

## Discrimination of Athletes and Non-athletes Based on the Latent Structure of Some Biometric Variables

Discriminación entre Atletas y No Atletas Basada en la Estructura Latente de Algunas Variables Biométricas

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**SUMMARY:** The aim of this exploratory study was to explore impact of organized physical activities on the latent structure of some morpho-functional variables. Discrimination between group of athletes (167 entities, aged 22.4 years) and group of non-athletes (150 entities, aged 25.7 years) has been explored in latent structure of 12 morphometric variables, 4 physiological variables and 7 hematological variables. The significant differences between athletes and non-athletes on four extracted latent factors, were explored through Canonical Discriminant Analyses. The confirmed significant differences between two explored groups indicate the impact of regular and well organized physical activities on morphometric characteristics, physiological abilities, and hematological parameters. The results of this exploratory study may encourage us to compose and to apply well organized physical activities for children, elders, and overweight persons that will be profitable for their health.

**KEY WORDS:** Canonical discriminant analyses; Latent factors; Morpho-functional variables.

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### INTRODUCTION

There are number of studies dealing with regularly sport training as well as with sport nutrition as two very important external factors, which together with genetic factor, significantly affect on morpho-functional performances of athletes (McArdle *et al.*, 2001). The measurement of the basic morpho-functional characteristics of the athletes are the foundation on which may be evaluated the efficiency of the training process on developing of these abilities. It is known that endurance and resistance exercises increase the amount of human growth hormone in circulation (Godfrey *et al.*, 2003; Jenkins, 1999; Sutton & Lazarus, 1976).

Many researches show that the athletes can show big potential and maintain their high performance, only if their cardio respiratory function, energy expenditure, and blood lactate system are well controlled (Imamura *et al.*, 1999). The elite athletes have lower heart rate at rest, before and after exercise, as well as they can recover quickly to a rest state, compared with non-athletes (Jack & David, 1999).

Enhancement of morpho-functional abilities of athletes such as aerobic and anaerobic capacity, speed, muscle strength, recovery and neuromuscular coordination, are the main duties of sport science training. Ability of an athlete to perform at peak performance during the main competition is also related to strength training (Zabukovec & Tiidus, 1995). According to many scientists (Bangsbo *et al.*, 2006; Howley *et al.*, 1995; Hoff *et al.*, 2002; Midgley *et al.*, 2007) the physical conditioning, respectively, aerobic capacity depend upon: maximal oxygen consumption, anaerobic threshold, work economy and recovery to maintain good performance throughout the competitive phase the gained physiological base, respectively skills, of the athletes must be maintained (Bompa & Carrera, 2005).

The determination of physiological variables, such as the anaerobic threshold and maximal oxygen uptake, will help in realization of the major requirement for coaches and athletes: to define the endurance performances of athletes (Bentley *et al.*, 2001).

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Prolonged bouts of strenuous exercise may cause a temporary depression of various aspects of immune function that usually lasts approximately 3-24 hours after exercises, depending on the intensity and duration of the exercise bout. This post-exercise immune function depression, respectively the higher susceptibility to infection in athletes, is most pronounced when exercise is continuous, prolonged, of moderate to high intensity and performed without food intake (Gleeson *et al.*, 2006).

Heavy exercise may also increase iron needs by up to another 1 to 2 milligrams day. This may be caused by a combination of factors, including iron loss in sweat, blood loss from the urinary tract or gastrointestinal system and the breakdown of the red blood cells in the circulation from heavy foot striking (foot-strike hemolysis). Approximately, 25% of female and 10% of male athletes have iron deficiency (Constantini *et al.*, 2000; Dubnov & Constantini, 2004). Even if, athletes are more sensitive to the effects of iron deficiency because they depend on the body's ability to transport oxygen to the muscles, among them, the prevalence of iron depletion without anemia seems to be significantly higher than among the general population (Constantini *et al.*).

The clinical signs of iron deficiency anemia are well-known: a decrease in physical and mental performance.

The aim of this exploratory study was to explore impact of organized physical activities on the latent structure of some morpho-functional variables of the people who trained systematically.

## MATERIAL AND METHOD

This research is a part of the project: "The differences between athletes and non-athletes of Kosova", realized in Center for Sports Medicine and Recreation in Prishtina, Kosova.

Differences between group of athletes (167 entities, aged 22.4 years) and group of non-athletes (150 entities, aged 25.7 years) has been explored in latent structure of 12 morphometrical variables, 4 physiological variables and 7 hematological variables. The tested athletes were professional footballers and basketballers from Kosova.

Trying to avoid mistakes during measurements, the sports entities were measured in the morning hours (08:00 – 11:00 Am).

The measurement procedures were done in the Center

of Sports Medicine and Recreation in Prishtina – Kosovo, during the period 2002 – 2003, and were in accordance with the ethical standards of the Ethics Committee of University Clinical Center in Prishtina.

The following 12 morphometrical variables were measured according to the standards and instructions of the International Biological Program, using the classic anthropometrical instruments (anthropometer, classic weigher, millimetric tape, and skinfold caliper):

Stature – Body height measures the distance from the standing surface to the top (vertex) of the skull.

Body volume and weight variables:

- Body Weight – Is a measure of body mass;
- Humeral Perimeter – shows maximum circumference of the arm (humerus);
- Chest Perimeter – shows maximum circumference of the thorax at the mammilla level;
- Abdominal Perimeter – shows circumference of the abdomen at the umbilicus level;
- Thigh Perimeter – shows maximum circumference of the thigh;
- Calf Perimeter – shows maximum circumference of the calf;
- Skinfold thickness variables:
  - Triceps Skinfold – shows subcutaneous adipose tissue on the back of the arm (humerus) over the triceps muscle;
  - Subscapular Skinfold – shows subcutaneous adipose tissue on the back just below the inferior angle of scapula;
  - Abdominal Skinfold – shows subcutaneous adipose tissue of the abdomen at the umbilicus level 5 cm on the left;
  - Thigh Skinfold – shows subcutaneous adipose tissue on the thigh;
  - Calf Skinfold – shows subcutaneous adipose tissue on the calf, measured at the same level like calf's perimeter;

Physiological variables:

- Heart Rate – is determined by the number of heartbeats per unit of time (expressed as beats per minute – BPM). Heart rate was measured by stethoscope on apex cordis.
- Systolic blood pressure – Is a measure of blood pressure while the heart is beating (has been measured with sphygmomanometer).
- Diastolic pressure – Is a measure of blood pressure while the heart is relaxed (has been measured with sphygmomanometer).
- VO<sub>2</sub>max – refers to the maximum amount of oxygen that an individual can utilize during intense or maximal exercise. It is measured as "milliliters of oxygen used in one minute per kilogram of body weight."

Hematological variables:

- Erythrocytes – or red blood cells, make up the largest population of blood cells, numbering from 4.5 million to 6 million per mm<sup>3</sup> of blood.
- Hemoglobin – is the essential protein that carries oxygen in the red blood cell. The hemoglobin test measures the grams of hemoglobin per 100 milliliters of blood volume. Normal values for women are 12 to 15 g/100 ml of blood.
- Leucocytes – or white blood cells are cells of the immune system involved in defending the body against both infectious disease and foreign materials.
- Hematocrit – The hematocrit test measures the percentage of plasma that red blood cells comprise.
- Glycemia – means the level of glucose in one’s blood.
- Urea – is an organic chemical compound which essentially is the waste produced when the body metabolizes protein.
- Creatine – is naturally produced in the human body from amino acids primarily in the kidney and liver. It is transported in the blood for use by muscles.

The gained results, initially, were analyzed in terms of basic statistical parameters. Through Factor Analysis has been analyzed the latent structure of measured variables. And, finally the differences between athletes and non-athletes on the level of the extracted latent factors were explored through applied the statistical procedures of T-test, and Canonical Discriminant Analysis.

Table I. Descriptive Statistical Parameters.

Variables	Athletes (n=167)		Non-Athletes (n=150)	
	Mean	SD	Mean	SD
Body Weight	71.13	9.55	72.31	9.33
Stature	1771.52	73.94	1759.83	51.09
Humeral Perimeter	275.95	26.65	286.60	26.32
Chest Perimeter	905.34	50.84	939.27	63.45
Abdominal Perimeter	776.41	59.67	810.12	82.31
Thigh Perimeter	545.71	41.83	545.41	46.55
Calf Perimeter	366.52	24.81	361.56	26.82
Triceps Scinfold	79.03	36.37	91.95	47.11
Subscapular Scinfold	86.80	33.89	105.39	46.66
Abdominal Scinfold	95.56	58.37	146.10	91.30
Thigh Scinfold	109.28	70.24	156.62	95.79
Calf Scinfold	82.49	40.68	91.19	46.78
Heart Rate 0'	66.87	11.30	75.99	12.56
Systolic Pressure	112.40	11.37	112.42	12.21
Diastolic Pressure	76.30	7.25	76.05	8.53
VO <sub>2</sub> max.abs	3.20	0.27	2.73	0.28
Erythrocytes	4.16	0.24	4.09	0.22
Hemoglobin	138.96	11.83	135.08	10.51
Leucocytes	6.38	1.36	6.10	1.36
Hematocrit	44.89	3.28	45.77	3.23
Glycemia	4.75	1.51	4.41	0.66
Urea	5.79	1.35	5.29	1.30
Creatine	73.29	10.76	77.58	7.71

## RESULTS AND DISCUSSION

All statistical procedure was based on the statistical package SPSS 17 for Windows. The findings of descriptive statistical parameters, for the measured variables in each treated group, are shown in Table I. According to results of Table I we can conclude the systematic differences on almost all measured variables between group of athletes and group of non-athletes.

Factor analysis is used to study the patterns of relationship among many dependent variables, with the goal of discovering latent variables which affect them. These independent variables could not be measured directly.

The appropriateness of factor analysis is tested by Kaiser-Meyer-Olkin (KMO) index, and Bartlett's Test of Sphericity.

Based on the high value of KMO index (0.856) and significance of Bartlett's Test of Sphericity (Sig.=0.000) shown on Table II, we can conclude that the relationships among measured variables are very strong - so we can continue with further procedures of factor analysis.

According to principal component analysis of Factor Analysis, with rotation method direct oblimin, and using SMC criterion (minimal common variability), have been extracted four latent components (factors) that explains 59.43% of total variance (Table II).

Once the optimal number of factors has been determined, we should try to interpret the meaning of these factors. The oblique rotation solutions are more interpretable than the orthogonal rotation solutions. And because the pattern matrix (Table III) allows the easiest interpretation of extracted latent factors, as well contains coefficients which represent unique contributions, we'll try to explain the results of this matrix.

Based on Table III we can conclude that the best projections on the first extracted latent factor have realized all the anthropometric variables that provide information about body weight, volume and skinfold. So, this factor, which explains 34.88% of total variance, might be appointed as factor of body weight, volume and skinfold.

Table II. Total Variance Explained, Community, Coefficient of multiple correlations, SMC criterion.

Component	Total	% of Variance	Cumulative %	h <sup>2</sup>	R <sup>2</sup>	SMC-criterion
1	8.02	34.88	34.88	0.96	0.95	
2	2.28	9.91	44.78	0.71	0.68	
3	1.95	8.48	53.26	0.75	0.75	
4	1.42	6.17	59.43	0.79	0.78	
5	1.37	5.97	65.39	0.82	0.85	
6	1.15	5.00	70.39	0.85	0.86	
7	1.09	4.75	75.15	0.71	0.68	
8	0.93	4.04	79.19	0.78	0.72	
9	0.86	3.73	82.92	0.82	0.82	
10	0.74	3.20	86.12	0.82	0.82	
11	0.57	2.49	88.61	0.87	0.84	
12	0.56	2.43	91.04	0.75	0.76	
13	0.39	1.70	92.74	0.76	0.41	
14	0.34	1.47	94.21	0.79	0.42	
15	0.26	1.11	95.32	0.78	0.43	
16	0.24	1.02	96.34	0.81	0.50	
17	0.22	0.93	97.27	0.90	0.88	
18	0.16	0.71	97.99	0.90	0.88	
19	0.14	0.59	98.57	0.33	0.07	
20	0.12	0.51	99.08	0.52	0.20	
21	0.11	0.48	99.56	0.42	0.07	
22	0.06	0.27	99.82	0.72	0.21	
23	0.04	0.18	100.00	0.71	0.25	<b>0.60</b>

On the second factor, which explains 9.91% of total variance, the best projections have realized four hematologic variables that provide us with information of hematogram. Two of these variables, which inform about red blood cells (erythrocytes 0.93, hemoglobin 0.93), realized the higher values of projections on this factor. Rightly, this factor might be known as the hematopoietic factor.

On third latent factor that explains 8.48% of total variance, the best projections have realized one anthropometric variable (Stature), together with heart rate (HR), as well maximal oxygen uptake (VO<sub>2</sub>max). This factor we might appoint as factor of stature and the aerobic ability.

On fourth extracted factor, which explains 6.17% of total variance, the best projections have realized the variables of blood pressure, blood sugar, urea, and creatine.

Table III. Pattern Matrix.

Variables	Factor 1	Factor 2	Factor 3	Factor 4
Body Weight	<b>*0.90</b>	0.01	0.27	0.16
Stature	0.23	0.12	<b>*0.42</b>	0.39
Humeral Perimeter	<b>*0.84</b>	-0.02	0.01	0.03
Chest Perimeter	<b>*0.80</b>	-0.02	0.06	0.08
Abdominal Perimeter	<b>*0.88</b>	0.04	-0.03	0.02
Thigh Perimeter	<b>*0.90</b>	-0.06	0.21	0.09
Calf Perimeter	<b>*0.75</b>	-0.09	0.37	0.08
Triceps Scinfold	<b>*0.77</b>	0.11	-0.23	0.00
Subscapular Scinfold	<b>*0.83</b>	0.06	-0.25	-0.13
Abdominal Scinfold	<b>*0.82</b>	0.00	-0.32	-0.08
Thigh Scinfold	<b>*0.81</b>	0.01	-0.33	-0.05
Calf Scinfold	<b>*0.72</b>	0.03	-0.17	0.00
Heart Rate 0'	0.23	0.06	<b>*-0.59</b>	0.16
Systolic Pressure	0.47	-0.03	0.15	<b>*-0.48</b>
Diastolic Pressure	0.46	-0.04	0.14	<b>*-0.58</b>
VO <sub>2</sub> max.abs	-0.09	0.07	<b>*0.81</b>	0.05
Erythrocytes	0.04	<b>*0.93</b>	0.04	0.04
Hemoglobin	-0.03	<b>*0.93</b>	0.06	0.02
Leucocytes	-0.04	<b>*0.26</b>	0.08	-0.21
Hematocrit	0.06	<b>*0.54</b>	-0.13	0.12
Glycemia	0.04	0.08	0.00	<b>*0.27</b>
Urea	0.05	0.00	0.18	<b>*0.56</b>
Creatine	0.12	-0.32	-0.06	<b>*0.51</b>

The results shown on Table IV, shows that the four extracted latent factors have not realized significant correlation between them, so they can stay independently.

One-dimensional differences of latent space, between group of non-athletes and group of athletes, have been explored using t-test. According to the results of Table V we can conclude the significant differences between non-athletes and athletes in first, second and third latent factor, whereas in fourth latent factor they are similar. Among three latent factors that have significant discriminant power, third factor, which informs us about stature and conditioning abilities of tested entities, has the higher impact in discrimination between groups.

As has been mentioned, the aim of this exploratory study was to determine the significant differences in latent structure between group of non-athletes

Table IV. Component Correlation Matrix.

Components	Factor 1	Factor 2	Factor 3	Factor 4
Factor 1	1.000			
Factor 2	1.749E-02	1.000		
Factor 3	-4.297E-02	3.044E-02	1.000	
Factor 4	4.622E-02	-1.633E-02	2.442E-02	1.000

Table V. T-test for independent groups.

Components	t	df	Sig.
Factor 1	3.214	315	0.001
Factor 2	-2.481	315	0.014
Factor 3	-13.153	315	0.000
Factor 4	.890	315	0.374

and the group of athletes. In this purpose, the canonical discriminant analysis was used to determine which of the latent variables better discriminates two tested groups. Because the measurements have been done on two groups, the obtained matrix is singular with one discriminant function (Summary of canonical discriminant functions: Function 1= 0.656, Rc= 0.629, Wilks' Lambda=0.604, Chi-square=157.864, Sig.=0.001).

Based on this results, we can ascertain the significant differences (Sig =0.000) between two tested groups on the system of the latent variables. On Table VI are shown the correlations that four latent factors were realized on discriminant function (structure of the canonical discriminant function).

Table VI. Structure Matrix.

Components	Function
Factor 3	0.915
Factor 1	-0.224
Factor 2	0.173
Factor 4	-0.062

Arithmetic mean of the discriminant values of the tested groups, which presents centroid of a group (Non-athletes=-0.852 and Athletes=0.765), indicates that differences between two tested groups are more than 1.5 Sigma.

According to the structure of discriminant function (Table VI), and values of the group centroids, can be explained the characteristics of groups that were tested: Athletes compared with non-athletes are characterized with higher stature, better aerobic abilities, lower values of adipose tissue, and more or less, better values of blood elements.

## CONCLUSIONS

The results of this exploratory study, confirm influence of regular physical activities on latent structure of morpho-physiological and hematological parameters, as well these results can be applied to few categories of population:

- Children – If parents encourage sports participation at an early age, the child will have a better chance for the healthy morphometrical and physiological development;
- Obese persons – Regular physical activities associated with healthy nutritional diet, significantly will impact on reducing of adipose tissue, as well on decreasing of overweight;
- Elders – Regular physical activities to this category will help them to maintain cardio-respiratory system, as well loco-motor system.

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**RESUMEN:** El objetivo de este estudio exploratorio fue determinar el impacto de las actividades físicas organizadas sobre la estructura latente de algunas variables morfo-funcionales. Se estudiaron y discriminaron entre un grupo de atletas (167 sujetos, edad promedio 22,4 años) y no atletas (150 sujetos, edad promedio 25,7 años) la estructura latente de 12 variables morfométricas, 4 variables fisiológicas y 7 variables hematológicas. Las diferencias significativas entre los atletas y no atletas en cuatro factores latentes se estudiaron mediante análisis discriminantes canónicos. Las diferencias significativas entre los dos grupos demuestran el impacto de las actividades físicas regulares y bien organizadas sobre las características morfométricas, capacidades fisiológicas y parámetros hematológicos. Los resultados de este estudio exploratorio pueden incentivarlos a componer y aplicar actividades físicas bien organizadas para niños, ancianos y personas con sobrepeso, las que serán beneficiosas para su salud.

**PALABRAS CLAVE:** Análisis discriminantes canónicos; Factores latentes; Variables morfofuncionales.

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