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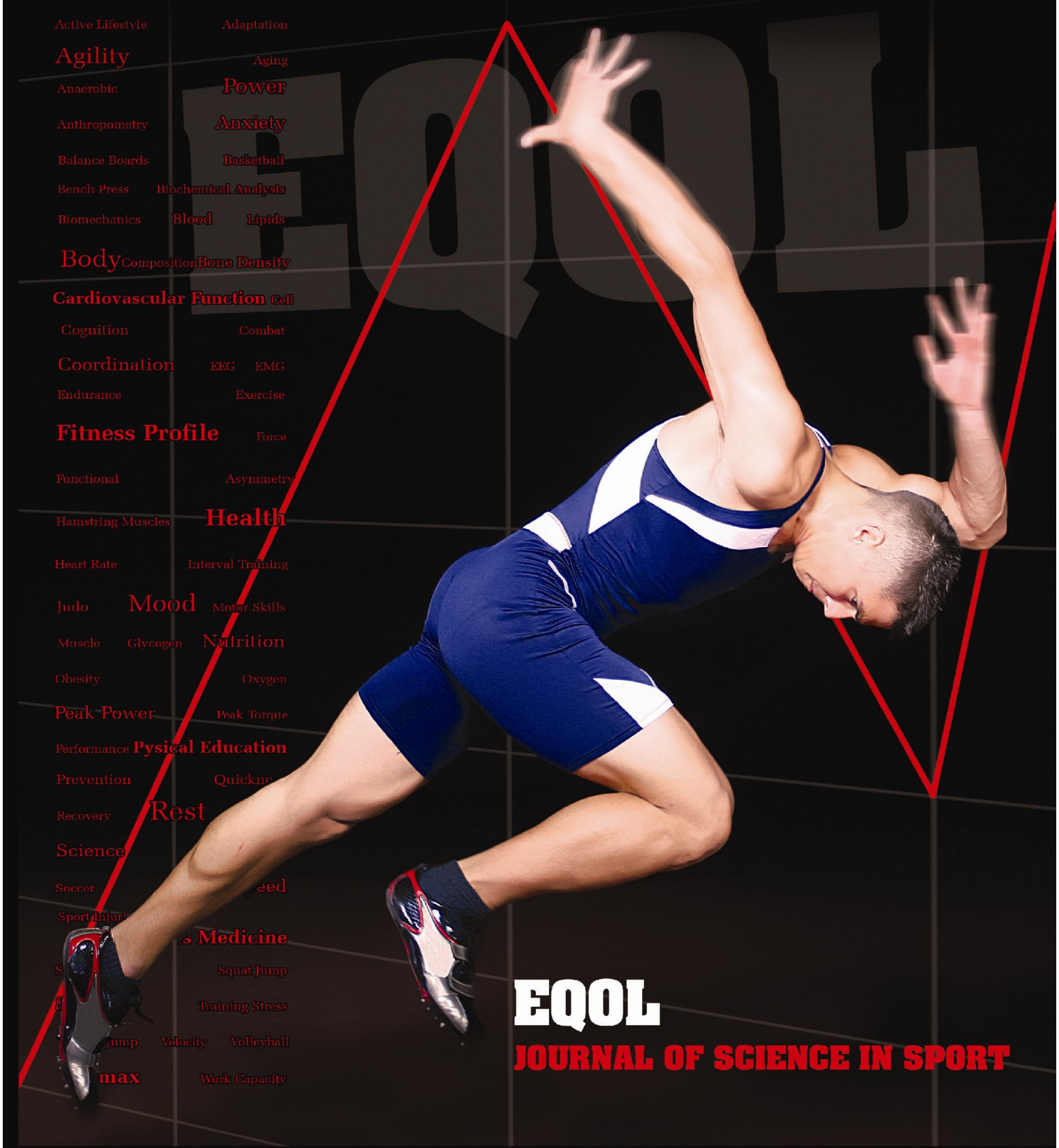

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Contents

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Research article

RELATIONS BETWEEN ANTHROPOMETRIC CHARACTERISTICS AND LATENT DIMENSIONS OF STRENGTH IN PERSONS OF ABOVE-AVERAGE MOTOR ABILITIES

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Abstract

Mere enrollment on the Faculty of Sport and Physical Education assumes that the population has been selected according to several criteria. One of the most typical criteria is motor development, hence students of sport and physical education might be treated as persons of above-average motor abilities. Test battery of 17 anthropometrical tests and 14 strength tests has been applied on the sample of 149 males, students of the Faculty of Sport and Physical Education in Novi Sad. The purpose of this paper is to determine relations between anthropometrical measures and latent dimensions of strength. Within the latent space of strength, after Promax rotation of major components and based on KG criteria, three strength factors have been isolated: static and repetitive strength, especially that of hands and trunk to a lesser degree, explosive strength of legs, and explosive strength of arms. Finaly, three statistically significant canonical correlations have been isolated. The first is that of explosive strength of arms having negative correlation with all anthropometrical variables, the second is explosive strength of legs which is in negative correlation with subcutaneous fat tissue of upper leg and triceps, but in positive correlation with the measures of longitudinal dimensionality of skeleton, whereas the third is static and repetitive strength of arms (and trunk to a lesser degree) being in negative correlation with body height and leg length.

Key words: students/ static and repetitive strength/ explosive strength

Introduction

Anthropometric characteristics are the most obvious area within the bio-psycho-sociological status of the human population. They are the manifestation of morphological dimensions such as the constitution, body composition, structure or assembly as an organized

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and relatively constant integrity of features relative to each other. This set is usually formed by endogenous factors (internal) and to a lesser extent by exogenous (external, middle).

Motor skills are usually defined as indicators of development level of the basic motion dimensions of human that influence the successful realization of movement, regardless of whether that skills are acquired through training or not. Motor ability, examined in this work - strength, Zaciorski (1975) defines as the ability of man to overcome the external resistance, or to confront him with straining of muscle.

The sample of respondents is comprised of persons of above average motor skills, in fact, students of the Faculty of Sport and Physical Education. Mere enrollment on this kind of faculty assumes that the population has been selected according to several criteria, including: the level of biological development, the level of health development (injured or sick respondents do not even take the entrance exam), the level of motor development and the level of intellectual and conative development . One of the most typical criterion is exactly the motor development, and hence it is mentioned above.

Researching of relationships between anthropometric characteristics and dimensions of latent power in people of above average motor skills was conducted by numerous authors starting from Kurelić, Momirović, Stojanović, Šturm, Radojevć and Viskić-Štalec (1975), and their capital work, to the latest researches by Pržulj and Pelemiš (2010). These authors have obtained relatively high correlation of areas mentioned.

The aim of this paper is to determine the relation between anthropometric characteristics and latent dimensions of strength of this specific population.

Method

The sample of participants in this paper consisted of 149 male students of Faculty of Sport and Physical Education from Novi Sad. The mean age of participants on the test day was 20.15 decimal years (± 0.83). All of the participants were clinically healthy and highly motivated to participate, on the test day.

The battery of 17 anthropometric measures was applied on respondents, 15 measures that are part of the International Biological Program (IBP) battery and two that are not, but the authors felt that their use will contribute to better understanding of relations between studied areas. Exactly as directed by IBP, measurements of anthropometric characteristics were carried out.

According to factorial morphological model (Viskić-Štalec, 1974; Kurelić, Momirović, Stojanović, Šturm, Radojević, & Viskić-Štalec, 1975; Stojanović, Solarić, Vukosavljević, & Momirović, 1975, etc..), the following measures were applied:

- For evaluation of the longitudinal dimensionality of the skeleton: Body height, Arm length and Leg length.
- For evaluation of the transversal dimensionality of the skeleton: Diameter of the ankle, Diameter of the knee joint and Diameter of the pelvis.
- For evaluation of the body volume and weight: Body weight, Circumference of the chest (middle), Circumference of the upper arm (stretched), Circumference of the upper arm (during flexion and contraction), Circumference of the upper leg and Circumference of the lower leg.

- For evaluation of the subcutaneous fat tissue: Skin fold on the back (subscapular), Forearm skin fold (triceps), Skin fold of the abdomen, Skin fold of the upper leg and Skin fold of the lower leg.

For the evaluation of strength a battery of 14 motor tests was applied, which in previous researches showed great reliability on the respondents of similar age and of similar life style. Applied battery is part of a far more complex battery defined by Metikoš, Prot, Hoffman, Pintar and Oreb (1989) and based on its standardization, qualified measurers performed the measurement.

The battery consisted of the following measuring instruments: Pull-ups, Lifting the trunk in 30 seconds, Horizontal endurance on the back, Standing long jump, Deep squat for 30 seconds, Throwing a medicine ball while lying on the back, Endurance in a push-up, Straightening of trunk, Standing high jump, Endurance under load in half-squat, Throwing a medicine ball from the chest during spread leg sitting, Hanging while in pull-up position, Push-ups and Standing triple jump.

Also, a detailed description and organizational details related to the measurement can be found in Cvetković (2007).

As far as statistical processing, we applied the following statistical procedures:

For all variables that were used, the basic descriptive statistics were calculated. Then, the variables which evaluated strength were factorized by rotating the initial matrix into a more favorable OBLIVAX oblique solution (Momirović, 1998). In the paper by Momirović (1999), the behavior of different types of oblique factorial solutions was described, and was found that OBLIVAX oblique rotation extracted latent dimensions with the most information and with greatest representativeness, even compared to other oblique rotations like Orthoblique rotation (Harris & Kaiser, 1964), Promax (Hendrickson & White, 1964) and Direct oblimin (Jenrich, & Sampson, 1966) which were applied in the same paper. The number of statistically significant factors was determined based on Intruder in the Dust (ITD) criterion (Momirović, 1998), which is a relaxed PB criterion (Štalec and Momirović, 1971) and also represent a compromise between the criteria with the hyper-factorization tendency (eg., KG (Kaiser, 1961)) and the criteria with hypo-factorization (eg., Scree (Cattel, 1966)). Factors extracted in this way are latent dimensions of power, and after extraction their definition followed. Relationships between the latent dimensions of strength and anthropometric characteristics were determined by canonical correlation analysis, while observing if the variables sets are well designed and which one was better designed in the second set, was performed by redundant analysis.

Results

Tables 1 and 2 show the basic descriptive statistics of variables.

Table 1

Basic descriptive statistics of anthropometric variables

VARIABLE	M	SD	MIN	MAX	SKE	KUR
Body height (mm)	1816.26	62.996	1670	1975	.054	-.625
Arm length (mm)	798.32	36.171	717	899	.036	-.304
Leg length (mm)	1022.36	44.142	894	1134	-.068	-.010
Ankle diameter (mm)	70.99	3.895	62	85	.694	1.132
Knee joint diameter (mm)	100.22	4.324	91	113	.166	-.204
Width of the pelvis (mm)	286.68	16.600	255	345	.505	.534
Body weight (kg)	77.900	9.3314	54.6	123.8	.894	3.223
Chest circumference, middle (cm)	96.71	5.440	80	118	.399	1.762
Circumference of stretched upper arm (cm)	28.13	2.614	22	36	.677	.890
Circumference of bent upper arm (cm)	31.89	2.785	24	40	.468	.609
Upper leg circumference (cm)	56.23	4.358	45	74	.404	1.317
Lower leg circumference (cm)	36.74	2.400	32	44	.269	.099
Back skin fold (mm)	118.56	33.335	68	254	1.375	2.777
Triceps skin fold (mm)	91.02	32.100	28	190	.605	.092
Abdominal skin fold (mm)	131.31	51.240	52	300	.696	-.062
Upper leg skin fold (mm)	157.95	47.499	50	300	.195	-.289
Lower leg skin fold (mm)	96.82	39.948	40	240	1.083	1.054

Legend: M – mean, SD – standard deviation, MIN – minimal result, MAX – maximal result, SKE – skewness, KUR - kurtosis

Based on the results from Table 1 it can be seen that the homogeneity of the sample is present on all the variables, except for variables of Back skin fold and Lower leg skin fold where some higher skewness results were observed, but nothing worrisome because it is not uncommon that the values for subcutaneous fat are not normally distributed (eg Momirović, Hošek, Prot and Bosnar, 2003). Also, skewness is positive in all variables that assess the subcutaneous fat tissue, which indicates that the distribution curve of results found in these variables moved to the area of small values, which in turn implies that the students of the Faculty of Physical Education are generally athletic type, which is expected.

Table 2.

Basic descriptive statistics of the strength variables

VARIABLE	M	SD	MIN	MAX	SKE	KUR
Pull-ups (freq.)	10.67	5.274	0	31	1.089	1.815
Lifting the trunk (freq.)	30.28	3.257	22	38	.173	.024
Horizontal endurance (s)	52.75	23.283	12	142	.890	1.561
Standing long jump (cm)	245.87	18.461	198	299	.228	.637
Deep squat (freq.)	32.15	2.432	23	39	-.159	1.340
Throwing a medicine ball (cm)	1034.56	142.024	640	1490	.146	.305
Endurance in a push-up (s)	43.92	17.968	16	127	1.059	2.168
Straightening of trunk (freq.)	67.42	29.806	11	200	1.855	4.977
Standing high jump (cm)	52.06	6.117	37	73	.527	.776
Endurance in half-squat (s)	64.92	34.406	12	255	1.694	5.798
Throwing a medicine ball (sit) (cm)	684.63	78.297	500	910	.243	.161
Hanging while in pull-up (s)	62.25	18.357	20	106	.196	-.312
Push-ups (freq.)	15.43	8.135	2	50	1.362	2.811
Standing triple jump (cm)	685.07	53.263	530	851	.268	.300

By looking at Table 2 we can observe that the value of the skewness in the variables Straightening of trunk, Endurance in half-squat and Pushups supports the fact that the motor ability assessed with these measuring instruments isn't applied on a homogeneous population. Since the strength is in question, where the difference in the quality of performance depends from person to person, even this finding isn't worrying.

Table 3

Results of OBLIVAX rotatation according to ITD criteria

VARIABLE	H*1	A**1	H2	A2	H3	A3
Pull-ups	**.816**	**.763**	.437	.183	-.298	.029
Lifting the trunk	**.613**	**.558**	.217	-.036	-.376	-.191
Horizontal endurance	.351	.327	-.250	-.558	-.554	-.616
Standing long jump	.369	.046	**.901**	**.862**	-.362	-.073
Deep squat	**.570**	**.558**	.163	-.059	-.270	-.092
Throwing medicine ball (back)	.337	-.015	.475	.237	**-.836**	**-.765**
Endurance in a push-up	**.780**	**.788**	.255	-.015	-.266	.006
Straightening of trunk	.236	.210	-.027	-.179	-.267	-.250
Standing high jump	.299	.001	**.865**	**.866**	-.272	.003
Endurance in half-squat	.266	.203	.068	-.084	-.304	-.259
Throwing a medicine ball (sit)	.156	-.225	.439	.252	**-.835**	**-.834**
Hanging while in pull-up	**.607**	**.683**	.286	.173	.090	.385
Push-ups	**.802**	**.761**	.362	.090	-.325	-.028
Standing triple jump	.307	-.005	**.870**	**.857**	-.317	-.047

Legend:, *H – structure, **A – pattern

After factorial analysis (Table 3) it was noted that three principal components were identified. The first principal component is composed of the following manifestations: Endurance in push-up, Pull-ups, Push-ups, Hanging while in pull-up and to a lesser degree Lifting the trunk and Deep squat, so this factor could be interpreted as *Static and repetitive strength* mainly of arms, and to a lesser degree of trunk.

The second factor was defined based on three manifestations: Standing high jump, Standing long jump and Standing triple jump and unambiguously is defined as *Explosive leg strength*.

The third factor consisted of: Throwing a medicine ball while sitting and Throwing a medicine ball while lying on back and was defined as *Explosive arm strength*.

Table 4

Factors correlations
(Pearson's correlation - the lower triangle, the statistical significance - the upper triangle)

FACTORS	1.	2.	3.
1. Static and repetitive strength		.565	.166
2. Explosive leg strength	-.048		.000
3. Explosive arm strength	.114	-.735	

By observing the Table 4 we can notice that there is statistically significance at the level of p = 0.000 between the second and third factor, Explosive leg strength and Explosive arm strength, suggesting that this is actually the one factor that is separated in two by a topological criterion. Also, this would mean that, in the case of continuing of factor analysis, entering the second-order factors, probably only one major component would be extracted – *the strength*. For this reason, factor analysis was completed in the space of first order.

Table 5

Results of cannonical correlation analysis

Latent variables of strength	**CV1s**	**CV2s**	**CV3s**
Static and repetitive strength	.399	.320	**-.859**
Explosive leg strength	-.126	**.931**	.343
Explosive arm strength	**.738**	-.674	-.041
Anthropometric variables	**CV1a**	**CV2a**	**CV3a**
Body height	-.297	**.530**	**.664**
Arm length	-.237	**.621**	.382
Leg length	-.212	**.519**	**.531**
Ankle diameter	**-.437**	.167	.208
Knee joint diameter	**-.532**	.166	.248
Width of the pelvis	-.290	.274	.296
Body weight	**-.918**	.131	.306
Chest circumference, middle	**-.800**	.166	-.036
Circumference of stretched upper arm	**-.805**	.108	-.281
Circumference of bent upper arm	**-.757**	.292	-.329
Upper leg circumference	**-.807**	-.215	.277
Lower leg circumference	**-.663**	-.085	.319
Back skin fold	**-.660**	-.326	.085
Triceps skin fold	**-.520**	**-.492**	.111
Abdominal skin fold	**-.606**	-.392	.184
Upper leg skin fold	-.476	**-.574**	.012
Lower leg skin fold	**-.514**	-.457	-.019
ρ	.780	.701	.473
ρ^2	.609	.492	.224
F	.154	.395	.776
p	.000	.000	.003

Legend: ρ – variance, ρ^2 - common variance of two canonical factors, F – Wilk's lambda, p – significance

By using canonical correlation analysis (Table 5) three statistically significant canonical correlations were extracted.

The first statistically significant canonical correlation from the area of strength was the Explosive arm strength, which is negatively correlated with all anthropometric variables, and especially with all the variables that hypothetically estimated Body volume and weight and Subcutaneous fat tissue. Within Transversal dimension of skeleton it is negatively correlated with the Diameter of knee joint and Ankle diameter.

Through overlapping analysis (Table 6) it can be noted that many variables of strength affect the anthropometric variables.

Table 6

Overlapping analysis

Latent variables of strength			Anthropometric set		
σ²	**ξ**	**α**	**σ²**	**ξ**	**α**
.719	**.089**	-.586	6.106	.133	.888
1.423	.115	.446	2.302	**.033**	.601
.858	.014	-.248	1.575	**.005**	.388

Legend: σ² – variance, ξ – redundancy index, α – reliability of canonical variable (canonical factor)

The second canonical correlation of strength area incorporated Explosive leg strength, which is negatively correlated with subcutaneous fat accumulated on the upper leg and triceps, and positively correlated with measures of longitudinal dimensionality of the skeleton. This correlation is better explained through the set on the right side, so there is a greater influence of anthropometry on explosive leg strength than the other way around.

The third canonical pair from strength area are Static and repetitive strength of arm and to a lesser degree of trunk and Body height and Leg length from the set on the right side. There is an evident negative correlation within the set and also a greater influence of anthropometric variables on the Static and repetitive strength than vice versa.

Discussion

By application of factor analysis in this study three latent dimensions of strength were extracted: static and repetitive strength, mainly of arms, and to a lesser degree of trunk, explosive leg strength and explosive arm strength. Using canonical correlation analysis the following three statistically significant canonical correlations were extracted.

First, it's the explosive arm strength that is negatively correlated with all anthropometric variables. Obtained results are logical because the larger volume, mass, diameters of joints, and especially the more subcutaneous fat, limit or even significantly reduce the expression of speed, and thus the explosiveness, of any movement.

Second it's the explosive leg strength, which is negatively correlated with subcutaneous fat tissue on the upper leg and triceps, and positively correlated with measures of longitudinal skeleton dimensionality. This is understandable because it is expected that longer leverages, that is limbs, also provide longer jumps, through which this latent ability was estimated.

Third it's static and dynamic strengths of arm (and slightly less of trunk) that are negatively correlated with body height and leg length. This obtained canonical pair is logical because the bigger longitudinality of skeleton causes the bigger mass, which in turn makes it difficult to maintain or repeat movement on the long run.

The results of this study suggest an optimal and effective use of motor tests and anthropometric measures to monitor a training effects while studying in the Faculty of Sport and Physical Education.

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