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Canonic discriminant analysis projected in space with standard matrix as optimum method for determining differences between athletes

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Abstract

The obtained result can easily be transformed into the form obtained under the canonic model of discriminant analysis. Matrix of discriminant coefficients can be defined as the matrix of partial regression coefficients, obtained by solving the following problem

$$\mathbf{ZW} = \mathbf{K} + \mathbf{E} \mid \text{path } (\mathbf{E}^t\mathbf{E}) = \text{minimum.}$$

As, in fact,

$$\mathbf{K} = \mathbf{ZR}^{-1/2}\mathbf{X},$$

It is obvious that E = 0, and that

$$\mathbf{W} = \mathbf{R}^{-1/2}\mathbf{X}.$$

Because of this vectors w_k from W are proportional to the coordinates of vectors of discriminant functions in slope coordinate system formed by vectors from **Z** with cosines of angles between coordinate axes equal to elements of correlation matrix **R.** Since the discriminant analysis can also be interpreted as an special case of component analysis with key components transformed by a some permissible singular transformation so as to maximize spaces between the E_p subgroups' centroides, i.e. canonic correlations ρ_k (Cooley and Lohnes, 1971; Hadžigalić, 1984; Popović, 1992), it is customary to base the identification of discriminant functions' content on structural vectors $\mathbf{f}_k$ from the matrix

$$\mathbf{F} = \mathbf{Z}^t\mathbf{K} = \mathbf{RW} = \mathbf{R}^{1/2}\mathbf{X} = (\mathbf{f}_k) = (\mathbf{Rw}_k),$$

analogusly to identification of the content of canonic variables obtained by Hotelling's method of biorthogonal canonic correlation analysis, since it can be demonstrated by a simple calculation that **F** is factorial matrix of the matrix **R** (Zorić and Momirović, 1996; Momirović, 1997).

Key words: canonic variables/matrix/singular transformation/function/vactors

1. Introduction

Motor abilities are usually considered to be directly responsible for performing tasks in sport and physical education, regardless of whether those tasks are related to educational, competitive or recreative activities. Measuring of motor abilities is a starting point in all processes of the aforementioned fields of sports' activities simply because managing this process cannot be imagined without the information on transformational and final condition of the system which is being managed.

Determining the level of specific dimensions of motor space is of a recent date and it belongs to the field of motor skills diagnostics. Since the abilities which define motor space are not given directly, but as latent dimensions, the quality and quantity of which is determined based on the output of the system, they cannot be measured by a direct methodology. Thus, the motor abilities are measured indirectly, by conventional movement manifestations known as ***motor tests.*** Apart from that, latent dimensions of motor space are not expressed as singular properties, but are mostly combined in different variations, which makes measuring of these dimensions even harder.

Motor tests, as the set of tasks for which model of presenting and evaluation of the result,s as well as their measuring characteristics have been developed in the course of the previous research, are used as the instruments for measuring motor

space. Motor tests as standardized mehods are the most valuable source of information on the level and development of movement abilities of the examinees.

2. Methods

2.1 Test group

On the basis of the chosen statistical-mathematical model, i.e. program, goals and hypothesis, it was decided that the sample consisted of about 200 athletes (about 100 judoists and about 100 karatists of both sexes) aged between 18 and 27. The majority of this sample had to meet the following criteria:

- that the effective of the sample was so large that it permited so many degrees of autonomy that any coefficient in the matrix assembly or any correlation coefficient equal to or larger than .21 could be considered different from zero with the conclusion deviation les than 01;

- the number of the subjects in the sample had to be five times larger than the number of applied variables so that, according to the recent principles, adequate statistical methods could be applied successfully;

Apart from the aforementioned, the subjects had to meet the following conditions:

- subjects were male;
- age was defined on the basis of chronological age, so that the research was performed on subjects from 18 to 27 years of age plus-minus 0.5 years;
- subjects had regular trainings in their clubs or national team of Serbia, which was confirmed by the evidence of attendance and number of trainings per month;
- subjects did not have any somatic deformity or aberrations and were physically and mentally healthy.

No other exclusion criteria were used in defining of the population from which the sample of subjects was taken apart from the listed ones (Popović, D. 1990).

2.2 Sample of the variables

Sixteen variables which involved the following regulatory mechanisms were applied:

a) Structuring of movement:
- Broaching and jumping over (PROPRE)
- Shooting the target by leg with a tennis ball (GACINOT)
- Wriggling with broaching (OSSAPRO)
- Polygon backwards (POLINAT)

b) Regulation of tone and synergistic regulation

- Side standing on a low balance beam with eyes closed (RAVZATOČ)
- Dominant hand tapping test (TAPTDR)
- 20 m sprint start running (TIVSTAR)
- Deep forward bend on the bench (DUPRENK)

c) Regulation of excitation intensity
- Stand still long jump (SUDS)
-Stand still high jump (SUS)
- Standing triple jump (TSK)
- Throwing medicine ball with both hands from the sitting back position (BMED)

d) Regulation of duration of excitation
- Under grip pull up on pull up bar (ZVPOT)
- Legs lifting in lying position (DNOL)
- Torso lifts in 30 sec lying on the back (PTLNL)
- Torso lifts in 30 sec lying on the stomach (PTLNS)

2. 3. Methods of processing of the results

Significance of a research depends not only on the sample of subjects studied and the sample of variables, that is on the importance of basic information, but on the applied processes for transformation and condensation of that information, too. Some scientific problems can be solved by means of a larger number of different, and sometimes equally valuable methods. However, from the same basic data and from the same results of different methods different conclusions can be drawn. This is why the problem of choosing particular methods for data processing is rather complex.

In order to reach satisfactory scientific solutions, the research was based on, primarily acceptable, adequate, unbiased and comparable procedures, which were appropriate to the nature of the problem posed and which enabled extraction and transformation of appropriate dimensions.

Taking all this into account, for the purpose of this research we chose procedures which are considered to be appropriate to the nature of the problem which do not impose too severe restrictions on the basic information and are based on the following assumptions:

- that latent dimensions, which are the subject of measuring by the applied measuring instruments, have multivariate normal distribution;
- that the relations between manifest and latent variables can be approximated by genaralized linear model of Gauss, Markov and Rao.

Lately, many researchers have been misusing their position and publishing more and more quazi scientific papers primarily based on mathematical artefacts. Apart from that, they have been using the existing statistical products without even understanding the logic of most multivariate models. For this reason, this paper will primarily focus on statistic processing of the data, as well as the choice of useful algorithms and programs.

All the data in this study were processed at the Multidisciplinary Research Center, Faculty of Sport and Physical Education, University of Priština with the help of the software system for data processing developed by Popovic, D. (1980), (1993), and Momirović, K. and Popovic, D. (2003).

CANONIC DISCRIMINANT ANALYSIS PROJECTED IN SPACE WITH STANDARD MATRIX

The obtained result is easily transformable into the form obtained under the canonic model of discriminant analysis.

Matrix of discriminant coefficients can be defined as the matrix of partial regression coefficients, obtained by solving the following problem:

$$\mathbf{ZW} = \mathbf{K} + \mathbf{E} \mid \text{path } (\mathbf{E}^t\mathbf{E}) = \text{minimum}.$$

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Because of this vectors w_k from W are proportional to the coordinates of vectors of discriminant functions in slope coordinate system formed by vectors from **Z** with cosines of angles between coordinate axes equal to elements of correlation

matrix **R.** Since the discriminant analysis can also be interpreted as an special case of component analysis with key components transformed by a some permissible singular transformation so as to maximize spaces between the E_p subgroups' centroides, i.e. canonic correlations ρ_k (Cooley and Lohnes, 1971; Hadžigalić, 1984; Popović, 1992), it is customary to base the identification of discriminant functions' content on structural vectors $\mathbf{f}_k$ from the matrix

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analogusly to identification of the content of canonic variables obtained by Hotelling's method of biorthogonal canonic correlation analysis, since it can be demonstrated by a simple calculation that **F** is factorial matrix of the matrix **R** (Zorić and Momirović, 1996; Momirović, 1997).

The cross structure of discriminant analysis in this metrics will be

$$\mathbf{U} = \mathbf{Z}^t\mathbf{L}\boldsymbol{\rho}^{-1} = \mathbf{Z}^t\mathbf{PZW}\boldsymbol{\rho}^{-1} = \mathbf{W}\boldsymbol{\rho}$$

As, of course, $\mathbf{W}^t\mathbf{Z}^t\mathbf{PZW} = \boldsymbol{\rho}^2$, so it is evident that **U** is factorial matrix of the matrix $\mathbf{Z}^t\mathbf{PZ}$, that is of the matrix of the intergroup covariance defined in the space with standard **I** metrics.

As the elements f_{jk} of the matrix **F** and the elements u_{jk} of the matrix **U** behave as regular product-moment correlation coefficients, and as they are the function of normally distributed variables and thus asymptotically normally distributed themselves, their asymptotic variances are

$$\sigma_{jk}^2 \sim (1 - \varphi_{jk}^2)^2 n^{-1}$$
$$j = 1,..., m; k = 1,..., s$$

that is

$$\xi_{jk}^2 \sim (1 - \upsilon_{jk}^2)^2 n^{-1}$$
$$j = 1,..., m; k = 1,..., s$$

and can be used for testing hypotheses type H_{jk}: $f_{jk} = \varphi_{jk}$, that is H_{jk}: $u_{jk} = \upsilon_{jk}$ where φ_{jk} and υ_{jk} are some hypothetical correlations between variables from V and discriminant functions in the population P because asymptotic distribution of the coefficients f_{jk} is

$$f(f_{jk}) \sim N(\varphi_{jk}, \sigma_{jk}^2),$$

and asymptotic distribution of the coefficients u_{jk} is

$$f(u_{jk}) \sim N(\upsilon_{jk}, \xi_{jk}^2),$$

where N denotes normal distribution.

RELIABILITY, INFORMATIVENESS AND SIGNIFICANCE OF DISCRIMINANT FINCTIONS

$$\mathbf{V}^2 = (\text{diag } \mathbf{R}^{-1})^{-1}$$

Is diagonal matrix the elements of which are estimations of the unique variances of the variables from V. As Momirović and Zorić showed (1996), reliability, or more precisely generalizability of discriminant functions can be estimated on the basis of the value of diagonal elements of matrix

$$\boldsymbol{\alpha} = (\text{diag } (\mathbf{W}^t(\mathbf{R} - \mathbf{V}^2)\mathbf{W}))(\text{diag } (\mathbf{W}^t\mathbf{R}\mathbf{W}))^{-1},$$

relative informativeness based on the elements of matrix diagonal

$$\iota^2 = (\mathbf{I} - \boldsymbol{\alpha})^{-1}\mathrm{m}^{-1}$$

and the significance of these functions based on the elements of diagonal matrix

$$\boldsymbol{\zeta} = \iota^2\boldsymbol{\rho}.$$

Obviously, these data can be of much greater importance than results of the tests of importance of canonic correlations for evaluating the actual meaning of discriminant functions.

3. Results

Motorics, i.e. anthropomotics, is a system of movement manifestations of man for communicating with the environment. This system is primarily defined as an ability to move the whole body or some of its parts in space with a certain amplitude, rhythm, direction, intensity, and goal. The information that the number of manifest moving activities i.e. their combinations, is practically infinite, is logical, or even the only possible direction for identification of the structure of motor abilities as the system which is in the basis of those manifestations, and which is justifiably reduced and limited by the available number of latent dimensions relative to the movement manifestations.

Planned, systematic and programmed training induces changes in anthropological status of athletes. These changes are most often manifested in the area of some abilities and characteristics, and especially in the domain of motor abilities and motor skills. Anthroplological characteristics appear, develop and change quantitatively and qualitatively. Quantitative changes are those which are articulated in space, or those which decrease the efficiency of a certain ability, characteristic or motor information. Qualitative changes include changes of the relations between characteristics. Both types of changes are inevitable. Changes in general can significantly be influenced by different means and in different ways. They are under the evident influence of exog-

enous factors i.e. the influence of the environment on formation and manifestation of changes in motor spece is of a great significance.

The results of discriminant analysis of motor variables show that the difference between the tested athletes in respect to the chosen sport is statistically significant. Analysis of the values presented in Table 1 shows that matching of the results between two groups of athletes of the registered indicators is considerable. Only one substantial discriminant function and one substantial canonic correlation (.83) were obtained. This indicates the existence of the relation between discriminant functions and it is a major indicator of quantitative structure. The significance of the differences between groups is presented by Wilks' lambda and the significance of canonic correlations was tested by Bartlett's X^2 test.

Table 4. shows the structure of the discriminant functions of motor variables which demonstrates the contribution of each variable in general distance of the group centroids.

Coefficients of the first discriminant function clearly show that this discriminant function is best defined by the tests for the estimation of segmentary speed of hands, repetitive force, coordination and flexibility. The size and the precursor of the group centroids show that judoists have greater strength and coordination, while karatists demonstrate better segmentary speed of hands and flexibility, which is in accordance with the findings demanded by these two sports.

Table 1 DISCRIMINANT ANALYSIS OF MOTOR VARIABLES

F	Kan. R.	λ	χ^2	df	Sig.
1	.83	,37	217,30	15	,00

Table 2 STRUCTURE OF CANONIC FACTOR IN H SPACE

Variable	D1
SUDS	,24
SUS	,21
TSK	-,38
BMED	-,29
ZVPOT	,44
DNOL	,46
PTLNL	-99
PTLNG	,28
TAPTDR	-,72
TIVSTAR	,41
DUPRENK	1,00
PROPRE	-,18
GACINOT	,22
OSSAPRO	-,15
POLINAT	,39

Table 3 GROUP CENTROIDS

Groups	D1
Judo	-1.44
Karate	1.56

Teble 4 STRUCTURE OF CANONIC FACTOR IN Z SPACE

Variable	D1
TAPTDR	-,45
TIVSTAR	,39
PTLNL	-,29
POLINAT	,23
DUPRENK	,24
PROPRE	,19
PTLNG	-,16
TSK	-,19
OSSAPRO	,17
DNOL	-,12
BMED	-,09
GACINOT	,07
SUDS	-,07
SUS	-,06
ZVPOT	-,02

4. Conclusion

The research was conducted with the aim to investigate specificities of motor dimensions in athletes who practice judo and karate and to determine the differences between them.

In order to determine specificities of the structure of tested anthropologic dimensions, 200 judoists and karatists, members of judo and karate clubs in Serbia (about 100 judoists and about 100 karatists), between 18 and 27 years of age, were tested.

Sixteen motor tests, chosen according to the structural model of Grdelja, Metikoš, Hošekova and Momirović (1975) and Popović (1990) and defined as mechanism for structuring of movement, mechanism for functional synergy and tone regulation, mechanism for regulation of excitation intensity and mechanism for regulation of excitation duration, were used for determining motor abilities.

All the data in this research were processed in the Centre for Multidisciplinary Research of the Faculty of Sport and Physical Education, University in Priština, by means of the system of programs for data processing developed by Popović, D. (1980), (1993) and Momirović, K. and Popović, D. (2003).

Complete algorythms and programs from this dissertation have been presented, and the results of those programs analyzed.

The results of discriminant analysis of motor variables show that the differences between the tested athletes regarding the chosen sport is statistically significant. Analysis of the values presented in Table 1. show that the matching of the results between the two groups of athletes of registered indicators is considerable. Only one substantial discriminant function and one substantial canonic correlation (.83) were obtained. This indicates the existence of the relationship between discriminant functions and it is a major indicator of quantitative structure. The significance of the differences between the groups is presented by Wilks' lambda and the significance of canonic correlations was tested by Bartlett's X^2 test. Table 4. shows the structure of the discriminant functions of motor variables which illustrates the contribution of each variable in general distance of the group centroids. Coefficients of the first discriminant function clearly show that this discriminant function is best defined by the tests for the estimation of segmentary speed of hands, repetitive force, coordination and flexibility. The size and the precursor of the group centroids lead to conclusion that judoists have greater strength and coordination while karatists have better segmentary speed of hands and flexibility, which is in accordance with the findings demanded by these two sports.

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