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RESEARCH ARTICLE

THE STRICTURE OF FUNCTIONAL ABILITES OF DANCERS

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ABSTRACT

Objectives: The research aimed to determine the structure of functional abilities of folk dancers.
Methods: In order to determine the structure of functional abilities, 100 dancers of the Academic Folk Ensemble "Oro" of the Student Cultural Center of Nis were tested. The dancers ranged in chronological age from 18 to 27 years. The average dancing experience of the dancers was 8 years, while the continuous multi-year training process implied three sessions per week. For the assessment of functional variables, systolic (FBPSYS) and diastolic (FBPDIA) blood pressures were measured. Pulse rate at rest (FPURE) was determined by palpating the respondents` carotid artery after their 15-minute rest in a sitting position, and the number of beats in 15 seconds was multiplied by 4. Thus obtained frequency per minute was taken for processing. All the 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 DRSOFT developed by Popovic, D. (1980), (1993) and Momirovic, K. & Popovic, D. (2003).
Results: Pulse frequency during physical exertion (FPUEX) was measured in the sixth minute of riding a cycle ergometer. Maximal values of oxygen uptake VO_2max, (FO_2LM) and (FO_2ML), or absolute and relative values, were determined by Astrand`s indirect method (Zivanic *et al*., 1999).
Conclusions: The factor structure of functional abilities was analyzed on the basis of all the information provided by a matrix of significant principal components (Table 1). Based on the Guttman measureλ_6, three characteristic roots (three latent variables) which explained 83.08% of the common variance were obtained.

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INTRODUCTION

Anthropological and methodological orientations of the studying of kinesiology or sport sciences dealing with man in general, are primarily reflected in an interdisciplinary approach to the study of man`s psychosomatic status. The anthropological status implies some human abilities and characteristics, such as: morphological characteristics, functional abilities, motor abilities, biomechanical characteristics, cognitive abilities, co native characteristics and sociological characteristics.

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This study focuses on functional abilities. Folk dancers have two-hour training sessions at least three or more times per week when they practice dance technique of various dances and their variants which are combined into a choreography, as well as stage performances of the entire folk ensemble. The main feature and specifics of the training process of folk ensemble dancers, besides systematicity and continuity, are that it is based on the interval training method. In addition, this method implies alteration and different dosage of volume and intensity of load with adequate rest periods, so it can be assumed that this entails development of specific functional abilities, which ultimately leads to the formation and existence of a special functional type of folk dancers. Beside visual artistic and stylistic expressiveness associated with graceful, harmonious and proportional morphology of folk dancers, it is highly important for them to have adequate functional abilities which ensure optimal functioning of the body during stage performances of folk dance ensembles. The specificity of a functional type of folk dancers is evident and determined primarily by the nature of dance as a specific physical activity and characteristics of the training process system in which dancers are involved constantly and continuously. In modern sport, athletes of certain disciplines can be recognized by their specific body constitution at first glance. Selection and increasingly high requirements for athletes, together with characteristics of modern sport training, give emphasis on the constitutional types of athletes, as well as those functional abilities that are appropriate for the nature of a particular sport activity. The morphological status of dancers implies appropriate morphological characteristics that highlight their harmonious and proportionate body structure. Conformity and establishment of optimal relations between the transverse and longitudinal dimensionalities of the skeleton, as well as body mass and volume and subcutaneous adipose tissue in dancers, are associated with an aesthetic component, visual artistic impression and stylistic expressiveness in dance. As is the case with athletes in other sport branches, constitutive characteristics of dancers are the result of the combinatory of genetics, selection and systematic and continuous training process in dance. Since it is evident that there are a small number of kinesiological studies on these issues, the main motive of this research was to make a contribution to the scientific determination of the morphological space structure in the studied population of dancers.

MATERIALS AND METHODS

Sample of Respondents

The research was carried out on a sample of 100 dancers of the Academic Folk Ensemble "Oro" of the Student Cultural Center of Nis. The dancers` chronological age ranged from 18 to 27 years. The average dancing experience of the dancers was 8 years, while the continuous multi-year training process implied three sessions per week.

Sample of Functional Variables

Among functional variables, systolic (FBPSYS) and diastolic (FBPDIA) blood pressures were measured. Pulse rate at rest (FPURE) was determined by palpating the respondents` carotid artery after their15-minuterest in a sitting position, and the number of beats in15 seconds was multiplied by 4. Thus obtained frequency per minute was taken for processing. Pulse frequency during physical exertion (FPUEX) was measured in the sixth minute of riding a cycle ergometer. Maximal values of oxygen uptake VO_2max (FO_2LM) and (FO_2ML), or absolute and relative values, were determined by Astrand`s indirect method (Zivanic *et al*., 1999).

Data processing methods

The value of a study does not only depend on the sample of respondents and sample of variables, that is, the value of basic information, but also on the applied procedures for transformation and condensation of this information. Some scientific problems can be solved with the help of a number of different, and sometimes equally valuable, methods. However, with the same basic data, different conclusions can be drawn from the results of different methods. Therefore, the problem of selection of certain data processing methods is rather complex. In order to reach satisfactory scientific solutions, the researchers used, primarily, correct, then adequate, impartial and comparable procedures which corresponded to the nature of the stated problem and allowed extraction and transformation of the appropriate dimensions, testing hypotheses about these dimensions as well as establishing regularities within the research area. Taking this into account, those procedures were selected for the purpose of this study that corresponded to the nature of the problem and did not leave too big restrictions on the basic information.

Except for Mulaik`s well-known textbook on factor analysis which has something on estimation of reliability of principal components (Mulaik, 1972) and Kaiser and Caffrey`s study in which, based on maximizing reliability of latent dimensions, their method of Alpha factor analysis was derived(Kaiser 1958), it seems that producers of different methods of component and factor analyses as well as the authors of books on this class of methods for latent structure analysis were not really concerned about how much the existence of the latent dimensions obtained by these methods can be trusted. This also refers to the latent dimensions obtained by orthoblique transformation of principal components, a method that has become a standard procedure for latent structure analysis among all those who did not acquire information on factor analysis reading seriously written texts from this field with their fingers or analyzed their data by means of some of the 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 always because they are significantly weaker than those almost exclusively misused today by ignorant scientists and a special sort of human beings called a strain of processors.

Though, in a paper which proposes competitive application of semi orthogonal transformation of principal components in exploratory and confirmatory analyses of latent structures, a procedure to assess reliability of latent dimensions based on Cronbach`s strategy for generalizability assessment is presented. But this procedure is as much justified as the assumptions under which Cronbach`s coefficient α was derived. For unclear reasons, everybody today calls this coefficient by his name, although exactly the same measure was proposed, long before Cronbach and under virtually the same assumptions, by Spearman and Brown, Kuder and Richardson, Guttman, and described, in somewhat simplified form, by Momirovic, Wolf and Popovic (1999) and some other psychometricians who worked in a nascent stage of development of measurement theory and the time which was not affected by the computer revolution. Therefore, the aim of this study was to propose three measures of a lower limit of reliability of latent dimensions obtained by semi orthogonal transformations of principal components. All the measures were derived within a classical model of decomposition of variance of a quantitative variable. The measures derived from some other measurement theory models will be proposed in one of the next articles. The first measure is an estimate of the absolute lower limit of reliability, and its logical basis is identical to that of Guttman`s measure$\lambda_1$. The second measure is anestimate of the lower limit of reliability of latent dimensions based on the estimate of the lower limit of reliability of variables which have the same field of meaning, and its logical basis is identical to that of Guttman`s measure λ_6. The third measure was derived assuming that reliability coefficients of the variables under study are known; its value, therefore, depends on the value of the procedures by which these coefficients were calculated or estimated.

Semiorthogonal transformation of principal components

Let Z be a matrix of the standardized data obtained by describing a set E of n entities on a set V of m quantitative, normal or at least elliptically distributed variables. Let R be an inter correlation matrix of these variables. Assume that matrix R is surely regular and it is possible to reject with certainty the hypothesis that variables from V have a spherical distribution, i.e. the eigenvalues of the matrix of correlations in population P from which sample E was drawn are equal. Let $U^2= (\text{diag } R^{-1})^{-1}$be Guttman`s estimate of unique variances of variables from V, and let λ_p, p = 1,...,m beeigen values of matrix R. Let c = trag (I - U^2). Define scalar k such that $\Sigma_p{}^k\lambda_p> c$, $\Sigma_p{}^{k-1}\lambda_p< c$.Nowk is the number of principal components of matrix Z defined on the basis of Stalec and Momirovic`s PB criterion (Stalec & Momirovic, 1971). Let $\Lambda = (\lambda_p)$; p = 1,...,k be a diagonal matrix of the first k eigen values of matrix R and let $X = (x_p)$; p = 1,...,k be a matrix of their associated eigenvectors scaled so that $X^tX = I$. Let T be an orthonormal matrix such that it optimizes the function XT = Q = (q_p); p (Q) = extremum, $T^tT = I$ where p (Q) is a parsimonic function, for example, the ordinary Varimax function $\Sigma_j{}^m\Sigma_p{}^k\ q_{jp}{}^4 - \Sigma_p{}^k\ (\Sigma_j{}^m\ q_{jp}{}^2)^2 =$ maximum where coefficients $q_{jp}$are elements of matrix Q (Kaiser, 1958). Now the transformation of principal components defined by vectors in matrix K = ZXinto semi orthogonal latent dimensions determined by the type II orthoblique procedure (Harris & Kaiser, 1964) is defined by the operation m L = KT = ZXT. The covariance matrix of these dimensions is $C = L^tL\ n^{-1} = Q^tRQ = T^t\Lambda T$. Denote the matrix of their variances by $S^2 = (s_p{}^2)$ = diag C. If the latent dimensions are standardized by the operation $D = LS^{-1}$, their intercorrelations will be in the matrix $M = D^tDn^{-1} = S^{-1}T^t\Lambda TS^{-1}$. Note that C and therefore M cannot be diagonal matrices and the latent dimensions obtained in this way are not orthogonal in the space of entities from E. The matrix of correlations between variables from V and latent variables, which is commonly referred to as a factor structure matrix, will be $F = Z^tDn^{-1} = RXTS^{-1} = X\Lambda TS^{-1}$; and as the elements of matrixFare orthogonal projections of vectors from Zonto vectors fromD, the coordinates of these vectors in the space spanned by vectors from D are elements of the matrix $A = FM^{-1} = XTS$. But since $A^tA = S^2$, the latent dimensions obtained by this techniqueare orthogonal in the space spanned by the vectors of variables from Z; the squared norms of the vectors of these dimensions in the space of variables are equal to variances of the dimensions.

Estimates of reliability of latent dimensions. Due to the simplicity and clear algebraic and geometric meanings of both latent dimensions and identification structures associated with these dimensions, reliability of the latent dimensions obtained by an orthoblique transformation of principal components can be determined in a clear and unambiguous manner.

Let G = (g_{ij}); i = 1,...,n; j = 1,...,m be a permissibly unknown matrix of measurement errors in the description of the set E on the set V. Then the matrix of true results of entities from Eon variables from Vwill be Y = Z - G.

If we, in accordance with the classical theory of measurement, assume that matrix G is such that $Y^tG = 0$ and $G^tGn^{-1} = E^2 = (e_{jj}{}^2)$ where E^2 is a diagonal matrix, the true covariance matrix will be $H = Y^tYn^{-1} = R - E^2$if $R = Z^tZn^{-1}$is anintercorrelation matrix of variables from V defined onthe set E. Assume that the reliability coefficients of variables from V are known; let Pbe a diagonal matrix whose elements ρ_j are these reliability coefficients. Then the measurement error variances for the standardized results on the variables fromVwill be elements of the matrix $E^2 = I - P$.

Now true values on the latent dimensions will be elements of the matrix $\Gamma = (Z - G)\ Q$ with the covariance matrix $\Omega = \Gamma^t\Gamma n^{-1} = Q^tHQ = Q^tRQ - Q^tE^2Q = (\omega_{pq})$. Therefore, true variances of the latent dimensions will be the diagonal elements of matrix Ω. Denote these elements by $\omega_p{}^2$. Based on the formal definition of reliability coefficients of some variable $\rho = \sigma_t{}^2 / \sigma^2$where $\sigma_t{}^2$ is the true variance of some variable and σ^2 is the total variance of that variable, that is, the variance that also includes error variance, reliability coefficients of the latent dimensions will be $\gamma_p= \omega_p{}^2 / s_p{}^2= 1 - (q_p{}^tE^2q_p)(q_p{}^tRq)^{-1}$ p = 1,...,k if reliability coefficients of the variables from which these dimensions are derived are known.

Proposition 1

Coefficients γ_p vary in the range (0,1) and can take the value of 1 if and only if P = I, i.e. if all the variables are measured without error, and the value of 0 if and only if P = 0and R = I, i.e. if the total variance of all the variables consists only of measurement error variance and variables fromVhave a spherical normal distribution.

Proof:

If the total variance of each variable from a set of variables consists only of measurement error variance, then, necessarily E^2= I and R = I and all the coefficients γ_p are equal to zero. The first part of the proposition is evident from the definition of coefficients γ_p. This means that reliability of each latent dimension, regardless of how the latent dimension is determined, equals 1if the variables from which the dimension is derived are measured without error. However, matrix of reliability coefficients P = (ρ_j) is often unknown, so measurement error variance matrix$E^2$is also unknown. But if variables from V are selected to represent a universe of variables U with the same field of meaning, the upper limit of measurement errorvariances is defined by elements of matrix U^2 (Guttman, 1945), that is, unique variances of these variables. Therefore, in this case, the lower limit of reliability of latent dimensions can be estimated by the coefficients $\beta_p = 1 - (q_p{}^tU^2q_p)(q_p{}^tRq_p)^{-1}$p = 1,...,k which are derived using a method identical to that by which coefficients γ_p are derived under the definition $E^2 = U^2$, that is, the same procedure through which Guttman derived his measure λ_6.

Proposition 2

Coefficients β_p vary in the range (0,1), but they cannot reach the value of 1.

Proof:

If R = I, then U^2 = I and all coefficients β_p are equal to zero. But as U^2 = 0is not possible if matrix R is regular, all coefficients β_p are necessarily less than 1 and tend towards 1 when the unique variance of the variables from which the latent dimensions are derived tends towards zero. Applying the same technology, it is also easy to derive measures of the absolute lower limit of reliability of latent dimensions defined by means of this procedure in the same manner as Guttman derived his measure λ_1. For that purpose, let E^2= I. Then $\alpha_p = 1 - (q_p^t R q_p)^{-1}$will be measures of the absolute lower limit of reliability of latent dimensions as, of course, $Q^tQ = I$.

Proposition 3

All coefficients $\alpha_p$are always less than 1.

Proof:

It is obvious that all coefficients α_p are necessarily less than 1 and tend towards 1 when m, the number of variables in the set V, tends to infinity because in this case, every squared form of matrix R tends to infinity. If R = I, then, obviously, all coefficients α_p are equal to zero. However, the lower value of coefficients α_p need n`t be zero because it is possible, but not for all coefficients α_p, that variance s_p^2ofa latent dimension is less than 1. Of course, the latent dimension that emits less information than any variable from which it is derived has no sense, and it canperhaps be best discovered based on the values of coefficients α_p. The type $\beta_6$measures (Momirovic, 1996) defined by functions $\alpha_1$and α_2 will be, for the result defined by function h,$\beta_{61} = \gamma^2\lambda^{-2}$ and$\beta_{62} = 1 - \delta^2\lambda^{-2}$. It is not difficult to show that, for regular sets of particles, the type α_1 measures are estimates of the lower limit of reliability of measures of types λ_6 and β_6 , and that the typeα_2 measures are estimates of the upper limit of reliability of measures of types λ_6 and β_6. All the data in this study were processed at the Multidisciplinary Research Center of the Faculty of Sport and Physical Education, University of Pristina, through a system of data processing software programs DRSTAT developed by Popovic, D. (1980), (1993) and Momirovic, K. and Popovic, D. (2003).

DISCUSSION

Three characteristic roots (three latent variables) were obtained by factorization of the intercorrelation matrix of latent functional variables (Table 1) which explained 83.08% of the common variance (CUM %). The individual contribution to the explanation of the common variance was 46.76 % for the first latent variable, 20.61% for the second, and 15.70% for the third latent variable. The first principal component with the characteristic root of 3.74 explains 46.76% of the total variability which amounts to 83.08%. Given that this is the first principal component, the percentage of the explained variability fully satisfies, and it is possible, with this percentage of variance, to designate the first principal component as a general functional factor. The functional tests (FPURE, FPUEX, FO_2LM and FO_2ML) have the largest projections onto the first principal component. The second principal component explains 20.61% of the total variability, and systolic (FBPSYS) and diastolic (FBPDIA) blood pressures have the biggest projections with the second principal component. The third principal component is determined by the age (AGE) and years of dancing experience (DANEXP). With its characteristic root of 1.25, it explains15.70% of the total variability variance.

Table 1. Matrix of principal components of functional variables

	FAC1	FAC2	FAC3	h^2
FBPSYS	.46	.73	.38	.90
FBPDIA	.52	.75	.22	.89
FPURE	-.63	.14	.46	.63
FPUEX	-.87	.36	-.24	.95
FO_2LM	.85	-.40	.10	.90
FO_2ML	.86	-.31	.34	.95
AGE	.53	.24	-.69	.82
DANEXP	.57	.24	-.40	.57
Charact. Roots	3.74	1.64	1.25	
%	46.76	20.61	15.70	
Cum. %	46.76	67.38	83.08	

Table 2. Pattern matrix of functional variables

	OBL1	OBL2	OBL3
FBPSYS	.06	.94	.05
FBPDIA	.01	.90	-.13
FPURE	-.29	.17	.66
FPUEX	-.97	-.03	.00
FO_2LM	.91	-.07	-.12
FO_2ML	.98	.12	.09
AGE	-.13	.02	-.94
DANEXP	.02	.20	-.67

Table 3. Structure matrix of functional variables

	OBL1	OBL2	OBL3
FBPSYS	.20	.94	-.16
FBPDIA	.21	.93	-.32
FPURE	-.50	-.01	.73
FPUEX	-.97	-.20	.35
FO_2LM	.94	.10	-.43
FO_2ML	.97	.27	-.27
AGE	.20	.20	-.89
DANEXP	.30	.34	-.72

Table 4. Matrix of oblimin factors

	OBL1	OBL2
OBL1	1.00	.23
OBL2	.23	1.00

In order to obtain a parsimonic structure, the initial coordinate system was rotated to an oblique oblimin solution, after which the same number of latent variables were retained. Upon applying the oblimin rotation, a pattern matrix containing parallel projections of vectors of certain variables (Table 2) and a structure matrix with orthogonal projections of vectors of the variables (Table 3) were obtained. Based on the data from the factor pattern matrix, three factors were isolated which can be interpreted as follows: The first isolated factor in the space of the applied functional variables is best defined by the variables of pulse frequency during physical exertion (FPUEX), maximal oxygen uptake (FO_2ML) and maximal oxygen consumption in liters per minute (FO_2LM). This isolated factor can be defined as an oxygen-transport-cardiovascular dimension. The second isolated factor in the space of the applied functional variables is best defined by the variables of systolic blood pressure (FBPSYS) and diastolic blood pressure (FBPDIA). This isolated factor can be defined as compensatory-regulatory dimension of the cardiovascular system. The third isolated factor in the space of the applied functional variables is best defined by the variables of pulse at rest (FPURE), age (AGE) and years of dancing experience (DANEXP). This isolated factor can be defined as a dimension of cardiovascular system adaptivity.

Conclusion

The research aimed to determine the structure of functional abilities of folk dancers. In order to determine the structure of functional abilities, 100 dancers of the Academic Folk Ensemble "Oro" of the Student Cultural Center of Nis were tested. The chronological age of the dancers ranged from 18 to 27 years. The dancers` average dancing experience was 8 years, while the continuous multi-year training process implied three sessions per week. For the assessment of functional variables, systolic (FBPSYS) and diastolic (FBPDIA) blood pressures were measured. The respondents` pulse rate at rest (FPURE) was determined by carotid artery palpation after their 15-minutes rest in a sitting position, and the number of beats in 15 seconds was multiplied by 4. Thus obtained frequency per minute was taken for processing. Pulse frequency during physical exertion (FPUEX) was measured in the sixth minute of riding a cycle ergometer. Maximal values of oxygen uptake VO_2max, (FO_2LM) and (FO_2ML), or absolute and relative values, were determined by Astrand`s indirect method (Zivanic *et al*., 1999). All the 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 program DRSOFT developed by Popovic, D. (1980), (1993) and Momirovic, K. & Popovic, D. (2003). The factor structure of functional abilities was analyzed on the basis of all the information provided by the matrix of significant principal components (Table 1). Based on Guttman`s measure λ_6, three characteristic roots (three latent variables) which explained83.08% of the common variance were obtained. In order to obtain a parsimonic structure, the initial coordinate system was rotated to an oblique oblimin solution, after which the same number of latent variableswere retained. Upon applying the oblimin rotation, a pattern matrix containing parallel projections of vectors of certain variables (Table 2) and a structure matrix with orthogonal projections of vectors of the variables (Table 3) were obtained. Based on the data from the pattern matrix, three factors were isolated that can be interpreted as follows:

The first isolated factor in the space of the applied functional variables is best defined by the variable of pulse rate during physical exertion (FPUEX), maximal oxygen uptake (FO_2ML) and maximal oxygen consumption in liters per minute (FO_2LM). This isolated factor can be defined as an oxygen-transport-cardiovascular dimension. The second isolated factor in the space of the applied functional variables is best defined by the variables of systolic (FBPSYS) and diastolic (FBPDIA) blood pressures. This isolated factor can be defined as a compensatory-regulatory dimension of the cardiovascular system. The third isolated factor in the space of the applied functional variables is best defined by the variables of pulse rate at rest (FPURE), age (AGE) and dancing experience (DANEXP). This isolated factor can be defined as a dimension of cardiovascular system adaptivity.

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