Determining the sport level of the players in ice hockey using multivariate analysis

Robert Roczniok [1], Miłosz Czuba [3],Adam Maszczyk [1], Przemysław Pietraszewski [1], Artur Gołaś[2], Robert Wilk[3], Paweł Grycman[3]

[1.] Department of Statistics and Methodology, The Jerzy Kukuczka Academy of Physical Education, Katowice, Poland
[2.] Department of Sports Training, The Jerzy Kukuczka Academy of Physical Education, Katowice, Poland
[3.] Department of Water Sports, The Jerzy Kukuczka Academy of Physical Education, Katowice, Poland
[4.] Department of Team Games, The Jerzy Kukuczka Academy of Physical Education, Katowice, Poland
r.roczniok.awf@gmail.com

Abstract: Ice hockey is a physically demanding contact sport involving repeated bouts of high energy output. Success at the elite level requires players to develop fitness including anaerobic sprint ability, strength, power and endurance. The ability to successfully identify elite versus non elite players could influence a team's success. Therefore, effective classification of players based on physical characteristics and performance parameters requires a critical analysis of the qualities deemed important for a particular sport. The surrounding reality is by nature complex and multidimensional and situations where one variable explains a given phenomenon is rather rare. The main research problem of this study was to present a mathematical model describing best players represented by the Players Development Index. Studies were carried out on a group of 25 Polish top level ice hockey players. Data collection was conducted in December 2013 and included two days of testing for each athlete. Independent variables related to physiological and physical profiles and on-ice performance. During the study the structure of the Players Development Index was analyzed, also through discriminate analysis and 3 classification functions calculated with its help. Their role consisted in the detailed selection of players for groups of a different level of development.
[Roczniok R, Czuba M, Maszczyk A, Pietraszewski P, Gołaś A, Wilk R, Grycman P. **Determining the sport level of the players in ice hockey using multivariate analysis.** *Life Sci J* 2014;11(10):228-231]. (ISSN:1097-8135). http://www.lifesciencesite.com. 31

Keywords: players development index; sports selection; prediction of sports results

1. Introduction

The ability to successfully identify elite versus nonelite players could influence a team's success. Therefore, effective classification of players based on physical characteristics and performance parameters requires a critical analysis of the qualities deemed important for a particular sport and the subsequent selection and implementation of appropriate tests to assess those attributes [1]. Ice hockey is a physically demanding contact sport involving repeated bouts of high energy output, with shifts lasting from 30 to 80 seconds [2; 3; 4]. Given the anaerobic nature of the sprint-based shifts (69% anaerobic glycolysis) and the aerobic recovery (31% aerobic metabolism) between shifts and periods, as well as the physical type of the game, success at the elite level requires players to develop fitness including anaerobic sprint ability, strength, power and endurance [5; 6].A longitudinal study by Cox et al. gathered physiological data on over 170 players from the National Hockey League (NHL) from 1980 to 1991. Over this time period VO2max was found to increase from an average of 54 ml/kg/min in 1980 to just over 62 ml/kg/ min (N = 635) in 1991 in the group of studied players. The above opinions make it obvious that ice hockey researcher has formulated an unambiguous criterion that could be used to quantify and arrange linearly the partial results of the somatic, physical skills and physiological – biochemical tests in order to create a variable i.e. a player development index. The surrounding reality is by nature complex and multidimensional and situations where one variable explains a given phenomenon is rather rare. Dependencies of single variables for explaining sport performance can be based on indirect or apparent relationships which obscure the studied phenomenon [7; 8]. This is why one should look for methodological solutions (econometric and statistical instruments) which will help in explaining the complex phenomenon of the Development Player Index, based upon complex testing of ice hockey players. This problem is quite complicated with regard to unquantifiable sports, where a single result of an event cannot be obtained for an individual athlete (unlike swimming or javelin throw), and requires the application of econometric tools. Therefore, the purpose of the present study was to construct the Player Development Index.

2. Material and Methods

2.1 Participants

The sample used in the research comprised 25 Polish top level ice hockey players. Data collection was conducted in December 2013 and included two days of testing for each athlete. The Players Development Index, based on on-ice special tests, was the explained variable. Independent variables related to physiological and physical profiles and off-ice performance. During the study, the structure of the Players Development Index was analyzed, also through discriminate analysis and 3 classification functions calculated with its help. Their role consisted in the detailed selection of players for groups of a different level of development.

Measurements were performed in the Human Performance Laboratory of the Academy of Physical Education in Katowice and the ice hockey arena. During statistical analysis multidimensional data mining technique – discriminate analysis [9] was used. For determining ice hockey players performance in the quotient scale, the Player Development Index on the ground of the Hellwig's algorithm was used. All study procedures were approved by the Bioethics Committee for Scientific Research at the Academy of Physical Education in Katowice. The research subjects were informed of the aim of the study and experimental risks. All statistical analyses were carried out on a PC using the statistical package STATISTICA 10.0 (Polish edition).

2.2 Data collection and tools of statistical analyses

Independent variables for econometric analysis were obtained by measuring the different characteristics of ice hockey players in the following groups: on ice special tests, anthropometric measurements, resting blood samples were drawn from the antecubical vein to determine hematological variables (hemoglobin concentration (HGB), hematocrit value (HCT), number of erythrocytes (RBC) (Advida 2120, Siemens, Germany)). Body mass and body composition were then evaluated by electrical impedance (Inbody 720, Biospace Co., Japan). Two hours after a light breakfast, a ramp cycloergometer test (0,5W/s) was used to determine aerobic capacity. During the test, the heart rate, minute ventilation (VE), oxygen uptake (VO2) and expired carbon dioxide (CO2) were continuously measured using a model MetaLyzer 3B-2R stationary spiroergometer (Cortex, Germany). Fingertip capillary blood samples for the assessment of lactate (LA) concentration (Biosen C-line Clinic, EKF-diagnostic GmbH, Germany) were drawn of the end of test, as well as during the 3rd, 6th, 9th, and 12th min of recovery. In the second day the Wingate test (0.80 Nm/kg) was used to determine anaerobic capacity. Fingertip capillary blood samples for the assessment of lactate (LA) concentration were drawn of the end of test, as well as during the 4rd and 8th min of recovery.

3. Results

In order to create an index PDI used only "on-ice" tests. In this study the Players Development Index, based on Wroclaw taxonomy measures [9], was the explained variable. It represented the best ice hockey performance accomplished by ice hockey players. The independent variables comprise physiological and physical profiles as well as off-ice performance. The ideal of sport performance measurement is to express in the physical quantities (meters, seconds…). To calculate the Players Development Index all features $x_{1...,}x_n$ of a given player were divided into stimulants:

$$\rightarrow \quad x_{ij} = \frac{x_{ij} - \min\limits_i \{x_{ij}\}}{\max\limits_i \{x_{ij}\} - \min\limits_i \{x_{ij}\}}$$

and destimulants:

$$\rightarrow x_{ij} = \frac{\max\limits_i \{x_{ij}\} - x_{ij}}{\max\limits_i \{x_{ij}\} - \min\limits_i \{x_{ij}\}}$$

To obtain only stimulants, destimulants were multiplied by -1. Then normalization was applied, from which we obtained values of variables within the interval [0,1]. For the best player in the group to be possibility similar to the model, the following numbers were created:

- $$c_{io} = \left[\sum_{i=1}^{n} (X_i^l - Y^l)^2\right]^{1/2}$$
- $$\bar{c}_o = \frac{1}{k}\sum_{i=1}^{k} c_{io}$$
- $$s_o = \left[\sum_{i=1}^{n} (c_{io} - \bar{c}_o)^2\right]^{1/2}$$
- $$d_i = 1 - \frac{c_{io}}{\bar{c}_o + 2s_o} \qquad 0 \le d_i \le 1$$

,

Players Development Index.

The closer to one the player is better. fig. 1).

This tool organizes players linearly based on the used variables. The Players Development Index has been used in many studies of several different sport disciplines where formal and methodological difficulties occurred during assessment of sport performance [10; 11; 9; 8]. This study contained as an experimental group, the group of ice hockey players of advanced level. The next stage of the analysis was to identify the variables that the best divide the ice hockey players. For this purpose a discrimination analysis was used. This procedure leads to obtain

classification functions which can identify new objects net belonging to the learning set. Tested participants were divided into three groups, similar in number, according to the Players Development Index, representing a different advancement level. As independent variables we used medium level (n=7, PDI: 0.01 – 0.16); high level (n=9, PDI: 0,17 – 0.33); and master level (n=9, PDI: 0.34 – 0.47). Upon applying the stepwise procedure for selecting variables, 7 variables best discriminating the group were chosen (VO_{2max}[ml/kg/min], Pmax [W/kg], $\Delta LA_{max\text{-}12min\ of\ recovery}$[mmol/l], Percent body fat, Body height [cm], Time to reach maximum power [s], Mean $Power_{30s\ Wingate\ test}$ [W/kg]). Power of the discriminate models was described by Wilk's Lambda. In this model the value is contained in the range (1.0 – lack of discriminate power 0.0 excellent discriminate power). In the resulting model, the value of Wilk's Lambda equalled 0.049, which indicated very good discrimination of objects. Such variables as VO_{2max}[ml/kg/min], Pmax [W/kg], $\Delta LA_{max\text{-}12min\ of\ recovery}$[mmol/l], Body height [cm], Time to reach maximum power [s] have the biggest share in general discrimination. The following variables: Percent body fat, Mean $Power_{30s\ Wingate\ test}$ [W/kg] contribute the least to the described discriminate models. The main objective of the analysis was to assign the participants to a specific group. General qualification correctness was very high (about 96,7%).

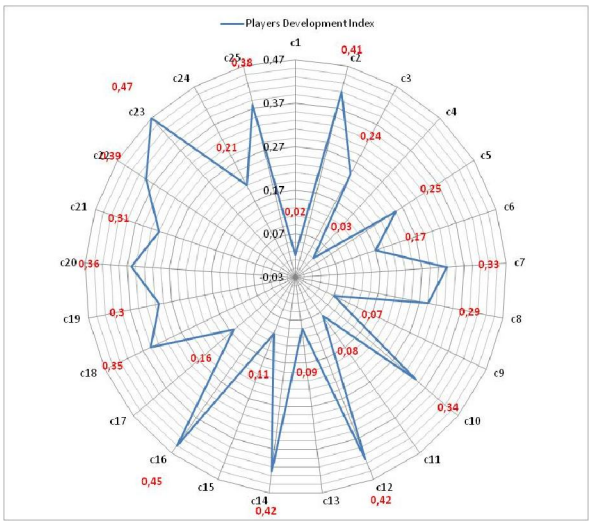

Fig. 1. Graphical interpretation of the Players Development Index.

4. Discussions

Nowadays, there is a necessity to apply multidimensional analyses in sport sciences. It is especially relevant in a sport selection process. It is extremely difficult to designate a criterion with the aid of which one could present accomplishments of a particular player on a quotient scale [12]. Statistical and mathematical predicting methods are becoming more and more significant in this area. Opportunities to employ tools of statistical analysis are wide, from the simplest taxonomic analyses to multidimensional exploration techniques for optimizing the recruitment process [13], through to the application of a variety of mathematical models or even artificial neural networks for optimization of selection at individual stages of sports advancement. Upon the applied discriminate analysis procedure for selected variables, 7 variables which best discriminated the groups were chosen: VO_{2max}[ml/kg/min], Pmax [W/kg], $\Delta LA_{max\text{-}12min\ of\ recovery}$[mmol/l], Percent body fat, Body height [cm], Time to reach maximum power [s], Mean $Power_{30s\ Wingate\ test}$ [W/kg]. Green et al. (2004) conducted a study on an NCAA Division I hockey team, focusing on their physiological profiles, including VO2max, blood lactate, and percent body fat, related to their performance. Using a discontinuous protocol in which blood lactate was measured between three-minute stages of treadmill running, blood lactate levels averaged 8.9 ± 2.1 mmols/L at the end of the fourth stage, the last stage completed by each of the subjects. This stage was tested at 12.9 km/h and a seven-percent grade on the treadmill. Aerobic fitness (VO_{2max}) accounted for 17% of the variance in performance, which was based on overall scoring chances while a particular player was on the ice. It was concluded that only VO_{2max} significantly predicted performance. For elite ice hockey players, anaerobic power and anaerobic endurance are of critical importance [14], making strength an important part of a hockey training program. Although players are not required to meet certain physical challenges (when compared to other multi sprint sports), power is required for acceleration, to maintain speed and for quick direction changes. Upper body strength allows players to shoot more powerfully and pass over a greater range of distance. The results presented in our study are also confirmed by those reported by other authors [1], which state that aerobic and anaerobic capacity are important physiological characteristics for ice hockey players [14; 12]. Because of the relatively short but intense work intervals found in an ice hockey game (from 30 to 60 s), the ability to produce anaerobic energy might dictate performance within a given shift when playing on ice [14; 12]. Although a variety of on-ice skating tests have been developed, the Wingate test on a cycle ergometer (from 15 to 45 seconds) remains the most commonly used test for assessing anaerobic power and capacity in hockey players [13]. Upper body strength allows players to shoot more powerfully and pass over a greater distance [15]. Good skating techniques, anaerobic capacity, maximum power and

time to maximum power production also play an important role during on-ice testing [16].

The main aim of research was to demonstrate the process of constructing the Players Development Index. Then we applied discriminate analysis which comprised test results (off–ice tests) that would best classify the ice hockey players into the medium level, high level and master level group, represented in this study by the Players Development Index. Poor league and lack of young talented players fighting their way through to senior teams lead to slow marginalization and descent of this discipline of sport in Poland [17]. Summing up discriminate analysis and the PDI may contribute to better decisions made by the coaching staff in team games.

Corresponding Authors:
Adam Maszczyk PhD
Department of Statistics and Methodology
The Jerzy Kukuczka Academy of Physical Education, Katowice, Poland
E-mail: a.maszczyk@awf.katowice.pl
Robert Roczniok PhD
Department of Statistics and Methodology
The Jerzy Kukuczka Academy of Physical Education, Katowice, Poland
E-mail: r.roczniok.awf@gmail.com

References

1. Vescovi JD, Murray TM, Fiala, KA, VanHeest JL. Off-Ice Performance and Draft Status of Elite Ice Hockey Players. International Journal of Sports Physiology & Performance, 2006; Sep; Vol. 1 Issue 3: p207
2. Green DJ, Maiorana A, O'Driscoll G, Taylor R. Effect of excersise training on endothlenium-derived nitric oxide function in humans. J Physiol, 2004; 561: 1-25
3. Lau S, Berg K, Latin RW, Noble J. Comparison of active and passive recovery of blood lactate and subsequent performance of repeated work bouts in ice hockey players. J Strength Cond Res, 2001; 5: 367-371.
4. Montgomerry DL. Physiology of ice hockey. SportMed, 1988; 5: 99-126.
5. Cox MH, Miles DS, Verde TJ, Rhodes EC. Applied physiology of ice hockey. Sports Med, 1995; 19: 184-201.
6. Glaister M. Multiple sprint work: physiological responses, mechanisms of fatigue and the influence of aerobic fitness. Sports Med, 2005; 35: 757-777.
7. Helwig Z. Problem optymalnego wyboru predykant. Przegląd Statystyczny 3, 1969; s. 221-237
8. Ryguła I. Proces badawczy w naukach o sporcie, 2003; AWF Katowice.
9. Ryguła I. Narzędzia analizy systemowej treningu sportowego, 2000; AWF Katowice.
10. Pietraszewski P. Analiza wielowymiarowa efektów sportowych młodzieżowych drużyn piłki ręcznej. Praca doktorska, 2004; AWF Katowice.
11. Ryguła I. Zastosowanie metod taksonomicznych w grach sportowych, 1995; Trening 3.
12. Roczniok R, Stanula A, Gabryś T, Maszczyk A. Application of aglomeration methods in aiding decision process for ice hockey playing. Current Research in Motor Control III, 2008; 241-249.
13. Roczniok R, Ryguła I, Kwaśniewska A. The use of Kohonene's neural networks in the recruitment Process for sport swimming. J Hum Kinet, 2007; 17: 75-89.
14. Leone M, Lariviere G, Comtois AS. Discriminant analysis of anthropometric and biomotor variables among elite adolescent female athletes in four sports. J Sports Sci; 2002; 20: 443-449.
15. Roczniok R, Maszczyk A, Czuba M, Stanula A, Pietraszewski P, Gabryś T. The predictive value of on-ice special tests in relation to various indexes of aerobic and anaerobic capacity in ice hockey players. *Human Movement.* 2012; 13 (1):28-32.
16. Skowronek T, Socha T, Roczniok R, Socha S. The predictive value of various anaerobic capacity indices in relation to specific on-ice performance tests in ice hockey players. *Life Sci J* 2013;10(4):2828-2832].(ISSN:1097-8135)
17. Roczniok R, Maszczyk A, Stanula A, Czuba M, Pietraszewski P, Kantyka J. and Starzyński M. Physiological and physical profiles and on-ice performance approach to predict talent In Male youth ice hockey players Turing draft to hockey team. Isokinetics and Exercise Science, 2013; 21; 121-127.

6/6/2014