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Measures of Lower Limit of Reliability of Tests with A Covariance Matrix of Particles in Determination of the Structure of Conative Dimensions of Selected Volleyball Players

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Abstract: The research was conducted in order to determine the structure of conative characteristics of volleyball players. To determine the structure of the treated anthropological dimensions, 100 volleyball players were tested. For the assessment of conative characteristics, CON6 measurement instrument was selected to assess the following conative regulators: activity regulator (EPSILON), regulator of organic functions (CHI), regulator defense reactions (ALPHA), regulator of attack reactions (SIGMA), system for coordination of regulatory functions (DELTA) and system of integration of regulatory functions (ETA). All data in this study were processed at the Multidisciplinary Research Center of the Faculty of Sport and Physical Education, University of Pristina, through the system of data processing software programs developed by Popovic D. (1980), (1993) and Momirović K. & Popovic D. (2003). Based on the Guttman criterion λ_6, three principal components were obtained that explained 70.30% of the total variance of the variables (Table 1). Thereby, already the first characteristic root extracted 29.88% of the common variance of the variables. Most of the variables have large positive projections on the first principal component: ETA .87, CHI .69, DELTA .65. This principal component is, undoubtedly, behaves like the general conative factor. The second principal component explains 22.31% of the variance, and the variable for regulation of defense reactions has the largest projection on it — ALPHA .83. The third principal component explains 17.16% of the variance, and the variable for regulation of attack reactions SIGMA .72 and variable EPSILON .66 have the largest projections on it.

Key words: variance, matrix, variable, universe, latent, dimension

1. Introduction

The fact that the human organism is a very complex, dynamic and hierarchically organized system whose capabilities and characteristics depend primarily on the process of reception, flow, retention and processing of information. This further conditions the necessity of studying the problems of the structure, functioning and management of individual segments of anthropological status in an integrated and interactive way.

Applied in sport, specifically in sports games, this knowledge conditions determination of specific requirements so that the transformation process in teaching or sport could take place to improve those

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characteristics of students or players under specific competitive conditions on which the level of success in sport mostly depends. These requirements arise from the fact that every sports game, besides general and common characteristics, contains its own specificities.

The anthropological status of an individual is determined by the following abilities and traits: morphological characteristics, functional abilities, motor abilities, cognitive abilities, conative characteristics and sociological characteristics.

Therefore, it is necessary to determine the ways of discovering heredity factors, which most of all influence the existence and development of human possibilities, and then, based on them, to program the selection in certain sports and predict the ultimate success in particular sports disciplines. It is necessary to determine their morphological, functional, motor, cognitive, conative and sociological structures that, as a general anthropological status, contribute to sports results.

Since there are specificities and differences in the competition structure of every sport and sports game, there is a need for continuous research and practical verification of these specificities, primarily, genetic conditionality of particular anthropological abilities and characteristics, then, their hierarchical value in sports games, as well as their structure and development under the influence of certain training means, methods and load.

In the past two decades, very serious efforts have been made to transform volleyball training from the chaotic state into an organized system that could be included into the contemporary trends of sports practice more successfully.

2. Methods

2.1 Sample of Subjects

The selection of a sample of subjects was conditioned by the organizational and financial capabilities necessary for the implementation of the research process. A sufficient number of qualified and fully trained measurers, appropriate instrumentation and standardized conditions for realization of the planned research were provided. The measurement was performed on a sample that was representative of the whole Republic of Serbia.

- The subjects were male,
- The subjects' age was defined on a chronological age basis, so the research included subjects aged 18-27.
- The subjects were registered as participants of federal competitions (two highest competitive levels).
- The subjects attended their training classes regularly as determined on the basis of the records kept by the coaches.
- Based on the selected statistical and mathematical models and programs, objectives and hypotheses, 100 subjects were included into the sample.

In defining the population from which the sample of subjects was drawn, except the above, no other restrictions or stratification variables were applied.

2.2 Sample of Variables for Assessment of Conative Characteristics

For the assessment of conative characteristics (Popovic D., Stankovic V., Kulic R. & Grigoropulos P., 1996), CON6 measurement instrument was chosen to assess the following conative regulators:

- activity regulator (EPSILON),
- regulator of organic functions (CHI),

- regulator of defense reactions (ALPHA),
- regulator of attack reactions (SIGMA),
- system for coordination of regulatory functions (DELTA) and
- system for integration of regulatory functions (ETA).

2.3 Data Processing Methods

The value of a research does not depend only on the sample of subjects and the sample of variables, or value of basic information, but also on the applied methods for transformation and condensation of this information. Some scientific problems can be solved by means of a number of different, and sometimes equally valuable, methods. However, with the same basic data, different conclusions can be drawn from different methods. Therefore, the problem of selection of particular data processing methods is rather complex.

In order to reach satisfactory scientific solutions, the researchers applied, in the first place, correct, then adequate, unbiased and comparable procedures which conformed to the nature of the problem and provided extraction and transformation of appropriate dimensions, the testing of hypotheses about those dimensions, determination of differences, relations, prognosis and diagnosis, as well as definition of principles within the research area.

Taking this into account, the methods which were considered to correspond to the nature of the problem and which did not leave too heavy restrictions on basic information were selected for the purpose of this study.

Let ξ^2 be a variance of the total result defined in any way, let τ^2 be a variance of the so defined real result, and let ε^2 be a variance of measurement error of a composite measuring instrument.

As $\mathbf{G}^t\mathbf{E} = \mathbf{U}^2 - \mathbf{U}^2\mathbf{R}^{-1}\mathbf{U}^2$ for the tests with regular covariance matrices of particles, and $\mathbf{G}^t\mathbf{E} = \mathbf{U}^2 - \mathbf{U}^2\mathbf{R}^{-}\mathbf{U}^2$ for the tests with singular covariance matrices of particles, the two theoretical definitions of reliability, $\alpha_1 = \tau^2\sigma^{-2}$ and $\alpha_2 = 1 - \varepsilon^2\sigma^{-2}$, are not equivalent when it comes to the measurement model based on Guttman's image theory. Let us first consider λ_6 measures (Guttman, 1945) defined by the functions α_1 and α_2. For the result defined by **b** function, these measures will be $\lambda_{61} = \eta^2\sigma^{-2}$, and $\lambda_{62} = 1-\theta^2\sigma^{-2}$.

The measures of type β_6 (Momirovic, 1996) defined by the functions α_1 and α_2, for the result defined by **h** function**,** will be $\beta_{61} = \gamma^2\lambda^{-2}$ and $\beta_{62} = 1 - \delta^2\lambda^{-2}$.

It is not difficult to show that, for regular sets of particles, α_1 measures are the estimates of reliability lower limit of λ_6 and β_6 measures.

Proposition 1

The coefficients γ_p vary in the range of (0.1) and can take the value of 1only if $\mathbf{P} = \mathbf{I}$, that is, if all the variables are measured without error and the value is 0 only when $\mathbf{P} = \mathbf{0}$ and $\mathbf{R} = \mathbf{I}$, i.e., if the total variance of all the variables consists only of the measurement error variance and variables from V have spherical normal distributions.

Proof

If the total variance of each variable from a set of variables consists only of the measurement error variance, it is necessary that $\mathbf{E}^2 = \mathbf{I}$ and $\mathbf{R} = \mathbf{I}$, and all γ_p coefficients are equal to zero. The first part of the proposition is evident from the definition of γ_p coefficients; that means that the reliability of each latent dimension, regardless of how that dimension is determined, equals 1if the variables from which that dimension is derived are measured without error.

However, the reliability coefficient matrix $\mathbf{P} = (\rho_j)$ is often unknown, so the measurement error variance matrix E^2 is also unknown. But if the variables from V are selected so as to represent the universe of variables with the same field of significance, the upper limit of the measurement error variance is defined by the elements of U^2 matrix (Guttman, 1945), or the unique variances of those variables. Therefore, in this case, the lower limit of reliability of latent dimensions can be estimated by the coefficients $\beta_p = 1 - (q_p{}^t U q_p)(q_p{}^t R q_p)^{-1} p = 1,...,k$ which are derived by the method identical to the one by means of which γ_p coefficients were derived with the definition $\mathbf{E}^2 = \mathbf{U}^2$, that is, in the same way as Guttman derived his λ_6 measure.

Proposition 2

β_6 coefficients vary in the range of (0.1), but they can`t reach the value of 1.

Proof

If $\mathbf{R} = \mathbf{I}$, then also $\mathbf{U}^2 = \mathbf{I}$, and all β_6 coefficients equal zero. However, since $\mathbf{U}^2 = \mathbf{0}$ is not possible if R matrix is regular, all β_6 coefficients are necessarily less than 1 and tend towards 1 when the unique variance of the variables, from which latent dimensions are derived, tends towards 0.

By applying the same technology, it is also easy to derive measures of the absolute lower limit of reliability of the latent dimensions defined by this method in the same way as Guttman derived his λ_1 measure. In this case, $\alpha_p = 1 - (q_p{}^t R q_p)^{-1}$ will be measures of the absolute lower limit of reliability of latent dimensions as, of course, $\mathbf{Q}^t\mathbf{Q} = \mathbf{I}$.

Proposition 3

All α_p coefficients are always less than 1.

Proof

It is obvious that all α_p coefficients are necessarily less than 1 and tend towards 1 when m, a number of variables in the V set, tends towards infinity, because, in this case, every quadratic form of matrix R tends towards infinity. If $\mathbf{R} = \mathbf{I}$, then, obviously, all α_p coefficients are equal to zero. However, the lower value of α_p coefficients need not be zero, because it is possible, but not for all α_p coefficients, that the variance $s_p{}^2$ of some latent dimension is less than 1. Of course, the latent dimension that emits less information than any other variable from which it is derived makes no sense, and it is perhaps best to be discovered based on the values of α_p coefficients.

β_6 measures (Momirovic, 1996) defined by α_1 and α_2 functions, for the result defined by **h** function, will be $\beta_{61} = \gamma^2\lambda^{-2}$ and $\beta_{62} = 1 - \delta^2\lambda^{-2}$.

It is not difficult to show that, for regular sets of particles, α_1 measures are the estimates of the lower limit of reliability of λ_6 and β_6 measures, and α_2 measures are the estimates of the upper limit of reliability of λ_6 and β_6 measures.

Proposition 4

If $m \geq 2$, $|\mathbf{R}| \neq 0$ and $T \subset \boldsymbol{\alpha}$ where $\boldsymbol{\alpha}$ is a set of all the vectors lying in the positive hyperquadrant of $\Re^m$ space, so $r_{jk} \geq 0 \ \forall \ t_j, t_k; j,k = 1,...,m$, in this case, for $\mathbf{x}$: $\mathbf{x}^t\mathbf{x} = 1$ is such that $\mathbf{x}^t\mathbf{R}\mathbf{x} = \lambda^2 =$ maksimum, $0 \leq \lambda_{61} \leq \beta_{61} < 1$.

Proof

Obviously, $0 = \lambda_{61} = \beta_{61}$ only when $\mathbf{C} = \mathbf{0}$, or $\mathbf{R} = \mathbf{I}$. If $\mathbf{x} \neq \mathbf{e}$, $\lambda^2 \geq \sigma^2$, therefore, it is essential to determine what is the difference between the functions $(\mathbf{x}^t\mathbf{C}\mathbf{x})(\mathbf{x}^t\mathbf{R}\mathbf{x})^{-1}$ and $(\mathbf{e}^t\mathbf{C}\mathbf{e})(\mathbf{e}^t\mathbf{R}\mathbf{e})^{-1}$. As $(\mathbf{x}^t\mathbf{C}\mathbf{x})(\mathbf{x}^t\mathbf{R}\mathbf{x})^{-1} - (\mathbf{e}^t\mathbf{C}\mathbf{e})(\mathbf{e}^t\mathbf{R}\mathbf{e})^{-1} = (\mathbf{x}^t\mathbf{U}^2\mathbf{R}^{-1}\mathbf{U}^2\mathbf{x})\lambda^{-2} - 2(\mathbf{x}^t\mathbf{U}^2\mathbf{x})\lambda^{-2} - (\mathbf{e}^t\mathbf{U}^2\mathbf{R}^{-1}\mathbf{U}^2\mathbf{e})\sigma^{-2} + 2(\mathbf{e}^t\mathbf{U}^2\mathbf{e})\sigma^{-2}$ and as $(2(\mathbf{e}^t\mathbf{U}^2\mathbf{e})\sigma^{-2} - 2(\mathbf{x}^t\mathbf{U}^2\mathbf{x})\lambda^{-2}) > ((\mathbf{e}^t\mathbf{U}^2\mathbf{R}^{-1}\mathbf{U}^2\mathbf{e})\sigma^{-2} - (\mathbf{x}^t\mathbf{U}^2\mathbf{R}^{-1}\mathbf{U}^2\mathbf{x})\lambda^{-2})$ because the off-diagonal elements of matrix $\mathbf{U}^2\mathbf{R}^{-1}\mathbf{U}^2$ are negative if $T \subset \boldsymbol{\alpha}$, and the $\mathbf{x}$ vector elements are in a negative relation with the $\mathbf{U}^2$ matrix elements, in this case, $\lambda_{61} \leq \beta_{61}$, which had to be proven.

It is possible to demonstrate in the same way that the relations defined by propositions 1, 2, 3, and 4 are also valid when $|\mathbf{R}| = 0$ and $\mathbf{U}^2 = (\text{diag } \mathbf{R}^-)^{-1}$, bearing in mind that $\mathbf{RR}^- = \mathbf{XX}^t$ where $\mathbf{X}$: $\mathbf{X}^t\mathbf{X} = \mathbf{I}$ is a matrix of eigenvalues of matrix R associated with nonzero eigenvalues of that matrix. However, in this case, due to the inflation of uniqueness in the singularity zone, reduction of all the measures of reliability based on the estimate of the unique variance of particles will almost always take place (Momirovic, 1999).

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

3. Results

In order to achieve superior athletic performance in every kinesiology activity, including volleyball, application of scientific research findings in the training process is crucial. Since success in sports depends on many factors, it is very important to have reliable indicators of which dimensions and to what extent affect the achievement of maximum results. Cognitive space is part of the personality which is responsible for the modalities of human behavior. As there are normal and pathological behavior modalities, analogously, there are normal and pathological conative factors.

The characteristic of normal conative factors is that they are mostly mutually independent and normally distributed in the population. Attempts to study normal behavioral modalities and normal conative factors are rare, therefore, this subspace of personality is not defined clearly enough.

In previous studies, pathological conative factors are much better defined than normal conative factors, and, in most cases, there are certain theoretical explanations for them.

It is believed that pathological conative factors are responsible for those behaviors that reduce a person`s adaptation level, considering his or her potential capabilities. The influence of conative factors is not the same on all the activities that are weakly sensitive to the influence of conative factors, and there are such activities on which the influence of these factors is crucial. This influence can be positive or negative, depending on the factors and activities. So, there is no activity that would be completely independent of the influence of conative factors, and the determination of the structure of conative regulatory mechanisms is very important in volleyball as well.

Therefore, the estimation of latent dimensions in such studies is possible on the basis of simple confirmatory algorithms which are suitable not only because of their significant efficiency and economy, but because they provide very simple interpretation of the results.

The algorithm applied in this study, together with its accompanying program, is an attempt to solve the structure of the treated spaces in the simplest way.

In order to determine the characteristics of the basic space of conative variables, transformation and condensation of the data into an intercorrelation matrix were performed and thus the characteristics of the measurement instruments were obtained.

Based on the Guttman criterion λ_6, three principal components which explained 70.30% of the total variance of the variables were obtained (Table 1). Thereby, already the first characteristic root extracted 29.88% of the common variance of the variables. Most of the variables have large positive projections on the first principal component: ETA .87, CHI .69, DELTA .65. This principal component is, undoubtedly, behaves like the general conative factor.

Table 1 Principal Components of Conative Variables of Volleyball Players

	FAC 1	FAC 2	FAC 3	h2
EPSILON	.03	.59	-.66	.76
CHI	-.69	-.03	.26	.52
ALPHA	.09	-.83	-.03	.67
SIGMA	.34	.46	.72	.84
DELTA	.65	-.17	-.18	.47
ETA	.87	-.01	.08	.74
Charact. root	1.89	1.44	.99	
% Variance	29.88	22.31	18.11	
Cumulat. %	29.88	52.19	70.30	

Table 2 Pattern Matrix of Conative Variables of Volleyball Players

	OBL 1	OBL 2	OBL 3
EPSILON	.13	.87	-.19
CHI	-.73	-.16	.0
ALPHA	.18	-.64	-.43
SIGMA	.10	-.06	.92
DELTA	.69	-.04	-.08
ETA	.81	-.09	.27

Table 3 Structure Matrix of Conative Variables of Volleyball Players

	OBL 1	OBL 2	OBL 3
EPSILON	.10	.85	-.13
CHI	-.73	-.13	.00
ALPHA	.20	-,68	-.47
SIGMA	.12	-.00	.91
DELTA	.69	-.07	-.07
ETA	.83	-.10	.28

Table 4 Intercorrelations of Oblimin Factors

	OBL 1	OBL 2	OBL 3
OBL 1	1.00		
OBL 2	-.05	1.00	
OBL 3	.02	.09	1.00

The second principal component explains 22.31% of the variance, and the variable for regulation of defense reactions has the largest projection on it — ALPHA .83.

The third principal component explains 17.16% of the variance, and the variable for regulation of attack reactions SIGMA .72 and the variable EPSILON .66 have the largest projections on it.

The communalities of all the variables are satisfactory. Although, unlike the first principal component, the other principal components cannot be given a specific reality, it is possible, by examining them, to identify those generators of variability which, according to the position of their importance, are responsible for the variability of the analyzed space.

In order to obtain a parsimonic structure, the whole initial coordinate system was rotated in one of the oblique rotations. On this occasion, Jennrich and Sampson’s direct oblimin criterion was used, whereby the same number of factors was retained and three matrices were obtained: a pattern matrix (Table 2), a structure matrix (Table 3) and a matrix of factor intercorrelations (Table 4). To obtain interpretable structures, the factor pattern matrix and the structure matrix will be interpreted simultaneously.

The first oblimin factor has the largest parallel and orthogonal projections with the test vectors whose intentional subjects of measurement were the regulator of organic functions CHI, coordination of regulatory functions DELTA and the system for integration of regulatory functions ETA.

The second oblimin factor represents the activity regulator EPSILON and the factor of the regulator of attacks reactions ALPHA.

The third oblimin factor represents the factor of the regulation of attack reactions SIGMA.

The factor intercorrelation matrix (Table 4) shows that the first latent dimension has no statistically significant correlations with the second one, which means that the isolated latent dimensions are factorially homogeneous. The cybernetic model of conative regulators, which is, in fact, integrated into the model of cognitive functions, works by means of the biologically and socially most important and complicated system for regulation and control of regulatory functions which is related to every other system. The effectiveness of the conative regulatory mechanisms depends partly on the physiological factors which determine the volume and stability of regulation and partly on the programs formed under the influence of exogenous factors, as well as on the interaction of social factors and physiological basis of the regulatory mechanisms. Since the player has no inner drive to perform aggressive movements in a volleyball game, except for extreme situations when the player`s concentration and control fall due to the stress caused by great responsibility. For that reason, the pathological personality trait should be studied separately with the help of all available measurement instruments.

4. Conclusion

The research was conducted in order to determine the structure of conative characteristics of volleyball players. To determine the structure of the treated anthropological dimensions, 100 volleyball players were tested.

For the assessment of conative characteristics, CON6 measurement instrument was selected to assess the following conative regulators:

- activity regulator (EPSILON)
- regulator of organic functions (CHI)
- regulator defense reactions (ALPHA)
- regulator of attack reactions (SIGMA)
- system for coordination of regulatory functions (DELTA) and
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The second principal component explains 22.31% of the variance, and the variable for regulation of defense reactions has the largest projection on it — ALPHA .83.

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In order to obtain a parsimonic structure, the whole initial coordinate system was rotated in one of the oblique rotations. On this occasion, Jennrich and Sampson`s direct oblimin criterion was used, whereby the same number of factors was retained, and three matrices were obtained: a pattern matrix (Table 2), a structure matrix (Table 3) and a matrix of factor intercorrelations (Table 4). To obtain interpretable structures, the factor pattern matrix and the structure matrix will be interpreted simultaneously.

The first oblimin factor has the largest parallel and orthogonal projections with the test vectors whose intentional subjects of measurement were the regulator of organic functions CHI, coordination of regulatory functions DELTA and the system for integration of regulatory functions ETA.

The second oblimin factor is represented by the activity regulator EPSILON and the factor of the regulator of defense reactions ALPHA.

The third oblimin factor is represented by the factor of the regulation of attack reactions SIGMA.

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