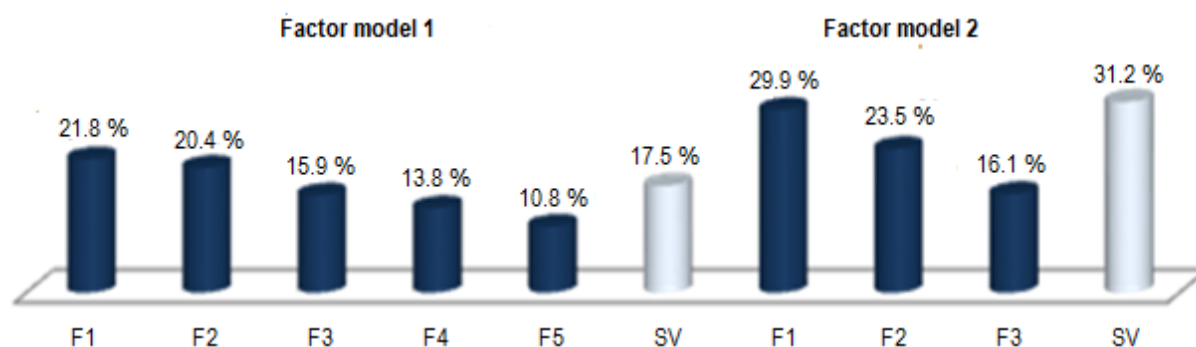


Fig. 2. Percentage of factor loading in the factor models

## Discussion

The factor matrix includes all the information whose meaning remains unclear. Therefore, individual percentages of saturation are presented graphically. This method of illustration provides a concise overview of the factor analysis [10]. These factors serve for the design of an acceptable model, which reproduces the observed data and whose variables are interpretable and present real equivalents. The applied tests are divided into two performance areas representing two independent units. In their essence, they form a cohesive unit, where test items are more or less interrelated. This results in the factor loading of individual variables and forms a more complex factorial structure of performance, which in terms of the presented research objective may be understood as a partial structure of skating profile. The evaluation of the factor structure of the motor fitness by means of multivariate analysis allows for exploration of relations and associations, which are not accessible through partial analyses. The percentage illustration of factor structure facilitates accessibility and comprehensibility, which magnifies its interpretability. The determination of the specific variance, which is not directly associated with motor factors, is used to analyze the effects that are causally related to motor fitness. The factor analysis is a multivariate mathematical and statistical method that forms hypotheses. The model of factor analysis is based on the

correlation structure of the variables and correlations among variables may be the consequence of a certain number of latent variables that cannot be directly measured. These factors are termed common factors [11].

## Conclusions

The primary purpose of the conducted diagnostics was to examine the variables covering the common variance, which may be termed as the "motor area". Factor and analytical procedures with the highest degree of verification enable clarifying criteria assessed by the individual test items. At the same time, they enabled reducing the number of redundant test items, which are possible to identify on the basis of multivariate mathematical statistics.

The comparative analysis of the test batteries resulted in two factor models, one of which demonstrated a sufficient degree of validity. With a high degree of probability, it is possible to conclude incidence of a common base of running parameters, which despite a different character of loading shared an identical base. This contradiction represents a certain knowledge paradox indicating that the implementation of these items into the test battery does not sufficiently assess the general fitness in ice hockey players and their number seems to be redundant. This finding has been confirmed by the saturation of jump ergometry as an indicator of lower-body explosive strength.

The attempt to analyze the simple structure of the factor model showed that several test items shared a common criterion. This enables both refining the test battery content and reducing their number as is the case of the variable: sit-and-reach, which does not fall into the proposed models due to the character of its content. We may assume that cooperation with experts in this field will enhance the quality of diagnostics in the training process.

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