

## THE LATENT STRUCTURE OF MORPHOLOGICAL CHARACTERISTICS OF TOP HANDBALL, BASKETBALL AND FOOTBALL PLAYERS

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### **Abstract**

*The aim of the research is to apply the system of 25 variables of morphological characteristics and determine its factor structure due to forming as rational procedures as possible during the implementation of continuous selection of sportsmen in those sports and determine the transformational training process; the research has been carried out on the sample of 158 top sportsmen of male gender (51 handball players, 51 basketball players and 56 footballers). By applying factor analysis (direct oblimin) and Kaiser-criterion ( $\lambda \geq 1.00$ ) for obtaining common characteristic roots and explained parts of common variant, in case of handball player five latent variables (mass and volume of the body and panniculus adipose of the torso, longitudinal dimension of the skeleton, transversal dimension of the lower limbs and chest, transversal dimension of the shoulder and elbow have been isolated; in case of basketball players there are also five latent variables (longitudinal dimension of the skeleton, mass and volume of the body and panniculus adipose of the torso, transversal dimension of the lower limbs and wrist, transversal dimension of hands and pelvis, panniculus adipose of the upper and lower limbs); and for footballers there are six latent variables (longitudinal dimension of the skeleton, panniculus adipose of the upper and lower limbs, mass and volume of the body, transversal dimension of the legs, shoulders and pelvis, panniculus adipose of the chest and transversal dimension of the arms). On the basis of identified factor structures of the latent variables and their common relations, it can be concluded that there are various morphological structures of sportsmen according to sports, among which there are internal and statistically important correlations.*

**Key words:** handball, basketball, football, morphological characteristics, factor analysis

### **Introduction**

As far as morphology is concerned, there are numerous works dealing with manifesting and latent characteristics of people. The measurement is based on measuring human body as a whole or its specific parts, so the methods of International Biological Program (IBP) are carried out in the world, using 39 anthropometric measures and including complete morphological status of the man (Stojanović, Momirović, Vukosavljević & Solarić, 1975; Malacko & Rađo, 2004).

The way of implementing specific morphological measures (anthropometric measures) and the way in which the influence of gene and/or ecological factors is interpreted are described and presented in the majority of recent research (Maver, Muftić, Rudan & Taboršak, 1975; Buzina, Grgić, Kovačević, Maver, Momirović, Rudan, Schmutzer & Štampaj-Plasaj, 1975). The majority of research dealing with transformation of morphological characteristics points out to the great complexity since they are mainly under the

influence of gene factors (endogenic influence), and it is important to state that the influence of gene factors is not the same for all latent morphological dimensions (Malacko & Doder, 2008).

Regarding this, it should be noted that such studies examine the effects of doing exercises on the changes within the morphological build, but also they examine other motor, cardiovascular and other parameters (Bompa, 2000). In earlier research the identification of the latent variables in the morphological sense is carried out by factor analysis, and there were more methods of taxonomy (cluster) algorithms with the aim of determining morphological structure of human organism, and then the relations of these characteristics with other anthropological characteristics, abilities and properties and how much they contribute to the success in sports achievements (Szirovicza, Momirović, Hošek & Gredelj, 1980; Malacko & Popović, 2001; Stanković, 2000; Stanković & Popović, 2001).

**Aim**

The aim of the research is to determine the structure of latent variables of morphological characteristics of top handball players, basketball players and footballers due to forming as rational procedures as possible for optimal modelling, planning, programming and controlling of training process and efficient monitoring of their development during continuous selection of sportsmen and implementing the transformational training process.

**Methods**

The system of 25 variables of morphological characteristics was applied on the sample of 158 sportsmen of the top level of Serbia (51 handball players, 51 basketball players, and 56 footballers) of the male gender, aged between 18 and 30 years, who actively participate in the training process and competitions. For the purposes of estimating morphological characteristics the following variables have been applied: *longitudinal dimension of the skeleton*: 1. HEIGBO – the height of the body, 2. SPAARM – span of the arms, 3. LENLEG – the length of the leg, 4. LENLFO – the length of the foot 5. LENARM – the length of the arms, 6. LENHAN – the length of the hand, *transversal dimension of the skeleton*: 7. PLPAHA – planimetric parameter of the hand 8. BIABRE – biacromial breadth, 9. BICBRE – bicrystal breadth, 10. DIAELB – diameter of the elbow, 11. DIAWRI – diameter of the wrist, 12. DIAKNE – diameter of the knee, 13. DIAANK – diameter of the ankle, *circular dimension and mass of the body*: 14. MASBOD – mass of the body, 15. PECHES – perimeter of the chest, PEUPAR – perimeter of the upper arm, 16. PEUNAR – perimeter of the underarm, 17. PEUPLE – perimeter of the upper leg, 18. PESHAN – perimeter of the shank, 19. panniculus adipose: 20. SKCRUA – skin creases of the upper arm, 21. SKCRBA – skin creases of the back, 22. SKCRBE – skin creases of the belly 23. SKCRAR – skin creases of the armpit, 24. SKCRUL – skin creases of the upper leg, 25. SKCRSH – skin creases of the shank. All above-mentioned variables are measured according to the methods of International Biological Program (IBP).

Determining the structure of latent morphological variables is carried out by factor analysis by using oblique rotation (direct oblimin); in case of extracting the number of characteristic roots the criterion  $\lambda \geq 1.00$  (Kaiser) is applied. The communalities ( $h^2$ ) are calculated specifically for all applied variables in order to get their informatics values.

The structure of the latent variables is calculated by matrix of the main components, the loading matrix which contains parallel projections (coordinates) of the variables on the factors, the matrix of structure, that is to say the correlations between manifesting and latent variables and matrices of inter-correlation factors. The data is processed by statistical package SPSS Statistics 17.

**Results**

The interpretation of the isolated morphological latent variables, due to the limited space, is carried out by oblique rotation (loading matrix) which contains parallel projections, that is the length of coordinates of the vectors in the coordination system.

Table 1: The structure of morphological latent variables of the handball players (matrix of the oblique oblimin rotation)

Variables	Lv-1	Lv-2	Lv-3	Lv-4	Lv-5	h <sup>2</sup>
HEIGBO	.00	.82*	.09	-.15	.17	.86
SPAARM	-.02	.90*	.04	-.05	.08	.87
LENLEG	-.17	.81*	.16	.13	.42	.86
LENLEFO	-.06	.57*	.00	-.43	-.23	.62
LENARM	.00	.98*	.06	.11	-.09	.87
LENHAN	.13	.58*	-.27	-.16	.08	.60
PLPAHA	.20	.75*	-.15	-.03	-.16	.69
BIABRE	-.07	.28	-.03	-.32	.48*	.54
BICBRE	.58*	.06	.05	-.19	-.03	.47
DIAELB	.12	.00	.02	.07	.83*	.72
DIAWRI	.63*	.37	-.34	.17	.10	.64
DIAKNE	.40	-.06	-.10	-.54*	.27	.65
DIAANK	-.03	.04	.04	-.75*	-.00	.58
MASBOD	.74*	.19	.10	-.21	.08	.88
PECHES	.75*	.12	.00	-.21	.00	.78
PEUPAR	.78*	-.07	.07	-.19	.19	.82
PEUNAR	.80*	.02	-.05	.09	.28	.73
PEUPLE	.66*	-.14	.19	-.21	.14	.69
PESHAN	.42	.11	.10	-.54*	-.12	.69
SKCRUA	.31	.16	.74*	.02	-.10	.82
SKCRBA	.86*	-.13	.17	.03	-.21	.84
SKCRBE	.78*	-.00	.29	.11	-.13	.80
SKCRAR	.81*	.01	.21	.16	-.07	.78
SKCRUL	.30	.07	.70*	-.01	.05	.72
SKCRSH	-.00	-.04	.90*	-.04	.06	.81
	Lv-1	Lv-2	Lv-3	Lv-4	Lv-5	
Lv-1	1.00					
Lv-2	.22	1.00				
Lv-3	.32*	-.11	1.00			
Lv-4	-.25	-.28*	-.05	1.00		
Lv-5	.13	.22	-.07	-.09	1.00	

Lv-1 - first latent variable, Lv-2 - second latent variable, Lv-3 - third latent variable, Lv-4 - fourth latent variable, Lv-5 - fifth latent variable, h<sup>2</sup> - communalities

The first latent variable (Lv-1) in case of handball players (Table 1) may be defined as mass and volume of the body and panniculus adipose of the torso whose structure consists of variables of the mass of the body, perimeter of the upper arm, perimeter of the underarm, perimeter of the upper leg, perimeter of the shank, skin creases of the back, skin creases of armpit, skin creases and skin creases of the belly, and planimetric parameter of the hand,

and diameter of the wrist; the second variable (Lv-2) as a longitudinal dimension of the skeleton (height of the body, span of the arms, length of the arms, length of the hand, length of the leg, length of the feet and biacromial breadth); the third variables as panniculus adipose of the upper and lower limbs (skin creases of the upper arm, skin creases of the upper leg and skin creases of the shank); the fourth (Lv-4) as transversal dimension of the lower limbs and chest (diameter of the knee, diameter of the ankle and perimeter of the chest); and the fifth variable (Lv-5) as transversal dimension of the shoulders and elbow (bicrystal breadth and diameter of the elbow). The communalities ( $h^2$ ) show that during measurement the biggest mistakes are made in case of variables of the bicrystal breadth ( $h^2=.54$ ) and planimetric parameter of the hand ( $h^2=.47$ ). There is a statistically important correlation in case of handball players between the first (the mass and volume of the body and panniculus adipose of the torso) and the third (.32) latent variable (panniculus adipose of the upper and lower limbs) as well as between the second (longitudinal dimension of the skeleton) and the fourth (-.28) latent variable (transversal dimension of the lower limbs and chest).

Table 2: The structure of morphological latent variables of the basketball players (the matrix of oblique oblimum rotation)

Variables	Lv-1	Lv-2	Lv-3	Lv-4	Lv-5	$h^2$
HEIGBO	.90*	.04	-.01	-.03	-.08	.89
SPAARM	.90*	.09	-.00	-.10	-.02	.92
LENLEG	.85*	-.02	.00	.09	-.05	.74
LENLEFO	.66*	-.00	.14	-.40	.01	.79
LENARM	.95*	.04	-.03	.03	.03	.88
LENHAN	.84*	.03	-.00	.07	-.13	.79
PLPAHA	.81*	-.07	-.01	-.09	.04	.63
BIABRE	.22	.02	.16	-.74*	-.05	.76
BICBRE	.44	.36	-.00	-.44*	-.05	.73
DIAELB	.59	-.05	.15	.59*	-.05	.69
DIAWRI	.43	-.14	.64*	-.02	.29	.80
DI AKNE	-.01	.26	.79*	.26	-.09	.75
DIAANK	-.09	-.12	.85*	-.29	.12	.79
MASBOD	.52	.58*	.10	-.09	.02	.88
PECHES	.36	.63*	.04	-.21	-.10	.80
PEUPAR	.14	.79*	.27	-.10	-.08	.83
PEUNAR	.11	.58*	.43	-.08	-.08	.72
PEUPLE	-.01	.85*	.11	-.01	.02	.77
PESHAN	.11	.58*	.27	-.09	-.11	.55
SKCRUA	.03	.39	.05	-.06	.71*	.80
SKCRBA	-.02	.90*	-.20	-.03	.14	.88
SKCRBE	-.18	.73*	-.05	-.08	.26	.71
SKCRAR	-.06	.80*	-.28	.13	.23	.78
SKCRUL	-.02	.16	-.01	-.01	.85*	.83
SKCRSH	-.03	-.13	.09	.08	.92*	.83
	Lv-1	Lv-2	Lv-3	Lv-4	Lv-5	
Lv-1	1.00					
Lv-2	.25	1.00				
Lv-3	.42*	.15	1.00			
Lv-4	-.15	-.16	-.12	1.00		
Lv-5	-.26	.21	-.02	-.06	1.00	

Lv-1 - first latent variable, Lv-2 - second latent variable, Lv-3 - third latent variable, Lv-4 - fourth latent variable, Lv-5 - fifth latent variable,  $h^2$  - communalities

The first latent variable (Lv-1) in case of basketball players (Table 2) may be defined as longitudinal dimension of the skeleton whose structure consists of variables of the height of the body, span of the arms, the length of the arms, the length of the hands, the length of the leg, the length of the feet and biacromial breadth; the second variable (Lv-2) as the mass and volume of the body and panniculus adipose of the torso (the mass of the body, perimeter of the upper arm, perimeter of the underarm, perimeter of the upper leg, perimeter of the shank, perimeter of the chest, skin creases of the back, skin creases of the armpit and skin creases of the belly); the third (Lv-3) as transversal dimension of the lower limbs and wrist (diameter of the knee, diameter of the ankle and diameter of the wrist); the fourth (Lv-4) as transversal dimension of the arms and pelvis (bicrystal breadth, planimetric parameter of the hand and diameter of the elbow); and the fifth variable (Lv-5) as panniculus adipose of the upper and lower limbs (skin creases of the upper arm, skin creases of the upper leg and skin creases of the shank). All the values of the communalities of the specific variables ( $h^2$ ) have satisfactory values and it means that the explained parts of the vectors of variables are satisfactory, that is to say that manifesting variables are statistically balanced and that they are measured without any bigger mistakes. There is a statistically important correlation in case of basketball players between the first (longitudinal dimension of the skeleton) and the third (.42) latent variable (transversal dimension of the lower limbs and wrist). The first latent variable (Lv-1) in case of footballers (Table 3) may be defined as longitudinal dimension of the skeleton whose structure consists of variables of the height of the body, span of the arms, the length of the arms, the length of the hand, the length of the leg, the length of the feet and planimetric parameter of the hand; the second (Lv-2) as panniculus adipose of the upper and lower limbs (skin creases of the upper arm, skin creases of the upper leg and skin creases of the shank); the third (Lv-3) as the mass and volume of the body (the mass of the body, perimeter of the upper arm, perimeter of the underarm, perimeter of the upper leg, the perimeter of the shank, perimeter of the chest); the fourth (Lv-4) as transversal dimension of the legs, shoulders and pelvis (biacromial and bicrystal breadth, diameter of the knee and elbow); the fifth (Lv-5) as panniculus adipose of the torso (skin creases of the back, skin creases of the armpit and skin creases of the back); and the sixth variable as transversal dimension of the arms (diameter of the elbow and diameter of the wrist).

Table 3: The structure of morphological latent variables of footballers (matrix of the oblique oblimin rotation)

Variables	Lv-1	Lv-2	Lv-3	Lv-4	Lv-5	Lv-6	h <sup>2</sup>
HEIGBO	.84*	-.12	-.03	.23	-.05	.06	.81
SPAARM	.91*	.10	.16	-.09	.02	.10	.88
LENLEG	.90*	-.03	-.01	.14	-.00	.03	.85
LENLEFO	.59*	-.11	-.26	.11	.04	.24	.76
LENARM	.79*	-.04	.24	.00	-.00	.18	.72
LENHAN	.79*	-.13	-.19	-.21	-.01	-.10	.77
PLPAHA	.18	.12	-.08	-.48*	.10	.40	.55
BIABRE	.22	.23	-.16	-.33*	.32	.20	.46
BICBRE	.52*	.09	-.40	-.20	-.00	-.07	.57
DIAELB	-.02	-.09	-.06	.01	-.04	.82*	.70
DIAWRI	.14	-.10	.12	.23	-.01	.81*	.82
DIAKNE	-.04	.20	-.22	.74*	.10	.15	.69
DIAANK	.25	.20	.02	.74*	-.02	.15	.73
MASBOD	.44	-.00	-.71*	.18	-.13	.06	.93
PECHES	.38	.28	-.45*	-.14	-.04	.12	.65
PEUPAR	-.19	-.12	-.88*	-.11	-.12	.03	.77
PEUNAR	.08	-.23	-.62*	-.06	.02	.30	.71
PEUPLE	.01	.03	-.83*	.02	-.04	-.06	.68
PESHAN	.01	.00	-.75*	.32	.28	.03	.74
SKCRUA	-.08	.82*	.06	.08	-.16	.07	.81
SKCRBA	-.23	.29	-.17	-.05	-.68*	.24	.74
SKCRBE	.06	.01	.13	.07	-.88*	-.00	.82
SKCRAR	.21	.11	-.16	-.11	-.84*	-.05	.83
SKCRUL	-.08	.89*	.08	.01	-.07	-.09	.87
SKCRSH	-.04	.78*	.06	.23	-.09	-.28	.86
	Lv-1	Lv-2	Lv-3	Lv-4	Lv-5	Lv-6	
Lv-1	1.00						
Lv-2	-.00	1.00					
Lv-3	-.27*	-.03	1.00				
Lv-4	-.06	.08	.07	1.00			
Lv-5	.08	-.27*	-.02	-.03	1.00		
Lv-6	.43*	-.02	-.27*	.03	.08	1.00	

Lv-1 - first latent variable, Lv-2 - second latent variable, Lv-3 - third latent variable, Lv-4 - fourth latent variable, Lv-5 - fifth latent variable, Lv-6 - sixth latent variable, h<sup>2</sup> - communalities

The communalities (h<sup>2</sup>) show that during measuring the biggest mistakes were made in cases of the variables biacromial breadth (h<sup>2</sup>=.55), bicrystal breadth (h<sup>2</sup>=.46) and planimetric parameter of the hand (h<sup>2</sup>=.57). There are statistically important correlations in case of footballers among the first (longitudinal dimension of the skeleton), the third (-.27) latent variable (the mass and volume of the body) and the sixth (.43) latent variable (transversal dimension of the arms). The second latent variable (panniculus adipose of the upper and lower limbs) is in the correlation (-.27) with the fifth (panniculus adipose of the torso), and the third (the mass and volume of the body) with the sixth (-.27) latent variable (transversal dimension of the arms).

**Discussion and conclusion**

The earlier research of the morphological space in the field of determining factor structure of the morphologically latent variables showed that the four basic isolated latent variables (dimensions) which determine the morphological structure of a human being as follows – longitudinal dimension of the skeleton, transversal dimension of the skeleton, the volume and mass of the body and panniculus adipose.

These latent variables are sometimes connected which depends on the age, gender, type of sport, the duration of the sports career, conditions and the level of achievement as well as other relevant characteristics so they often form larger number, or only one or two latent variables. When they are joined into two latent variables, that is on the one hand skeleton complex (longitudinal and transversal dimension of the skeleton) and voluminous complex (the mass and volume of the body and panniculus adipose). This research is directed towards determining factor structure of the morphological latent variables (constitutional types) of the top handball players, basketball players and footballers, that is to say, within three different sports. The obtained results showed that in case of handball players five latent variables have been isolated (the mass and volume of the body and panniculus adipose of the torso, longitudinal dimension of the skeleton, panniculus adipose of the upper and lower limbs, transversal dimension of lower limbs and chest, transversal dimension of shoulders and elbow); in case of basketball players there are also five latent variables (longitudinal dimension of the skeleton, the mass and volume of the body and panniculus adipose of the chest, transversal dimension of the lower limbs and wrist, transversal dimension of the arms and pelvis, panniculus adipose of the upper and lower limbs); and in case of footballers there are six latent variables (longitudinal dimension of the skeleton, panniculus adipose of the upper and lower limbs, the mass and volume of the body, transversal dimension of the legs, shoulders and pelvis, panniculus adipose of the torso and transversal dimension of the arms). On the basis of identified factor structures of latent variables and their common relations, it can be concluded that there are various morphological structures of the sportsmen according to sports and between them there are internal and various statistically important correlations.

The first latent variable in case of handball players which has the biggest informatics value has integrated the volume (perimeter) of the arms and legs, transversal dimension (width) of the hand and wrist and panniculus adipose of the torso into its specific structure; therefore, constituent type of handball player has been defined. The results showed that in case of handball player there is the dominance of the mass of the body, volume of the body, panniculus adipose of the torso and width of the hand and wrist, and there are longitudinal dimension of the skeleton, skin creases of the arm and legs as well as transversal dimension of the upper and lower limbs. In case of basketball players the distribution of latent variables is a bit different.

The first latent variable has integrated the longitudinal dimension of the skeleton into its specific structure, and through the second (the mass of the body, volume of the arms and legs and panniculus adipose of the torso), the third and the fourth (transversal dimension of the arms and legs) the latent variables the other latent variables. It means that constituent type of the basketball players dominantly determines the longitudinal dimension of the skeleton, and then in the second place there are mass of the body, volume of the arms and legs, panniculus adipose of the torso as well as transversal dimension of the arms and legs. The first latent variable in case of the footballers, similarly to the basketball players,

has integrated longitudinal dimension of the skeleton in its specific structure, whereas the variables of panniculus adipose of the upper and lower limbs have been integrated into the second latent variable. In contrast to handball and basketball players, in case of footballers the variables of the mass and volume of the body have been integrated into the third latent variable, and in the fourth there are the variables of transversal dimension of lower limbs and variables of shoulder and pelvic girdle. The variables of panniculus adipose of the torso have been integrated into the fifth, and the variables of transversal dimension of elbow joint and wrist have gone into the sixth latent variable.

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## LATENTNA STRUKTURA MORFOLOŠKIH ZNAČAJKI VRHUNSKIH RUKOMETASA, KOŠARKAŠA I ODBOJKAŠA

### **Sažetak**

*Cilj istraživanja je da se na uzorku 158 vrhunskih sportista muškog spola (51 rukometaš, 51 košarkaš i 56 fudbalera), uzrasta od 18 do 30 godina, primjeni sistem od 25 varijabli morfoloških karakteristika i utvrdi njihova faktorska struktura radi formiranja što racionalnijih procedura tokom provođenja kontinuirane selekcije sportaša u tim sportovima i transformacioni trenažni proces. Primjenom faktorske analize (direktni oblamin) i Kaiser-kriterija ( $\lambda \geq 1.00$ ) radi dobijanja zajedničkih karakterističnih korjenova i objašnjenih dijelova zajedničke varijance, kod rukometaša je izolirano pet latentnih dimenzija (masa i voluminoznost tijela i potkožno masno tkivo trupa, longitudinalna dimenzionalnost skeleta, potkožno masno tkivo gornjih i donjih ekstremiteta, transverzalna dimenzionalnost donjih ekstremiteta i grudnog koša, transverzalna dimenzionalnost ramena i lakta), kod košarkaša takođe pet latentnih dimenzija (longitudinalna dimenzionalnost skeleta, masa i voluminoznost tijela i potkožno masno tkivo trupa, transverzalna dimenzionalnost donjih ekstremiteta i ručnog zgloba, transverzalna dimenzionalnost ruku i karlice, potkožno masno tkivo gornjih i donjih ekstremiteta), a kod fudbalera šest latentnih dimenzija (longitudinalna dimenzionalnost skeleta, potkožno masno tkivo gornjih i donjih ekstremiteta, masa i voluminoznost tijela, transverzalna dimenzionalnost nogu, ramena i karlice, potkožno masno tkivo trupa i transverzalna dimenzionalnost ruku). Na osnovu identificiranih faktorskih struktura i njihovih međusobnih relacija, može se zaključiti da se radi o različitim morfološkim strukturama sportista po sportovima, između kojih postoje interne i statistički značajne korelacije.*

**Ključne riječi:** rukometaši, košarkaši, fudbaleri, morfološke značajke, faktorska analiza

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