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Discriminant analysis in space with standard metric

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Abstract

The resulting solution is very easily to convert into a form which is obtained under the canonical model of discriminant analysis. Discriminant coefficient matrix can be defined as a matrix of partial regression coefficients. It is obtained by solving the problem $\mathbf{ZW} = \mathbf{K} + \mathbf{E} \mid \text{trag}(\mathbf{E}^t\mathbf{E}) = \text{minimum}$.As , in fact, $\mathbf{K} = \mathbf{ZR}^{-1/2}\mathbf{X}$, it is immediately evident that $\mathbf{E} = \mathbf{0}$ and $\mathbf{W} = \mathbf{R}^{-1/2}\mathbf{X}$.Therefore, $\mathbf{w}_k$ vectors of W are proportional to the coordinates of the vector of discriminant functions in the oblique coordinate system consisting of vectors of Z with cosines of the angles between the coordinate axes equal to the elements of the correlation matrix R. As discriminant analysis can also be interpreted as a special case of component analysis with principal components transformed by an admissible singular transformation to maximize distance between the centroids of E_p subsets, or canonical correlation ρ_k (Cooley and

Lohnes , 1971 ; Hadžigalić 1984 ; Momirović and Dobrić , 1984), identification of the content of discriminant functions is customarily based on structural vectors $\mathbf{f}_k$ of matrix $\mathbf{F} = \mathbf{Z}^t\mathbf{K} = \mathbf{RW} = \mathbf{R}^{1/2}\mathbf{X} = (\mathbf{f}_k) = (\mathbf{Rw}_k)$, analogous to the identification of the content of canonical variables obtained using Hotelling method of biorthogonal canonical correlation analysis, because by easy calculations it can be shown that **F** is a factor matrix of R matrix (Zorić and Momirović 1996 ; Momirović , 1997) . In this metric, the cross structure of discriminant functions will be $\mathbf{U} = \mathbf{Z}^t\mathbf{L}\rho^{-1} = \mathbf{Z}^t\mathbf{PZW}\rho^{-1} = \mathbf{W}\rho$ because, naturally, $\mathbf{W}^t\mathbf{Z}^t\mathbf{PZW} = \rho^2$, and it is immediately clear that **U** is a factor matrix of matrix $\mathbf{Z}^t\mathbf{PZ}$**,** or matrix of intergroup covariances defined in a space with the standard **I** metric.As f_{jk} elements of F matrix and u_{jk} elements of matrix **U** in act as ordinary product-moment correlation coefficients, and since they are a function of normally distributed variables, therefore they themselves are asymptotically normally distributed, their asymptotic variances are, of course, $\sigma_{jk}^2 \sim (1 - \phi_{jk}^2)^2 n^{-1}$ $j = 1,..., m; k = 1,..., s$, or $\xi_{jk}^2 \sim (1 - \upsilon_{jk}^2)^2 n^{-1}$ $j = 1,..., m; k = 1,..., s$, and can be used to test hypotheses of type H_{jk}: $f_{jk} = \phi_{jk}$, or H_{jk}: $u_{jk} = \upsilon_{jk}$, where ϕ_{jk} and υ_{jk} are some hypothetical correlations between variables of **V** and discriminant functions in population P because asymptotic distribution of f_{jk} coefficients is $f(f_{jk}) \sim N(\phi_{jk}, \sigma_{jk}^2)$, and asymptotic distribution of u_{jk} coefficients is $f(u_{jk}) \sim N(\upsilon_{jk}, \xi_{jk}^2)$ where N is a mark for normal distribution.

Keywords:/distribution/correlation/dimension/matrix/coefficients/discriminant analysis/

1. Introduction

Dance, as a type of human activity associated with music, is a form of rich tradition and artistic creativity of people. It is part of their spirit, perceptions and aspirations, a mirror of human life, thinking and actions in general. Dance originated with the man, followed him in life and work and developed in accordance with the development of human society; at different levels of development it changed, modified, enriched, until the final form of stylized artistic dance. Conceptually it can be characterized as a structure of specific elements of motion composed in a visible form by which the complexity of man's inner life is expressed. Dances, first of all, express the idea of a creator through various structures of motion and movement as well as gestures, or expression of imaginations through dancers` body activities. It is composed of free or specially structured movements and motion joined in certain figures, wholes, which alternate in the same or a different sequence, in the same or different rhythm and tempo. Motion and movements are generally emphasized by the lower extremities, while the whole body follows the expression shaping the story into a whole. The particularly large contribution of dance elements refers to improvement of movement coordination, creation of movement habits, development of motor memory, musical hearing, rhythm and memory, physical development, development of functional skills, increase of neuromuscular coordination and, it is very important that in combination with music or a song they create an optimistic, joyful atmosphere, strengthen friendship and cooperation in a group, develop a sense of socialization and cooperation between the sexes, and represent an excellent tool in physical education instruction. Aesthetic formation of personality carried out through a body exercise process with the use of aesthetic regularities, or aesthetic education, is very close to these activities. The role of aesthetic education is to teach performers to recognize the beauty in body exercise and sports activities through which they will go, express themselves, and which they will creatively introduce into all spheres of life.

The content of aesthetic education in a body exercise process is formation of human body beauty which implies proportional harmony, proper posture, formation of body shapes, harmonious development of movement skills and physical properties of the body, formation of knowledge, habits and skills which are a precondition for the beauty of movement expression which implies unity of technical perfection and style when creating movement habits and skills in body exercise and sports activities, as well as development of sense of rhythm with musical expression through movement in everyday locomotion.

2. The research methods

2.1. The sample of respondents

In order to carry out the research correctly and get results stable enough in terms of sampling error, it was necessary to take a sufficient number of respondents in the sample. The sample size for this nature of research was conditioned by the research objectives and tasks, population size and degree of variability of the applied parameter system.

In addition, the number of respondents in the sample depends on the level of statistical inference and the choice of mathematical and statistical models. Based on the chosen statistical-mathematical model and programs, goals and tasks, the sample included 257 respondents divided into two subsamples (male dancers n = 130 and female dancers n = 127). During all factor procedures, it should constantly be kept in mind that the analysis results depend on three main systems which determine selection and transformation of information: from the sample of variables, sample of respondents and selected extraction, and rotary methods.

Bearing these criteria in mind, based on the experience from previous studies, it is believed that the sample of 257 respondents was sufficient for this research. In defining the population from which the sample was drawn, except for the above, no other restrictions or stratification of the target variable were applied.

The population from which the sample was drawn for this study can be defined as a population of male and female folk dancers of folk dance ensembles of Serbia aged 15-18 years.

Based on the formulated problems, subject and objectives of the research, and taking into consideration the organizational and financial capabilities necessary to carry out the research procedure, an optimal number of subjects were taken in the sample in order to do research correctly and get exact results.

The research was conducted in the following Folk Dance Ensembles:

- Niš
- Leposavić

2.2. The sample of variables

2.2.1.The sample of motor variables

It was not possible to cover the entire motor space by this research. Therefore, a certain reduction of tests was made and only those segments were taken that would provide adequate information relevant to the research.

As already mentioned, when selecting tests to define the motor space, it was taken into account that they had been verified by previous studies on the Yugoslav population as relevant to this age group. The battery of tests was designed to meet, first of all, the requirements arising from the subject, goals and tasks of the research. The final formation of the test battery was greatly influenced by the intention to make the obtained results comparable with the results obtained by the group of the following authors: Kurelić et al. (1971 and 1975), Momirović et al. (1969) and Gredelj et al. (1975).

For the evaluation of motor skills, 20 motor tests were used. They were selected according to the structural model designed by Gredelj, Metikos, Hošek and Momirović in 1975 and defined as a mechanism for movement structuring (MSK), a mechanism for functional synergies and tonus regulation (SRT), a mechanism for regulating excitation intensity (RIE), and as a mechanism for regulating duration of excitation.

2.4. The data processing methods

In order to get satisfactory scientific solutions, the researchers used, in the first place, correct, then adequate, impartial and comparable procedures which conformed to the nature of the given problem and made it possible to extract and transform the appropriate dimensions, test hypotheses about these dimensions, identify differences, relations, predictions and diagnoses as well as formulate regularities within the research area.

Taking that into account, the procedures selected for the purpose of this research were to conform to the nature of the problem, not to leave too great restrictions on general information, and to be based on the assumptions that

- latent dimensions subject to measurement with the applied measuring instruments have multivariate normal distribution;

- relations between manifest and latent variables can be approximated by the generalized Gauss-Markov-Rao linear model. In recent years, a big number of researchers have been misusing their position and publishing a growing number of quasi-scientific works which are based primarily on mathematical artifacts. In addition, they have been using the existing statistical products and have never basically understood the logic of most multivariate models. Therefore in this paper, special attention is paid to statistical analysis and selection of those algorithms and programs that actually have a use value and the data will not be analyzed by any of the poorly conceived and even worse written commercial statistical software packages, such as, but not limited to, SPSS, CSS, Statistica, BMDP and Statgraphics, not to mention other products whose popularity is much lower, but not necessarily because they are substantially weaker than those now applied almost exclusively by ignorant scientists and a special sort of people called the processor strain.

All the data in this study were processed at the Center for Multidisciplinary Studies, Faculty of Sports and Physical Education, University of Priština, by means of the system of software programs for data processing developed by Popović, D. (1980), (1993) and Momirović, K. and Popović, D. (2003).

2.4.1. Discriminant analysis in a space with the standard metric

The resulting solution is very easy to convert into a form which is obtained under the canonical model of discriminant analysis.

Discriminant coefficient matrix can be defined as a matrix of partial regression coefficients obtained by the solution to the problem

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

As, in fact,

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

it is immediately clear that $\mathbf{E} = \mathbf{0}$ and that

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

Therefore, $\mathbf{w}_k$ vectors of $\mathbf{W}$ are proportional to the coordinates of the vectors of discriminant functions in the oblique coordinate system made by the vectors of Z with the cosines of the angles between the coordinate axes equal elements of the correlation matrix R. As discriminant analysis can be interpreted as a special case of component analysis with principal components transformed, by a permissive singular transformation, so that they could maximize the distance between the centroids of E_p subsets, that is ρ_k canonical correlations (Cooley and Lohnes, 1971; Hadžigalić 1984; Momirović Dobrica, 1984), it is customary that identification of the content of discriminant functions is based on $\mathbf{f}_k$ structural vectors from the matrix

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

analogous to identification of the content of the canonical variables obtained using Hotelling biorthogonal canonical correlation analysis, because it is possible to show, through easy calculations, that $\mathbf{F}$ is a factor matrix of the R matrix (Zorić and Momirović 1996; Momirović, 1997).

In this metric the cross structure of discriminant functions will be

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

because, certainly, $\mathbf{W}^t\mathbf{Z}^t\mathbf{PZW} = \boldsymbol{\rho}^2$, and it is immediately clear that $\mathbf{U}$ is a factor matrix of $\mathbf{Z}^t\mathbf{PZ}$ matrix, or the inter-group covariance matrix defined in the space with standard $\mathbf{I}$ metrics.

Since f_{jk} elements of the $\mathbf{F}$ matrix and u_{jk} elements of the $\mathbf{U}$ matrix act as ordinary product-moment correlation coefficients, and since they are a function of normally distributed variables, and therefore they themselves are asymptotically normally distributed, their asymptotic variances are, of course,

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

respectively

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

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

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

and the asymptotic distribution of u_{jk} coefficients is

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

where *N* denotes normal distributions.

2.4.2. Reliability, informativeness and significance of discriminant functions

Let

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

is a diagonal matrix whose elements are unique variance estimates of variables from V. Now, reliability, or, more precisely, generalizability of discriminant functions can be estimated, as demonstrated by Momirović and Zoric (1996), on the basis of the diagonal element values of the matrix

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

relative informativeness based on the elements of the diagonal matrix

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

and redundancy of these functions on the basis of the elements of the diagonal matrix

$$\zeta = \iota^2 \rho.$$

Of course, in making judgments about what is the real meaning of discriminant functions, these data may be of much greater importance than the outcome of significance tests of canonical correlations.

3. Research results and discussion

In kinesiological anthropology the subject of interest is sporting groups, their structure, development and breakup, interaction within the groups, values and motives of the groups, as well as their relations with certain kinesiological (sport) phenomena. When elite sporting groups are concerned, of the greatest importance are, on the one hand, the relations between the group and the quality of individual group members, and, on the other hand, the group and its success in competitions.

Upon entering a sport organization, an athlete must accept certain patterns of behavior, since each sporting group has its own specific patterns of behavior and relationships as well as relationships and processes that characterize it at a given moment. Each sporting group has its own history built by generations of athletes and coaches, as well as its symbols, its rituals and its own style which are a reflection of social relations in the past and at present. An individual has relatively little opportunity for variability in individual behavior, as far as it doesn`t undermine the intergrity and success of the group.

Nevertheless, individuals contribute to dynamic process of social transformation bringing to sport teams a certain personal feature, which, on the one hand, contains social standards of another society, and on the other hand, intellectual (cognitive) abilities and personality (conative) characteristics of each individual, his or her goals, motives, and evaluation. Accordingly, the group dynamics, the nature of relationships and processes, evaluation and motivation of elite sport teams, can not be considered separately, but only, on the one hand, as a result of social determinateness of relationships and processes in elite sport, and on the other hand, relatively independent participation of individuals and groups in the formation of these relationships and processes.

Sport itself is neither good nor bad, it really is what people are engaged in it, whether they that he use it or misuse, because it is a reflection of the time and society, its morality and immorality. In this paper, the specifics of the structure of social variables and their differences with respect to the preferred sporting discipline will be determined.

Motorics, or anthropomotorics, is a system of motor manifestations by means of which a person interacts with his or her environment. This system is generally defined as the ability to move the whole body or its particular parts in space with a certain amplitude, rhythm, direction, intensity, and goal, of course.

Knowing that the number of manifest motor actions, or combinations, is virtually infinite, there is a logical, or even the only possible, orientation on the identification of the motor skill structure as a system which is a base of all these manifestations and which is, in relation to motor manifestations, reasonably reduced and limited to the available number of latent dimensions.

Planned, systematic and program-aimed training causes changes in the anthropological status of athletes. These changes are most frequently manifested in the area of some abilities and characteristics, especially in the field of motor abilities and motor skills. Anthropological characteristics arise, develop and change in quantitative and qualitative terms. Quantitative changes are those changes which are expressed in a space or decrease of an ability efficiency, trait or motor information.

Qualitative changes include changes in the relationship between characteristics. Both types of change are inevitable. It is possible to influence substantially on changes in general by a variety of means and in different ways. So, they are under visible influence of exogenous factors, namely, the influence of the environment on formation and expression of changes in a motor space is very important.

The results of the discriminant analysis of motor variables show that statistically the tested athletes in relation to the preferred sport field differ significantly. Analyzing the values of Table 1 it can be concluded that the agreement of the results between the two groups of athletes of the registered indicators is high. Two significant discriminant functions and two significant canonical correlations (.99 and .82). This suggests an association of the discriminant functions and this is the main indicator of the quantitative structure. The significance of differences between the groups is presented by Wilks`s lambda, and the significance of canonical correlations was tested by means of Bartlett`s X^2 test for each correlation separately.

Table 1 presents the structure of discriminant functions of motor variables which indicates the contribution of each variable in the general centroid distance of the groups.

The first discriminant function is best defined by the tests for estimation of speed, jumping ability, hand segment motion speed, coordination, accuracy, flexibility, and repetitive force. Based on of the values and sign of the group centroid, it can be concluded that these abilities belong to the male dancers.

The second discriminant function is best defined by the tests for the assessment of coordination, static strength, flexibility, segment motion speed, accuracy, and explosive power.

Based on the values and sign of the group centroids, it can be concluded that these abilities belong to the female dancers. If all the data are summed up, it necessarily follows that female dancers are far more versatile in motor skills in relation to the male dancers. That was expected because female dancers perform complex dance movements better and more beautifully than male dancers, therefore athletes have better expressed motor skills mentioned above, (Boli, E., 2011).

DISCRIMINANT ANALYSIS OF MOTOR VARIABLES

Table 1

Func.	Svojstv.vr	% Varian.	Cumula. %
1	50,43	95,2	95,2
2	2,12	4,0	99,2

STRUCTURE OF MOTOR VARIABLES

	FUN1	FUN2
MPSG	,04	,00
MZGP	,73	,39
MPTR	,24*	-,04
M20VS	,23*	-,13
MSVIS	-,17*	,04
MINP	,14*	,06
MISP	,11*	,02
MTAN	-,09*	,03
MS3M	,06*	,05
MGHCR	,04*	,02
MDNL	,03*	,03
MDŠAK	-.33	.58*
MSDM	-.22	.39*
MBMLP	.04	-.31*
MCDŠ	.01	-.25*
MTAR	.04	,17*
MDPK	.06	.11*
MITP	-.09	.09*
MKOOP	.04	-.08*

CENTROIDS GROUP

	FUN1	FUN2
MALE DANCERS	2.17	-.99
FEMALE DANCERS	3.93	1.05

4. Conclusion

The research was conducted in order to determine differences in the structure of motor dimensions with male and female folk dancers.

In order to determine differences in the structure of motor dimensions, 257 male and female dancers, members of Serbian folk dance ensembles were examined.

To estimate motor skills 20 motor tests were used. They were selected according to the structural model designed by Gredelj, Metikoš, Hošek and Momirović in 1975. It was defined as a mechanism for movement structuring, mechanism for functional synergies and tone regulation, mechanism for excitation intensity regulation, and a mechanism for regulation of excitation duration.

All the data in this research were processed at the Center for Multidisciplinary Studies, Faculty of Sports and Physical Education, University of Priština, by the system of software programs for data processing developed by Popović, D. (1980), (1993) and Momirović, K. and Popović, D. (2003).

To determine differences between the male and female folk dancers, a modified method of canonical discriminant analysis in Mahalanobis space.

The algorithms and programs used within this research are presented in full and the results of the programs are analyzed.

The results of the discriminant analysis of motor variables show that statistically the tested athletes in relation to the preferred sport field differ significantly. Analyzing the values of Table 1 it can be concluded that the agreement of the results between the two groups of athletes of registered indicators is high. Two significant discriminant functions and two significant canonical correlations (.99 and .82) were obtained. This suggests an association between discriminant functions and is the main indicator of the quantitative structure. The significance of differences between the groups is presented by Wilks`s lambda, and the significance of canonical correlations was tested by means of Bartlett`s X^2 test for each correlation separately.

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Based on the values and sign of the centroids of the groups it can be concluded that these abilities belong to the female dancers. If all the data are summed up, it necessarily follows that the female dancers are far more versatile in motor skills than the male dancers. This was expected because female dancers perform the complex dance movements better and more beautifully than male dancers, therefore athletes have better expressed motor skills mentioned above, (Boli, E.: 2011).

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Summary

The research was conducted in order to determine differences in the structure of motor dimensions with male and female folk dancers. In order to determine differences in the structure of motor dimensions, 257 male and female dancers, members of Serbian folk dance ensembles were examined.To estimate motor skills 20 motor tests were used. They were selected according to the structural model designed by Gredelj, Metikoš, Hošek and Momirović in 1975. It was defined as a mechanism for movement structuring, mechanism for functional synergies and tone regulation, mechanism for excitation intensity regulation, and a mechanism for regulation of excitation duration.All the data in this research were processed at the Center for Multidisciplinary Studies, Faculty of Sports and Physical Education, University

of Priština, by the system of software programs for data processing developed by Popović, D. (1980), (1993) and Momirović, K. and Popović, D. (2003).To determine differences between the male and female folk dancers, a modified method of canonical discriminant analysis in Mahalanobis space.The algorithms and programs used within this research are presented in full and the results of the programs are analyzed. The results of the discriminant analysis of motor variables show that statistically the tested athletes in relation to the preferred sport field differ significantly. Analyzing the values of Table 1 it can be concluded that the agreement of the results between the two groups of athletes of registered indicators is high. Two significant discriminant functions and two significant canonical correlations (.99 and .82) were obtained. This suggests an association between discriminant functions and is the main indicator of the quantitative structure. The significance of differences between the groups is presented by Wilks`s lambda, and the significance of canonical correlations was tested by means of Bartlett`s X^2 test for each correlation separately.Table 1 presents the structure of discriminant functions of motor variables which indicates the contribution of each variable in the general centroid distance of the groups. The first discriminant function is best defined by the tests for estimation of speed, jumping ability, hand segment motion speed, coordination, accuracy, flexibility, and repetitive force. Based on the values and sign of the centroids of the groups it can be concluded that these abilities belong to the male dancers.The second discriminant function is best defined by the tests for the assessment of coordination, static strength, flexibility, segment speed, accuracy, and explosive power.Based on the values and sign of the centroids of the groups it can be concluded that these abilities belong to the female dancers. If all the data are summed up, it necessarily follows that the female dancers are far more versatile in motor skills than the male dancers. This was expected because female dancers perform the complex dance movements better and more beautifully than male dancers, therefore athletes have better expressed motor skills mentioned above,(Boli, E.: 2011).