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Latent Relations Between Selected Morphometric, Physiological and Biochemical Parameters

Relaciones Latentes entre Parámetros Morfométricos, Fisiológicos y Bioquímicos Seleccionados

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SUMMARY: The main purpose of this study was to explore the latent relations of the selected morphometric, physiological and biochemical parameters. Thirty-six variables (12 morphometric, 9 physiological and 15 biochemical variables) were measured on 317 male-entities aged 17 – 35 y/o. The obtained data were analysed through the factor analysis of the first and second order. The statistical analyses were performed with the IBM SPSS Statistics software package, version 20. The factorization of the first order enabled extraction of 12 latent factors that explain 74.8 % of the total variance, while the factorization of the second order enabled extraction of five latent components that explain 51.39 % of the total variance. The final results of this study confirm the main hypothesis that there exist the numbers of latent variables that explain the latent structure of selected biometric measures. The nature of the extracted latent factors/ components in both orders of factorization is relatively clear, understandable, and easy to interpret. The higher projections of the manifest biometric variables on the extracted latent factors of the first and second order were accordingly with the nature of the measured variables. The results of this research might be considered as one step more in the holistic approach to the biometric measures.

KEY WORDS: Multi-dimensional; Factor analysis; Total variance; Biometric measures; Human homeostasis; Manifest variables; Latent factors; Latent components.

INTRODUCTION

Cybernetically a human being operates as a multi-dimensional automatic system consisting of few subsystems interrelated with one another and with highly adaptable features. The physiological impairment of one subsystem certainly will impact the normal functioning of other subsystems. Without a holistic approach to the human being, it will be difficult, if not impossible to define or to have an adequate approach to the internal or external factors that have a significant impact on maintaining of the human homeostasis.

Recent studies are increasingly holistically designed, with a multidimensional approach to the human being. Studying the interrelation between different body sub-systems Al-Sendi *et al*. (2003) found a significant correlation between the body obesity and the blood pressure of Bahraini adolescents. Similar results were found by Gaskin *et al*. (2015). These authors have found a significant positive correlation between body weight gain and increasing blood pressure for children growing up. Additionally, these authors in order to prevent risks of increased blood pressure have emphasized the importance of establishing “intervention programs that will prevent the development of childhood and adolescent obesity”. Kondaki *et al*. (2011) in their study trying to find risk anthropometric factors among overweight people for developing of the pathological condition such as insulin resistance have found strong statistically significant relations between waist circumference and waist to height ratio with insulin resistance compared to the rest of anthropometric indices.

Results of many studies indicate that both kinds of the physical activities (continued and interval physical activities) have positive impact on almost all physiological variables, such as the improve of VO2max, elevation of the blood volume, increase of the stroke volume and cardiac output, decrease of the heart rate and blood pressure while resting (Warburton *et al*., 2004). The study of Warburton *et al*. indicates that in long-term the endurance training has no significant effect on volume-regulatory hormones.

Manifest variables mean the measures that can be either measured or observed, while the latent factors mean the opposite of the manifest variables. The notion "latent

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structure" means the unknown site (structure) of phenomena. According to Dalipaj (2017) the etymology of the notion "Latent" derives from the word "La'terrt" that belongs to the Gheg dialect of Albanian language that means La-Left and Terrë-Darknes “Left in darkness", "Acting invisibly", "Concealed", "Unnoticed", "Covered" (17).

The factor analysis discovers the underlying factors which explain the latent structure of the phenomena. The extracted latent factors provide the best explanation of the manifest variables. In fact, the latent factors derive from the manifest variables and represent the condensation (reduction) of the manifest variables in a smaller number of latent factors that explain the latent structure of manifest variables, always respecting the principle of parsimony (Warne & Larsen, 2014).

Since the study of the manifest structure of phenomena is a daily routine, more and more the studying of the latent structure of phenomena is becoming a main aim of studies. Jost (2010) has studied the hierarchical latent structures of the manifest motor and morphological variables. Jost found that the independent primary factors of the first order of factorization were crucial for understanding the latent dimensions of the potential performance model on the second and third level of factorization. Pribacic Ambrozic *et al*. (2015) have found the significant differences in latent morphological variables of the body and head in both men and women in a geographically limited area of Rab Island. Hanley *et al*. (2002), using factor analysis, have investigated the clustering of variables in latent factors of metabolic syndrome. According to these authors, the factorisation of the metabolic syndrome variables produced two latent factors which have been stable across sex, glucose tolerance, and ethnic subgroups. The first extracted latent factor, explaining 30 % of total variance, is comprised of anthropometric and metabolic variables. While the second extracted latent factor, explaining 10 % of total variance, is comprised of the variables that inform systolic and diastolic blood pressure. Many studies have emphasised the importance of the principal component factor analysis in identification of the cluster of risk factors for chronic diseases such as cardiovascular diseases (Han *et al*., 1995; Chen *et al*., 2000; Goodman *et al*., 2005; Badaruddoza et at., 2011). Adeyemi James *et al*. (2014) have highlighted the relevance of the factor analysis to investigate variability among anthropometric data involving diverse population. Also, according to these authors, the collected data from this study may be suitable as a database for school design in Nigerian tertiary institutions.

The aim of the present study was to explore the latent structure and its hierarchy of the measured morphometric, physiological and biochemical manifest variables.

The main hypothesis of the present study is that there exist the numbers of latent variables that explain the latent structure of selected morphometric, physiological and biochemical variables. This hypothesis will be tested by the factor analysis.

MATERIAL AND METHOD

Research design. This study as a cross-sectional study with transversal design and a part of a project 'Biometric differences between athletes and non-athletes', was carried out within the framework of the Centre for Sport, Fitness and Nutrition ‘Corpore Sano’ at the Institute of Sports Anthropology in Prishtina, Kosovo, and has been approved by the Ethics Committee of this Institute.

Site of study and sampling. Thirty-six biometric variables were measured in 317 Kosovo male entities aged 17 – 35 years old. The measurements were done during the period April – October 2002. The examined entities were chosen randomly, always respecting the rule that their psycho-physical condition was in the normal range.

Measuring tools and data collection. In conformity with the International Biological Program (IBP) the following 12 morphometric variables were measured:

· MBH – Body Height (cm) was measured with a classical anthropometer;
· MBW – Body Weight (kg) was measured with a digital weighing scale;
· MArmCir – Arm Circumference (mm) shows maximum circumference of the arm (humerus);
· MChesCir – Chest Circumference (mm) shows maximum circumference of the thorax at the mammilla level;
· MAbdCir – Abdominal Circumference (mm) shows circumference of the abdomen at the umbilicus level;
· MThighCir – Thigh Circumference (mm) shows maximum circumference of the thigh;
· MCalfCir – Calf Circumference (mm) shows maximum circumference of the calf;
· MTricSkin – Triceps Skinfold (mm) shows subcutaneous adipose tissue on the back of the arm (humerus) over the triceps muscle;
· MSubscCir – Subscapular Skinfold (mm) shows subcutaneous adipose tissue on the back just below the inferior angle of scapula;
· MAbdSkin – Abdomial Skinfold (mm) shows subcutaneous adipose tissue of the abdomen at the umbilicus level 5 cm on the left;
· MThighSkin – Thigh Skinfold (mm) shows subcutaneous adipose tissue on the thigh;
· MCalfSkin – Calf Skinfold (mm) shows subcutaneous adipose tissue on the calf, measured at the same level like calf ’s perimeter;

The following 9 physiological variables were measured while resting:

· PhHR0' – Heart Rate while resting was measured by stethoscope on cord-apex;
· PhSatO_2 – Blood oxygen saturation (%) means the fraction of oxygen-saturated haemoglobin relative to total haemoglobin in the blood;
· PhTensis0' – Sistolic Blood Pressure (mmHg) while resting was measured with mechanic sphingmanometer);
· PhTendia0' – Diastolic Blood Pressure (mmHg);
· PhRespir0' – frequency of respiration per minute while resting;
· PhBodTem0' – Body temperature (ºC) while resting;
· PhVO_2max.abs – Absolute maximal oxygen uptake (L/min) was calculated by using the Döbeln formula:

$$VO_2 \text{ max abs} = 1.29\sqrt{\frac{L}{fh-60}}e^{-0.00884T}$$

L = level of the load (kpm/min)
fh = Heart rate in 5th minute during the Astrand Submaximal Bike Test
e = Coefficient 2.72
T = Years of age

· PhVO_2max.rel – Relative Maximal Oxygen uptake (ml/kg/min);
· PhCarOut – Cardiac output (L/min) means the volume of blood that heart pumped out per minute at the end of the Astrand Submaximal Bike Test;

The following 15 biochemical variables were measured while resting (before the submaximal Astrand Bike Test):

· BErythro – Erythrocytes or red blood cells;
· BHaemglo – Hemoglobin is composed of globin and heme that carries oxygen from the lungs to the tissues and carbon dioxide from the tissues to the lungs;
· BLeukoc – Leucocytes or white blood cells;
· BHematoc – The hematocrit means the ratio of the volume of red blood cells to the total volume of blood;
· BGlycemi – Glycaemia refers to the level of glucose in one's blood;
· BUrea – Urea is a crystalline compound that is the main nitrogenous breakdown product of protein metabolism in the human organism excreted in urine;
· BCreatin – Creatinine is a waste product of the muscles metabolism that is produced constantly in the body and filtered by the kidneys in the urine;
· BToChol – Total blood cholesterol is a measure of the cholesterol components such as Low-Density Lipoprotein (LDL cholesterol), Very-Low Density lipoprotein (VLDL cholesterol) and High-Density Lipoprotein (HDL cholesterol);
· BUSG – Urine specific gravity is a urinalysis parameter useful for evaluation of concentration of solutes in the urine;
· BpHU – The urine pH shows the acidity or alkalinity of the urine;
· BUrinProt – Proteinuria shows the presence of protein in urine;
· BUrinGlu – Glycosuria is the excretion of glucose into the urine;
· BUrinKet – Ketonuria is a medical condition in which ketone bodies are present in the urine;
· BUrinUrobil – Urobilinogen is a colorless pigment that is produced from the metabolism of bilirubin;
· BUrinEryth – Hematuria or erythrocytes in urine means the presence of erythrocytes in the urine.

Data analysis. The statistical analyses were performed with the IBM SPSS Statistics software package, version 20. The obtained data were analysed through the descriptive parameters (arithmetic means and standard deviation) and the factor analysis. While the manifest structure of the morphometric, physiological and biochemical variables was described through descriptive statistical parameters, the latent structure of the measured variables was explored through the factorial analysis of the first order and the second order. The second order of the factor analysis consists of repeating steps of factor analysis in the latent structure of the same phenomena. The main purpose of the second order of the factor analysis is to enable the researcher to see the hierarchical structure of the studied phenomena.

Ethical considerations. This project was approved by the Ethics Committee of the Institute of Sports Anthropology. The authors declare no conflict of interest and no financial or commercial benefits for the performing of this study.

RESULTS AND DISCUSSION

The descriptive results of the measured variables (minimum, maximum, mean and standard deviation values) are shown in Table I. All measured variables have been within the normal range of values.

The factor analysis was applied to identify the latent structure of the morphometric, physiologic and biochemical measured variables. This form of analysis was applied to reduce large number of measured manifest variables into a few numbers of the latent core factors. The suitability of the data for structure detection, respectively the appropriateness of the factor analysis is tested by Kaiser-Meyer-Olkin (KMO) index, and Bartlett's Test of Sphericity. The KMO index is a statistical measurement that indicates the proportion of variance in the measured variables that might be explained by underlying factors. While the higher values of KMO indicate usefulness of a factor analysis for structure detection of the measured variables, the lower values ($p<0.5$) indicate useless the factor analysis in detecting of the latent structure of the measured variables. Bartlett's test of sphericity tests the suitability of the collected data for their reduction if the measured variables are unrelated and therefore unsuitable for structure detection. Small values of the significance level ($p<0.05$) indicate that the factor analysis may be useful in detecting the latent structure of the measured variables.

Table I. Descriptive Statistics.

	Minimum	Maximum	Mean	Std. Deviation
MBW	47.50	108.00	71.69	9.45
MBH	1584.00	2020.00	1765.99	64.32
MArmCir	213.00	393.00	280.99	26.99
MChesCir	740.00	1140.00	921.39	59.53
MAbdCir	610.00	1105.00	792.36	73.14
MThighCir	443.00	697.00	545.56	44.06
MCalfCir	275.00	445.00	364.17	25.86
MTricSkin	2.60	30.80	8.51	42.23
MSubscSkin	3.00	31.80	9.56	41.43
MAbdSkin	3.40	55.00	11.95	79.74
MThighSkin	2.60	45.10	13.17	86.48
MCalfSkin	2.60	32.00	8.66	43.82
PhHR0’	43.00	105.00	71.18	12.74
PhSatO_2	95.00	99.00	97.77	0.67
PhTensis0’	85.00	160.00	112.41	11.76
PhTendia0’	55.00	110.00	76.18	7.87
PhRespir0’	14.00	30.00	20.53	3.25
PhBodTem0’	34.41	37.27	36.25	0.48
PhVO_2max.abs	2.16	4.05	2.98	0.36
PhVO_2max.rel	13.11	62.80	42.16	7.43
PhCarOut	14.38	27.02	19.86	2.42
BErythro	3.57	4.79	4.13	0.23
BHaemglo	108.00	188.00	137.12	11.37
BLeukoc	4.00	12.00	6.25	1.37
BHematoc	37.00	54.00	45.30	3.28
BGlycemi	3.00	21.30	4.59	1.20
BUrea	3.20	10.70	5.55	1.35
BCreatin	53.00	100.00	75.32	9.66
BToChol	1.70	9.40	4.05	1.01
BUSG	1000.00	1030.00	1023.23	7.92
BpHU	0.00	9.00	5.22	0.68
BUrinProt	0.00	3.00	0.14	0.27
BUrinGlu	0.00	17.00	0.15	1.08
BUrinKet	0.00	15.00	0.10	1.19
BUrinUrobil	0.00	102.00	10.52	7.45
BUrinEryth	0.00	250.00	1.90	15.59

Results in Table II indicate that according to KMO measure (0.576) and Bartlett's test ($p<0.000$) it can be concluded that the gained matrix is not an identity matrix and in this form can be preceded with further statistical procedures of the factor analysis.

Factor Analysis method was applied to discover and to describe a lower number of unobserved and uncorrelated variables called latent factors always respecting the law of parsimony (with a smaller number of the latent factors to explain as much as possible the variability of the manifest variables) (Ferguson, 1954). The extraction of the latent structure, respectively the determination of the optimal number of the latent factors has been done based on the Hoteling’s method of principal components, according to the Keiser criterion, which means the retaining of the components with an eigenvalue greater than 1.0 (Warne & Larsen). Based on this criterion and according to the principal component analysis of the Factor Analysis, the rotation method direct oblimin (21 iterations), were extracted 12 latent components (factors) that explain 74.8 % of the total variance.

Table II. KMO & Bartlett’s Test.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.576
Bartlett's Test of Sphericity	Approx. Chi-Square	124.354
	df	66
	p	0.000

The data of the pattern matrix (Table III) indicate the linear combination of the morphometric, physiological and biochemical variables, respectively the projections of these manifest variables on 12 extracted latent factors; whereas, the communality indicates the percentage of variance of each variable explained by all extracted factors. According to the data of Table III the percentage of explained cumulative variance of each manifest variable by 12 extracted latent factors (communality), vary from 53 – 96 %. Variables with high values of communality indicate their good representation in the extracted common latent space. Among the measured variables, the higher communalities (>90 %) show the variables that impact the Maximal Oxygen Uptake (Body Weight, Absolute and Relative Maximal Oxygen Uptake, Cardiac Output, Erythrocytes and Haemoglobin). The nature of the extracted factors is determined accordingly with the nature of the variables that realize the higher projections on the corresponding factor. According to this rule were appointed all extracted latent factors of the first and the second order.

As was expected, the projections of the manifest variables on the extracted latent factors of the first order were accordingly with the nature of the measured variables.

· The first extracted latent factor has explained 24.35 % of the total variance and contains the higher projections of 10 morphometric variables that measure the volume and under-skin fat tissue (MArmCir 0.56; MChesCir 0.43; MAbdCir 0.64; MThighCir 0.68; MCalfCir

Table III. Pattern Matrix & Communalities.

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12	Commun.
MBW	0.51	0.08	-0.02	0.61	-0.05	0.01	0.17	0.07	-0.06	-0.08	0.01	0.01	0.96
MBH	-0.13	0.08	0.10	0.86	0.09	-0.05	-0.05	-0.04	0.06	0.05	-0.03	0.00	0.73
MArmCir	0.56	-0.04	-0.07	0.25	-0.06	0.05	0.19	0.16	-0.13	-0.10	0.11	0.11	0.76
MChesCir	0.43	-0.09	-0.06	0.40	-0.11	0.11	0.20	0.15	-0.11	-0.10	0.07	0.10	0.76
MAbdCir	0.64	-0.08	0.01	0.29	-0.09	0.08	0.15	0.07	-0.07	-0.10	-0.12	0.07	0.84
MThighCir	0.68	0.17	-0.08	0.32	-0.04	-0.03	0.14	0.11	-0.08	-0.09	0.05	-0.07	0.86
MCalfCir	0.48	0.27	-0.09	0.41	-0.07	-0.02	0.18	0.07	-0.02	-0.05	0.16	-0.12	0.71
MTricSkin	0.93	-0.01	0.08	-0.08	0.02	-0.04	-0.06	-0.03	0.06	0.04	-0.01	-0.02	0.78
MSubscSkin	0.86	-0.10	0.01	-0.06	0.05	0.03	0.08	-0.02	0.02	-0.06	-0.06	0.11	0.83
MAbdSkin	0.84	-0.17	-0.05	-0.04	-0.03	0.04	0.04	-0.01	-0.03	-0.01	-0.05	0.09	0.81
MThighSkin	0.95	-0.11	-0.02	-0.11	0.03	-0.02	-0.03	-0.03	0.00	0.07	-0.01	-0.01	0.87
MCalfSkin	0.91	0.06	0.04	-0.08	0.06	-0.05	-0.07	-0.05	0.04	0.10	0.02	-0.16	0.75
PhHR0’	0.06	-0.70	0.10	0.17	0.07	-0.12	0.02	-0.06	0.00	0.05	0.15	-0.14	0.62
PhSatO_2	0.05	0.27	0.06	-0.25	0.02	0.02	0.16	-0.22	0.13	0.49	0.06	0.10	0.51
PhTensis0’	0.00	-0.02	0.05	-0.01	0.04	0.00	0.84	0.03	0.06	0.02	0.18	-0.01	0.75
PhTendia0’	0.01	-0.05	0.03	0.01	0.07	-0.03	0.86	-0.08	0.07	0.02	-0.12	0.10	0.75
PhRespir0’	-0.02	0.01	0.14	-0.11	0.13	0.11	0.05	-0.12	0.01	-0.24	0.70	-0.22	0.67
PhBodTem0’	-0.06	-0.15	-0.02	0.09	-0.16	-0.06	0.02	0.06	-0.03	0.16	0.67	0.20	0.59
PhVO_2max.abs	-0.04	0.95	0.05	0.20	0.00	-0.05	-0.02	0.02	-0.05	0.03	0.00	-0.02	0.95
PhVO_2max.rel	-0.34	0.60	0.03	-0.35	0.10	-0.06	-0.14	-0.05	-0.01	0.08	0.00	-0.02	0.91
PhCarOut	-0.04	0.95	0.05	0.20	0.00	-0.05	-0.02	0.02	-0.05	0.03	0.00	-0.02	0.95
BErythro	0.02	-0.01	0.96	0.09	-0.01	-0.02	0.06	-0.03	0.04	0.02	0.02	-0.05	0.93
BHaemglo	-0.02	0.03	0.95	0.03	0.02	0.00	0.04	-0.02	0.01	-0.02	0.05	-0.03	0.92
BLeukoc	-0.04	0.09	-0.01	0.00	0.10	0.02	0.08	-0.13	0.04	-0.10	0.02	0.82	0.70
BHematoc	0.05	-0.07	0.44	-0.05	-0.12	-0.02	-0.06	0.23	-0.24	0.09	-0.04	0.40	0.56
BGlycemi	0.03	-0.03	0.01	0.02	-0.02	-0.91	0.07	0.07	0.04	0.02	-0.03	0.01	0.84
BUrea	0.08	0.22	0.08	-0.10	0.17	-0.05	-0.14	0.76	0.18	-0.10	0.02	-0.03	0.71
BCreatin	-0.12	-0.15	-0.16	0.14	0.07	-0.04	0.08	0.68	0.03	0.27	-0.04	-0.09	0.64
BToChol	0.04	0.01	0.12	-0.14	-0.22	0.10	0.21	0.40	-0.15	-0.40	-0.11	-0.04	0.57
BUSG	0.02	-0.04	0.03	0.10	0.84	0.08	0.07	0.15	0.06	0.00	-0.01	-0.03	0.75
BpHU	-0.06	0.03	0.04	0.01	-0.87	0.04	-0.04	-0.03	0.18	0.03	0.03	-0.12	0.76
BUrinProt	-0.03	-0.06	0.05	0.09	-0.05	-0.02	0.20	-0.10	0.69	-0.03	-0.29	-0.15	0.63
BUrinGlu	0.03	0.02	0.00	-0.02	-0.02	-0.92	-0.01	-0.01	-0.07	-0.15	0.01	-0.01	0.86
BUrinKet	-0.08	0.04	0.00	-0.07	0.05	-0.12	0.01	-0.15	0.11	-0.80	0.07	0.13	0.69
BUrinUrobil	0.03	-0.07	0.11	0.29	0.01	0.04	-0.36	0.00	0.48	-0.02	0.03	0.24	0.53
BUrinEryth	0.03	-0.02	-0.07	-0.12	-0.04	-0.01	0.04	0.27	0.65	-0.01	0.18	0.05	0.53

Extraction Method: Principal Component Analysis. Rotation Method: Oblimin with Kaiser Normalization. a. Rotation converged in 21 iterations.

0.48; MTricSkin 0.93; MSubscSkin 0.86; MAbdSkin 0.84; MThighSkin 0.95; MCalfSkin 0.91). This factor might be named as the factor of the body volume and under-skin fat tissue;

· The second extracted latent factor has explained 8.31 % of the total variance and contains the higher projections of the variables that determine maximal oxygen uptake (PhVO_2max.abs 0.95; PhVO_2max.rel 0.60) and cardiac output (PhCarOut 0.95). This factor might be appointed as the factor of the maximal oxygen uptake;

· The third extracted latent factor has explained 6.58 % of the total variance and contains the higher projections of red blood cells (BErythro 0.96), haemoglobin (BHaemglo 0.95) and haematocrit (BHaemato 0.44). This factor might be named as the factor of the red blood cells;

· The fourth extracted latent factor has explained 5.46 % of the total variance and contains the higher projections of the variable of the body weight (MBW 0.61) and the body height (MBH 0.86). This factor might be named as the factor of the body height and weight;

· The fifth extracted latent factor has explained 4.89 % of the total variance and contains the higher values of the projections of the variables that inform the urine specific gravity (BUSG 0.84) and the urine pH (BpHU - 0.87). This factor might be identified as the factor of the urine specific gravity and acidity;

· The sixth extracted latent factor has explained 4.60 % of the total variance and contains the higher projections of the variables: glycaemia, and glycosuria (BGlycemi - 0.91; BUrinGlu - 0.92). his factor might be named as the factor of the glucose concentration in the blood and urine;

· The seventh extracted latent factor has explained 4.19 % of the total variance and contains the higher projections of the variables of the blood pressure while resting (PhTensi0' 0.84; PhTendia0' 0.86). This factor might be named as the factor of the blood pressure;

· The eighth extracted latent factor has explained 3.82 % of the total variance and contains the higher projections of the variables that inform the glomerular filtration rate (BUrea 0.76; BCreatin 0.68). Meanwhile, the variable of the total cholesterol realizing the same projection in two different latent factors (eighth factor 0.40 and tenth factor -0.40) shows its bipolarity. This factor might be named as the factor of the glomerular filtration;

· The ninth extracted latent factor has explained 3.48 % of the total variance and contains the higher projections of the variables: proteinuria (BUrinProt 0.69), urobilinogen in urine (BUrinUrobil 0.48) and erythrocytes in urine – haematuria (BUrinEryth 0.65). This factor might be named as the factor of urine proteins, erythrocytes and urobilinogen;

· The tenth extracted latent factor has explained 3.22 % of the total variance and contains the higher projections of the variables: blood oxygen saturation (PhSatO2 0.49), and the urine ketones (BUrinKet - 0.80). This factor might be named as the factor of the blood oxygen saturation, urine ketones and the total cholesterol;

· The eleventh extracted latent factor has explained 3.13 % of the total variance, and contains the higher projections of the variables: the frequency of respiration per minute while resting (PhRespir0'), and the body temperature while resting (PhBodTem0'). This factor might be named as the factor of the respiration and the body temperature;

· The twelfth extracted latent factor has explained 2.81 % of the total variance, and contains the higher projections of the variable that inform the number of white blood cells – Leucocytes (BLeukoc). Meanwhile the higher projection of the variable BHematoc (the haematocrit) in this factor (0.40) and in the third factor (0.44) shows its bipolar nature (Table III). This factor might be named as the factor of white blood cells.

Aiming to extract the uncorrelated latent factors, which may stand independently, there was proceeding with the factorization procedures of the second order. Thus, finding out the hierarchical structure of the latent factors of the second order will enable easier interpretation and understanding of the latent structure of treated variables. Following the same procedures of the Factor Analysis as in the factorization of the first order, were extracted 5 latent components (factors) that explain 51.39 % of the total variance. The data of the pattern matrix (Table IV) indicate the projections of 12 latent factors of the first order on 5 extracted latent factors of the second order. The nature of the extracted latent components of the second order is determined based on the nature of the latent factors of the first order that have realised the higher projections on the latent components of the second order.

Table IV. Pattern Matrix & Communalities.

	Component 1	Component 2	Component 3	Component 4	Component 5
Factor 1	0.68	0.03	-0.06	0.09	-0.30
Factor 2	-0.18	-0.05	0.12	-0.69	0.15
Factor 3	-0.06	0.73	0.04	-0.32	-0.03
Factor 4	0.25	0.07	0.09	0.06	-0.64
Factor 5	0.06	-0.14	0.65	-0.19	0.07
Factor 6	0.31	-0.03	-0.30	0.13	0.54
Factor 7	0.76	-0.14	0.01	-0.08	0.05
Factor 8	0.05	-0.09	-0.18	0.03	-0.57
Factor 9	-0.11	0.04	0.63	0.24	-0.12
Factor 10	-0.23	-0.15	0.20	0.56	0.17
Factor 11	0.34	0.46	0.35	0.12	0.19
Factor 12	-0.19	0.63	-0.26	0.19	-0.01

Extraction Method: Principal Component Analysis. Rotation Method: Oblimin with Kaiser Normalization. Rotation converged in 23 iterations.

· The first extracted latent component has explained 14.15 % of the total variance and contains the higher projections of the 1st and 7th extracted latent factor. This component might be named as the factor of the body composition and the blood pressure;

· The second extracted latent component has explained 10.25 % of the total variance and contains the higher projections of the 3rd, 11th and 12th extracted latent facto. This component might be named as the factor of the body composition and the blood pressure;

· The third extracted latent component has explained 9.55 % of the total variance and contains the higher projections of the 5th and 9th. This component might be named as the factor of the kidneys filtration and reabsorption;

· The fourth extracted latent component has explained 8.83 % of the total variance and contains the higher projections of the 2nd and 10th extracted latent factor. This component might be named as the factor of the cardiorespiratory fitness and the urine ketones;

· The fifth extracted latent component contains the higher projections of the 4th, 6th and 8th extracted latent factor. This component might be named as the factor of the body morphometry, glycaemia and the glomerular filtration.

CONCLUSION

According to the average values of the measured variables it can be concluded that the tested entities belong to the group of entities with the average high stature, normal body weight and with normal and consistent physiological and biochemical variables.

The factor analyses method of the first and the second order was used to find out the final hierarchical structure of the latency of the morphometric, physiological and biochemical measured variables. The factorization of the first order enabled extraction of 12 latent factors, which explained 74.84 % of the total variance, while the factorization of the second order enabled extraction of five latent components (51.39 % of the total variance). Although at the factorization of the second order, compared with the factorization of the first order, the number of factors and the explained percentage of total variance were decreased rapidly, the nature of the extracted latent factors/components in both orders of factorization is relatively clear, understandable, logical and relatively easy to interpret.

These clear manifest and latent relations between selected morphometric-physiological-biochemical variables are not enough to come to final conclusions that will help the holistic approach to these biometric variables. Furthermore, these manifest and latent relations between morphometric-physiological-biochemical dimensions should be explored form the point of view of anatomy, physiology, biochemical and other sciences of medicine.

REXHEPI, A. M. & BRESTOVCI, B. Relaciones latentes entre parámetros morfométricos, fisiológicos y bioquímicos seleccionados. *Int. J. Morphol., 37(3)*:830-837, 2019.

RESUMEN: El objetivo principal de este estudio fue explorar las relaciones latentes de parámetros morfométricos, fisiológicos y bioquímicos seleccionados. Treinta y seis variables (12 morfométricas, 9 fisiológicas y 15 bioquímicas) se midieron en 317 hombres de 17 a 35 años. Los datos obtenidos fueron analizados a través del análisis factorial de primer y segundo orden. Los análisis estadísticos se realizaron con el software IBM SPSS Statistics, versión 20. La factorización del primer orden permitió la extracción de 12 factores latentes que explican el 74,8 % de la varianza total, mientras que la factorización del segundo orden permitió la extracción de cinco componentes latentes que determinaron el 51,39 % de la varianza total. Los resultados finales de este estudio confirmaron la hipótesis principal de que existen números de variables latentes que explican la estructura latente de las medidas biométricas seleccionadas. La naturaleza de los factores/componentes latentes extraídos en ambos órdenes de factorización es relativamente clara, comprensible y fácil de interpretar. Las proyecciones superiores de las variables biométricas manifiestas en los factores latentes extraídos del primer y segundo orden correspondieron a la naturaleza de las variables medidas. Los resultados de esta investigación podrían considerarse como un paso más en el enfoque holístico de las medidas biométricas.

PALABRAS CLAVE: Multidimensional; Análisis factorial; Varianza total; medidas biométricas; Homeostasis humana; Variables manifiestas; Factores latentes; Componentes latentes.

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