FACTOR STRUCTURE OF BOXER'S MORPHOLOGICAL CHARACTERISTICS

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Abstract
On the sample of 92 boxers from Croatian boxer clubs, different weight categories we applied 12 morphological variables in order to determine their factor structure that will help forming more rational procedures for optimal modelling, planning, programming and control of training process. Applying factor analysis (direct oblimin) and Kaiser Criteria ($\lambda \geq 1.00$) in order to obtain mutual characteristic roots and interpreted parts of mutual variance, two latent variables were isolated. The first variable was interpreted as dimensionality and body voluminous and their structure consists of dimensionality variables (body height, leg length, arm length, biacromial width, bicristal width and wrist diameter), body voluminous (body weight, upper leg volume, upper arm in flexion). Second latent variable was interpreted as subcutaneous fat tissue since it is defined by all applied variables of fat tissue (upper arm skin fold, back skin fold and abdomen skin fold). Since between manifest variables (r=.60-.99) and isolated latent variables (r=.70) we obtained statistically significant correlation on the level .00 (p=.00), the conclusion is in forming top results in boxing the entire morphological structure is included but with slightly increased advantage in skeleton dimensionality and body voluminous.

Key words: *boxers, morphology, factor analysis, latent dimensions*

Introduction

It is familiar that morphological characteristics appeared as a result of mutual effects of endogen and exogenous factors. Interpretation of morphological characteristic variations , as well as review of correlation coefficient calculated in values (in cm, mm or dg) of some variables in different sport fields and disciplines and the way of conducting certain morphological measuring (anthropometric measures) and the way of interpreting influence of genetic and/or ecological factors were described and presented in details in many researches we conducted (Maver, Muftić, Rudan & Taboršak, 1975; Buzina, Grgić, Kovačević, Maver, Momirović, Rudan, Schmutzer & Štampaj-Plasaj, 1975). In morphological area there are many works that study manifest and latent characteristics of people. In anthropometric measuring in starting researches we mostly applied body height and body mass. However, today, in anthropometry the measuring is based on measuring of entire human body and its certain parts and according to that throughout the world the method of International Biological Program (IBP) is conducted with 39 anthropometric measures and includes entire morphological status of a human (Kurelić, Momirović, Stojanović, Šturm, Radojević & Viskić-Štalec, 1975; Stojanović, Momirović, Vukosavljević & Solarić, 1975).

Which anthropological measures will be applied in some research depends on a problem, subject and the aim of the research. In kinesiological anthropology there is still actual problem; each anthropological measuring on one time basis can be significantly loaded with measuring error, so the best is to accept the metric solutions that in advance enable minimization of error variance which indicates that each anthropometric measuring should be repeated several times to achieve better measuring reliability. In starting researches only body mass and body height were applied as anthropometric measuring, while in statistic data processing univariate analysis prevailed. In the recent years methods of factor analysis are being applied and much more methods of taxonomic (cluster) algorithms (Stojanović, Vukosavljević, Hošek & Momirović, 1975; Stojanović, Momirović, Hošek, Zakrajšek & Vukosavljević, 1978; Szirovicza, Momirović, Hošek & Gredelj, 1980; Malacko & Popović, 2001). In previous research the identification of latent variables in morphological sphere was conducted mostly with factor analysis. Authors with appliance of this analysis isolated morphological factors that were defined as latent variables (dimensions) and according to measuring – manifest variables. Modern authors through their work, wanted to determine morphological structure of a human body, relations of this characteristics with other anthropological abilities and characteristics.

Then to determine how much morphological characteristics contribute the success in sport (Savić, 1986; Blažević, 2007). Results of the research indicated that some boxer's morphological characteristics have considerable level of correlation with success in fighting. In series of research it was concluded that tall boxers and boxers with long hands and legs have certain advantage regarding short boxers, boxers with short extremities, that boxers with a lot of fat tissue inferior to the ones with the same weight but without this unnecessary ballast, while boxers with wider hands more accurately punch the opponent and strike harder (because of force feedback and glove amortization) as well as the larger boxers are usually stronger and better take the punches into their body (Blažević, 2006).

The aim

The aim of the research is to determine structure of latent variables in morphological characteristics of top level boxers, to be able to form as rational procedures for optimal modelling, planning, programming and controlling of training process as possible, as well as following its development during continuous selection of sportsmen and conduction of transformational training process.

Methods

Based on the sample of 92 boxers from Croatian boxing clubs and different weight categories, we applied system of 12 morphological characteristic variables. To estimate morphological characteristics the following variables were applied; *skeleton longitudinal dimensionality* – 1. Body height (VISTEL), 2. Leg length (DUŽNOG), 3. Arm length (DUŽRUK), *skeleton transversal dimensionality* – 4. Biacromial width (ŠIRRAM), 5. Bicristal width (ŠIRKAR), 6. Wrist diameter (DIJRUK), *body mass and volume* – 7. Body weight (TEŽINA), 8. Upper leg circumference (OBNATK), 9. Upper arm circumference in flexion (OBNADF) and *subcutaneous fat tissue,* - 10. Upper arm skin fold (NABNAD), 11. Skin fold of the back (NABLED) and 12. Abdominal skin folds (NABTRB). Mentioned measures were taken applying method of International Biological Program (IBP), and reliability of these measuring ensured (Stojanović, Solarić, Momirović & Vukosavljević 1975). For each applied variable the following central and dispersive parameters were calculated; arithmetic mean (M), minimal value (min), maximal value (max), standard deviation (S) and standard arithmetic mean error (Se). Normality of variable distribution was tested with skewness (Sk) and kurtosis (Ku).

Correlations between applied manifest variables were conducted through variable correlation matrix. Determining structure of latent morphological characteristic was conducted with factor analysis applying askew transformation (direct oblimin) and for extraction of characteristic root number we applied (Kaiser) criteria $\lambda \geq 1.00$. Communalities (h^2) are calculated individually for all applied variables in order to obtain their informational values. Latent variable structure was calculated by main components matrix, circuit matrix (A-matrix), which contains parallel variable projections (coordinates) regarding factors, matrix structure (F-matrix), in other words correlations between manifest and latent variables and factor correlation matrix (M-matrix). Data were processed with statistic programs SPSS 11. for Windows and STATISTICA 6.0.

Results

In table 1 we presented results of central and dispersive statistic parameters of morphological variables as well as their inequality. In skewnes (Sk) analysis with bolding and with a star (*) we marked variables with normal (symmetric) distribution, which means the result ranges from 01.00 of standard deviation.

Table 1: Central and dispersive parameters of morphological variables

Variable	M	min	max	S	Se	Sk	Ku
VISTEL	176.97	159.20	196.60	8.51	.88	.12*	-.47
DUŽNOG	99.37	89.10	118.20	6.03	.62	.86*	.40
DUŽRUK	78.05	68.30	91.40	5.70	.59	.35*	-.77
BIKROM	42.81	36.10	55.10	5.04	.52	.90*	-.39
BIKRIS	29.11	24.00	39.40	3.55	.37	.79*	.32
DIJRUK	6.26	4.90	7.80	.72	.07	-.03*	-.81
TEŽINA	70.22	51.80	108.70	12.94	1.34	.80*	.24
OPNATK	53.80	43.10	68.00	6.09	.63	-.01*	-.71
OBNADF	34.18	29.20	43.10	3.09	.32	.61*	-.01
NABNAD	4.90	3.00	17.00	2.70	.28	2.91	9.15
NABLED	5.07	3.00	18.00	2.93	.30	2.87	8.76
NABTRB	6.41	4.00	24.00	3.79	.39	3.18	10.68

M – arithmetic mean , min – minimal value, max – maximal value, S - standard deviation, Se – arithmetic mean standard error, Sk - skewnes, Ku - kurtosis

From this table it is obvious that all applied variables of body dimensionality and voluminosity resulted with normal (symmetric) distributions because they don't exceed values bigger then 1.00 of a standard deviation, while variables of subcutaneous fat tissue are abnormally distributed and their asymmetry is expressed in positive direction (2.91, 2.87, 3.18) which means that a number of respondents had much bigger values which means they have increased fat tissue. Analyzing table 2, where we presented correlations between individual morphological variables it is obvious that all applied variables have great (r =.60-.99) and statistically significant correlations on the level .00 (p=.00), marked with a star (*).

Table 2: Correlations and eigenvalues

Variable	1	2	3	4	5	6	7	8	9	10	11
1. VISTEL	1.00										
2. DUŽNOG	.95*	1.00									
3. DUŽRUK	.97*	.96*	1.00								
4. BIKROM	.90*	.92*	.92*	1.00							
5. BIKRIS	.86*	.88*	.88*	.87*	1.00						
6. DIJRUK	.91*	.88*	.93*	.85*	.85*	1.00					
7. TEŽINA	.95*	.96*	.96*	.94*	.92*	.89*	1.00				
8. OPNATK	.93*	.90*	.92*	.87*	.89*	.93*	.93*	1.00			
9. OBNADF	.90*	.90*	.92*	.88*	.90*	.89*	.94*	.94*	1.00		
10.NABNAD	.67*	.77*	.68*	.74*	.82*	.63*	.81*	.73*	.78*	1.00	
11.NABLED	.66*	.76*	.68*	.75*	.82*	.63*	.80*	.71*	.76*	.99*	1.00
12.NABTRB	.63*	.74*	.65*	.72*	.79*	.60*	.77*	.68*	.73*	.98*	.99*

λ	%	CUM %
10.27	85.63	85.63
1.12	9.34	94.97

λ – characteristic roots, % - individual contribution, CUM % - common variance

With matrix factorization of variable correlation and appliance of Kaiser's criteria ($\lambda \geq 1.00$), we obtained two characteristic roots that explain 94, 97% of mutual variance (CUM %) and individual contribution in this for the first latent variable is 85.63% and for the second 9.34%. Determining structure of latent variables was based on main components matrix, set matrix and structure matrix (Table3). With inspection of main components matrix it is visible that the first component (Gk-1)is responsible for variability of entire applied morphological variable system and according to the regulation explains the most of information, so in this research it can be defined as integrated latent morphological characteristics variable that in its structure always contains variables of longitudinal and transversal dimensionality of skeleton, body mass and body volume as well as subcutaneous fat tissue. Interpretation of isolated morphological latent variables was conducted with askew transformation with structure matrix (A-matrix), which contains parallel projections, in other words length of vector coordinates in coordinate system. The first latent variable (Lv-1) can be interpreted as body dimensionality and voluminosity whose structure consist of variables of longitudinal and transversal dimensionality (body height, leg length, arm length, biacromial width, bicristal width and wrist diameter) and body voluminosity (body weight, upper leg circumference and upper arm circumference in flexion). The second latent variable can be interpreted as subcutaneous fat tissue, since it is defined by all applied fat tissue variables (upper arm skin fold, skin fold on the back and abdominal skin folds). Al the values of individual variable comunality (h2) have high results and range from .89 -.99 which indicates that interpeted parts of vector variables are satisfying in other words that manifest variables are statistically balanced and measured without bigger errors. From matrix of latent variable correlation (M-matrix) which is also presented in table 3. it is visible there is statistically significant correlation between isolated latent variables (.70).

Table 3: Oblique position of latent morphological variables and their correlations

Variable	Matrix of main components		A-circuit matrix		h^2
	Gk-1	Gk-2	Lv-1	Lv-2	
VISTEL	.93*	-.28	1.05*	-.11	.96
DUŽNOG	.96*	-.12	0.88*	.12	.94
DUŽRUK	.95*	-.26	1.04*	-.08	.97
BIKROM	.94*	-.10	0.84*	.13	.89
BIKRIS	.94*	.03	0.69*	.32	.89
DIJRUK	.90*	-.30	1.05*	-.14	.91
TEŽINA	.98*	-.07	0.84*	.19	.97
OPNATK	.94*	-.18	0.94*	.02	.93
OBNADF	.95*	-.09	0.84*	.15	.92
NABNAD	.86*	.49	0.07	.94*	.99
NABLED	.85*	.51	0.05	.96*	.99
NABTRB	.83*	.54	0.00	1.00*	.99

Lv	Lv-1	Lv-2
Lv-1	1.00	
Lv-2	.70*	1.00

Gk-1,2 –main components, Lv-1,2 –latent variables, h^2 – variable communalities

Discussion and conclusion

Based on many previous factor researches of morphological field certain number of factors was determined and these factors gave information about morphological latent variable structure. Four basic latent variables were determined (dimensions) which determine morphological structure of a man – longitudinal skeleton dimensionality, transversal skeleton dimensionality, and body volume and body mass and subcutaneous fat tissue. These latent variables are sometimes connected, which depend on age and sex and often they form one or even two factors. When connected in two factors, then on one side we have skeleton complex (longitudinal and transversal skeleton dimensionality) and voluminous complex (body mass and body volume and subcutaneous fat tissue). Because of great correlation between longitudinal and transversal skeleton dimensionality, body volume and body mass with subcutaneous fat tissue, these factors sometimes connect into two factors – skeleton dimensionality and body voluminosity. In boxing besides researches in the field of morphological characteristic factor structure it is advisable to determine the level of influence of morphological construction on the success in fighting. We can expect that arm length, leg, foot, biacromial width, body weight, chest circumference, upper arm, lower arm and upper leg, hand and foot width, wrist diameter and skin folds on the back and stomach are in significant correlation with success in fighting more then other dimensions.

If body mass and voluminous is large only because of subcutaneous fat tissue, then this factor will greatly complicate the way of fighting since it turned out to be unnecessary (ballast, bothering) mass. Considering that this research was directed only toward determining factor structure of morphological latent variables, obtained results indicated that with boxers we isolated two latent variables. The first one was interpreted as body dimensionality and voluminosity, their structure consists of dimensionality variables (body height, leg length, arm length, biacromial width, bicristal width and wrist diameter) and body voluminosity ((body weight, upper leg circumference and upper arm circumference in flexion). A second latent variable was interpreted as subcutaneous fat tissue since it is defined by all applied fat tissue variables (upper arm, back and abdominal skin fold).

Finally we can conclude that at boxer's two latent morphological variables exist; body dimensionality and voluminosity on one side and subcutaneous fat tissue on the other. Since between applied manifest variables (r =.60-.99) and isolated latent variables (r=.70) we obtained statistically significant correlation on the level .00 (p=.00), the conclusion is: For achievement of top results in boxing entire morphological structure participates but with slightly increased skeleton dimensionality and body voluminosity.

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FAKTORSKA STRUKTURA MORFOLOŠKIH ZNAČAJKI BOKSAČA

Sažetak

Na uzorku 92 boksača iz hrvatskih boksačkih klubova i različitih težinskih kategorija, bio je primijenjen sustav od 12 morfoloških varijabli, sa ciljem da se utvrdi njihova faktorska struktura radi formiranja što racionalnijih procedura za optimalno modeliranje, planiranje, programiranje i kontrolu trenažnog procesa. Primjenom faktorske analize (direktan oblimin) i Kaiser-kriterija ($\lambda \geq 1.00$) radi dobivanja zajedničkih karakterističnih korjenova i objašnjenih dijelova zajedničke varijanse, izolirane su dvije latentne varijable, od kojih je prva interpretirana kao dimenzionalnost i voluminoznost tijela, čiju strukturu sačinjavaju varijable dimenzionalnosti (tjelesna visina, dužina noge, dužina ruke, širina ramena, širina karlice i dijametar ručnog zgloba), i voluminoznosti tijela (težina tijela, obujam natkoljenice i obujam nadlaktice u fleksiji). Druga latentna varijabla je interpretirana kao potkožno masno tkivo, pošto je definiraju sve primijenjene varijable masnog tkiva (kožni nabor nadlaktice, kožni nabor leđa i kožni nabor trbuha). Pošto je između primijenjenih manifestnih varijabli (r =.60-.99) i izoliranih latentnih varijabli (r =.70) dobivena statistički značajna korelacija na razini .00 (p=.00), to konkretno znači da u formiranju vrhunskih rezultata u boksu sudjeluje kompletna morfološka struktura, ali sa nešto povećanom prednošću dimenzionalnosti skeleta i voluminoznosti tijela.

Ključne riječi: *boksači, morfologija, faktorska analiza, latentne dimenzije*

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