CANONICAL RELATIONS BETWEEN MORPHOLOGICAL – MOTOR FEATURES IN FIRST GRADE STUDENTS

Miroljub Ivanović
College for professional education, Sremska Mitrovica, Serbia

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Abstract
On the representative sample of 164 examinees, at the age of 7.5, from Valjevo, the system of 25 manifest variables in total has been applied, including 14 anthropometric measures and 11 motor tests. Data processing and deducing relations between morphological (predictive) and motor (criteria) variables have been executed using the bi orthogonal linear model of canonical correlation analysis. Algorithm of this multi-variation model has extracted only one pair of significant canonical functions. Achieved standardized coefficient of canonical correlation is R=0.77, it has positive tendency and relatively high intensity, on the level of statistical importance (p<.01), while calculated value of determination canonical coefficient R^2=0.55 indicates on maximal amount of 55% of explained information in relation to total variance of analyzed groups of variables. Extracted function has been defined (on the hypothetical level) as the general canonical morphological factor and general canonical morphological factor. Examining the complex latent structure of the first pair of canonical factors and their cross canonical maximal pressures, indicates on following statistical interpretation of linear correlations: if examinees have higher values in latent morphological dimensions (longitudinal dimensionality of skeleton, transversal dimensionality of skeleton, volume and body weight, and subcutaneous fat tissue), then they achieve better results in motor factors (explosive strength, flexibility, coordination of movements, static and dynamic strength of arms, repetitive strength, balance and frequency of movements), and vice versa.

Key words: *morphological characteristics, motor abilities, canonical function, determination coefficient, variance, canonical factor*

Introduction

Theory of integral child development (Ismail and Gruber, 1971) accentuates the complex structure of morphological – motor features of the students. Due to this fact it is necessary to identify the latent structure and all relevant relations between anthropometric features and motor abilities for the purpose of choosing the methods for standard selection in sport, hiking, control and programming of training processes, as well as successful evaluation of the development of relevant anthropological features (Kurelić, Momirović, Stojanović, Šturm, Radojević and Viskić-Štalec, 1975; Viskić-Štalec and Mejovšek, 1975; Metikoš, Gredelj and Momirović, 1979; Mraković, 1994; Blašković; 1997; Findak, 1999; Tokić and Prskalo, 1999,). During the first decade of XXI century very few researchers were drawn to problem of canonical relations between morphological and motor features in the earliest stages of students development in the class / school environment. (Malacko, 2002; Malacko and Popović, 2005; Bala, 2007; Grbavac, 2007; Blažević, Bilić, Bonacin, Širić and Bonacin, 2007; Širić, Manić and Bonacin, 2008). Determining the significant relations between the variables of morphological and motor areas in different sexes and ages is especially important if we are aware of the very few findings which corroborate the fact that in certain motor activities one morphological structure directly prevents realization of certain kinetic activities on the one hand, while on the other hand that same body structure optimally influences execution of some other motor tasks (Kurelić et al., 1975; Viskić-Štalec et al.,1975; Malacko and Rađo, 2004). Due to this fact, it is very important to obtain (by further research) new information about statistically significant and interrelated (crisscrossed) linear correlations between latent morphological – motor specific features in students of youngest school age. In doing so, we would be able to more precisely define, control, maintain and transform the existing parameters of anthropological abilities and characteristics; leading to full understanding, planning and

execution of appropriate kinesiology diagnostic and PE curriculum's. Based on research topic thus defined, this paper sees formulation of two basic goals: (1) establishing canonical structures of morphological – motor areas, (2) determining linear correlations (direction, intensity and natural relations) between the entirety of anthropometrical and entirety of motor canonical variables. Having in mind thus defined goals, this empirical research led to hypothesis H : Expected findings - identification of canonical structure and statistically significant relations between the systems of anthropometric (predicative) variables and the set of motor (criteria) variables in first grade students.

Methods

On appropriate sample (N = 164) of first grade students of male sex (Valjevo), a system consisting of 27 variables was applied (14 anthropometric measurements and 15 tests of motor abilities). Sample of manifested anthropometrically independent (predicative) variables was reached according to standards of IBP (International Biological Program) – *International Biological Program* (Mišigoj-Duraković, 1995) based on 14 standard anthropometric measures presented in the tables as coded:Body height (VISTEL), Length legs –height *spine iliace anterior superior* (DUŽNOG), Arm length (DUŽRUK), Shoulders span (ŠIRRAM), Pelvis span (ŠIRKAR), Wrist radius (DIJRUZ), Knee radius (DIJKOL), Body mass (MASTEL), Forearm circumference (OBIPOD), Shank circumference (OBIPOT), Average circumference of the chest (OBIGRU), Thickness of skin fold on forearm (NABNAD), Thickness of skin fold on stomach (NABTRB) and Thickness of skin fold on the back (NABLEĐ).

In order to evaluate motor abilities, a group of 11 manifested criteria (dependable) variables was applied: polygon backwards (POLINAT), Stepping aside (KORACS), Standing on both feet, diagonally on balance bench, eyes opened (STAJOO), touch-toe aside (PRETKR), Hand taping (TAPRUK), Foot taping (TAPNOG), Long jump from a spot (SKOUDM), Throwing a ball weighing 20 g to the distance (BACLOP), sprint for 20 m standing start (TRČ20M), Lifting the upper body while laying on the back and with crouched legs (PODTRL) and Pulling upwards with crouch (IZDRŽV).

Defined representative sample of motor measure instruments was based on the model by Gredelj, Metikoš, Hošek and Momirović (1975). Each and every single motor task in the appropriate indicator of the structured tests was executed three times. Relations between two different, multidimensional anthropological groups of manifested variables were determined by standard mathematical – statistic principle of *Hotelling* linear canonical correlation analysis. Coefficients of canonical correlation and inter correlations between applied anthropometrical measuring and motor tests were established, as well as correlations between canonical dimensions extracted from both groups of variables. Statistical significance of canonical correlation was tested by Bartlett hi-square test (χ^2), and with allowed margin of error ($p < 0.01$) significance of influences of manifested variables on canonical morphological factors and canonical motor factors was analysed. Results were then put through program package *Statistics for Windows, ver.* 6.0.

Results and discussion

For interpreting the results of anthropometric features and motor tests we will use tabular excerpts from matrix showing the most representative items defined through canonical factors. Excerpts from the basic results of the analysis of canonical correlations of variables are shown in condensed form in tables 1, 2 and 3.

Table 1. Statistical significance of canonical functions

	C R	C R²	χ²	DF	P
1	0.77	0.55	221.17	64.00	0.01
2	0.39	0.15	69.86	51.01	0.33
3	0.79	0.21	0.03	48.23	0.54
4	078	031	0.09	21.25	0.97
5	0.92	0.22	0.01	8.13	0.91

Key : C R – canonical coefficient of correlation; C R² – canonical coefficient of determination or square of canonical correlation; **χ²** – Bartlett hi-square test of canonical correlations' significance; **df** – number of degrees of freedom **p** – statistical significance of canonical functions

In the course of identifying canonical relations on previously regulated and standardized data taken for 27 manifested variables, only one statistically significant and high canonical correlation was established (Table 1).

Thus established FIRST CANONICAL FUNCTION is statistically significant because its standardized coefficient of canonical correlation has got positive direction and relatively high intensity. (CANONICAL R = .77) which qualifies it as statistically significant ($p < .01$). What this actually means is that its configuration reduced many isolated non-zero linear relations between the pairs of anthropometric and motor variables to liner relations of the two canonical structures from the both groups. Determined value of the coefficient of canonical correlation points to the fact that based on large number of linear combination within both analysed groups of variables there is coherence of two structures of canonical factors in defined group of test subjects.

By solving the algorithm of characteristic matrix equation we get the canonical coefficient of determination or square of canonical correlation (CANONICAL R^2 = 0.55). its value points to the higher quantity of 55% explainable proportion of standardized variant taken from the total variability of the analyzed variable groups. Meaning that given redundancy index as an average value of a square over multiple correlation coefficient of the one group and each and every variable from the other group, we established presence of relatively large proportion of explained information, i.e. more than ½ of the initial data related to total variability, which in turn proves relevance informative value of the first canonical function. Other four isolated canonical functions are given only for informative purposes and will not be considered any further because they are not significant and do not carry statistically relevant quantity of shared variables. That is to say that they do not have any influence on relations between morphological – motor canonical variables.

Statistically significant interconnection of the analyzed morphological area can be explained by the first pair of canonical functions (Table 2). It is obvious that this extracted canonical linear combination is predominantly defined by average and high values of canonical load – weight, of the positive direction and with a span varying from r = .37 to r = .62. Predominant influence in saturation of the complex structure of the first pair of canonical morphological factor belongs to (according to hierarchical values of projection) vectors of the following predicative variables with the positive sign of canonical coefficient : body height (0.81), Length legs –height *spine iliace anterior superior* (0.79) and arm length (0.76), pelvis span (80.62), shoulders span (0.54), knee radius (0.45) and ankle radius (0.39), body mass (0.66), forearm circumference (0.34), shank circumference (0.43) chest circumference (0.37), thickness of skin fold on stomach (-0.77), thickness of skin fold on the back (-0.72) and thickness of skin fold on forearm (-0.70).

Table 2. Matrix of canonical coefficient and structural vectors of canonical morph. factor

VARIABLE	kan 1
VISTEL	0.81
DUŽNOG	0.79
DUŽRUK	0.76
ŠIRKAR	0.62
ŠIRRAM	0.54
DIJKOL	0.45
DIJSKZ	0.39
MASTEL	0.66
OBIPOD	0.34
OBPOTK	0.43
OBIGRU	0.37
KOŽTRB	0.59
KONLEĐ	0.57
KONNAD	0.51

Analysing given anthropometrical variables (equally metrically directed) and canonical coefficients which reflect part of the variable shared by the initial variable and new integrated canonical variable, it becomes clear that resulting vector of this canonical factor is represented with high canonical load (of a positive direction) of variables with latent dimensions (*longitudinal dimensionality of the skeleton, transversal dimensionality of the skeleton, mass and volume of the body and subcutaneous fat tissue*). According to the absolute values of the linear correlations with this extracted canonical factor, as well as relative participation of each predicative variable in the complex composition of the first canonical function, dimensions distributions of this interpretable latent structure of bone segments growth and body development can be interpreted (hypothetically) as GENERAL CANONICAL MORPHOLOGICAL FACTOR.

As for motor abilities (Table 3), statistically significant interconnection could be explained by the first pair of canonical function.

As shown in the table, some projections of the motor tests are considerably lover compared to morphological variables.

Table 3. Matrix of canonical coefficient and structural vectors of canonical motor factor

VARIABLES	KAN 1
POLINAT	-0.26
KORACS	-0.21
STAJOO	0.24
PTRETR	0.55
TAPRUK	0.27
TAPNOG	0.23
SKOUDM	0.71
BACLOP	-0.21
TRČ20M	0.62
PODTRL	0.27
IZDRŽV	0.29

Span of canonical coefficients which determine the first bipolar canonical dimension in this motor sphere oscillate from r = .21 to r = .71. Predominant canonical loads(with the positive sign) on uniform group of hyper - ellipsoid of the resulting vector of this canonical factor have got hierarchical value compared to values of statistically significant correlations on the one hand, criteria variables like long jump from a spot (0.71), sprint for 20 m standing start (0.62), touch-toe aside (55), pulling upwards (-0.29), lifting the upper body while laying on the back and with crouched legs (-0.27), hand taping (-0.27); while on the other hand canonical loads with negative sign have got variables like polygon backwards (-0.26), throwing a ball weighing 20 g to the distance (-0.21) and stepping aside (-0.21).

In order to comprehend calculated coefficients of correlation with proportional values of the negative signs, it is necessary to clarify that the coefficients of some tests (POLINAT and KORACS) change their signs due to the structure of the motor task and the mode of registering achieved results. Items in these tests are registered according to time units, which in turn mean that test scores are better if it is accomplished in shorter time interval.

Result thus achieved has got lesser numerical values. However, it logically points to the more efficient execution of the task i.e. its realistic ranking would be on the positive pole of the extracted factors.

Analysis of resulting vector of this canonical factor of the polarized structure (different metrical directions) shows that it is defined by primary variable of hypothetical latent motor dimensions *explosive strength, dynamic arm strength, static arm and shoulders strength, repetitive strength of the upper body, speed of the alternating moves, flexibility and balance.* Having in mind relative contribution of each criteria variable in the complex composition of the configuration of first canonical function and values of linear correlation, this shared latent structure of movement regulation and realization of the kinetic chain can be hypothetically defined as GENERAL CANONICAL MOTOR FACTOR. Linear connection between isolated canonical variables (according to Kurelić and associates, 1975) is generated (hypothetically) by latent functional mechanisms of the central nervous system; mechanisms which are responsible for variety of *movement structures* (movements coordination), *synergy regulation and tonus regulation* (flexibility , speed of alternating moves and balance), *regulation of excitement intensity* (explosive strength) and regulation of excitement duration (static and repetitive strength). Analysis of the structure of interrelated correlations matrix, i.e. interrelations of cosines of angles between the vectors of the first pair of canonical factors, established existence of two latent dimensions in two different multidimensional anthropological systems of variables. They can be hypothetically interpreted as GENERAL CANONICAL MORPHOLOGICAL FACTOR on the one hand, and GENERAL CANONICAL MOTOR FACTOR, on the other hand. Considering canonical variables extracted from the results of anthropometric measuring and motor tests leads to the assumption that at the very foundation of the structure of the first pair of canonical factors (formed by predicative and criteria variables of interrelated canonical maximal loadings in multidimensional domains of anthropometrical and motor attributes) every variable influences every canonical function. This means that statistically relevant linear cross correlations between morphological and motor canonical factor can be defined (hypothetically) in the following manner: if students achieve better results within the group of adequate anthropometric measuring (body height, length legs –height *spine iliace anterior superior*, arm length, shoulders span.

Also pelvis span, wrist diameter, knee diameter, body mass, forearm and shank circumference, average chest circumference, thickness of forearm skin fold, thickness of stomach skin fold and thickness of ,back skin fold), than they achieve better results within the group of tests of motor abilities (polygon backwards, stepping aside, standing on both feet, diagonally on balance bench, eyes opened, touch-toe aside, hand taping, foot taping, long jump from the spot, throwing a ball weighing 20 g to the distance, sprint for 20 m standing start, lifting the upper body while laying on the back and with crouched legs and pulling upwards with crouch). It is also assumed that calculated shared variable of the first pair of canonical factors can be influenced in the opposite direction as well: if students achieve lower values in applied anthropometric measuring, they will also achieve lesser results in the set of tests of motor abilities. According to the logic of the applicable numerical algorithm of the canonical correlative analysis, results gained by this canonical study corroborated the tested hypothesis (H), which relates to identification of canonical structure and statistically significant relations between the group of anthropometrically independent (predicative) variables and the group of criteria (dependant) motor variables in first grade students.

Conclusion

On appropriate sample (N = 164) of the test subject, males, age 7,5 (± 6 months), clinically healthy, chosen from school population in Valjevo, a system of 27 manifested variables was applied (14 anthropometrical measuring/predicative group/ and 11 tests of motor abilities /criteria group/). In accordance to the research goal, a large number of items was interpreted using standard multivariate method of Hotelling's linear canonical correlation analysis.

Based on the value of the first extracted canonical function, i.e. standardized coefficient of the canonical correlation (R = .77) which qualifies it as statistically significant ($p < .01$) and of positive direction between the first pair of the extracted canonical factors, as well as on canonical coefficient of determination or, square of canonical correlation ($R^2 = 0.55$), we were able to identify 55% of information compared to the entire variable between the two analysed multidimensional systems.

By analysing the relations of the matrix of canonical structure between anthropometric measuring and motor abilities, we were able to determine the existence of the configuration of the first canonical factor. Resulting vector out of this latent canonical structure consists of the following linear combinations of the initial predicative and criteria variables: (1) proportion of the variable which manifested anthropometric variables share with the new morphological variable - defined as GENERAL CANONICAL MORPHOLOGICAL FACTOR and (2) relative contribution of canonical coefficients of every manifested motor variable on new bipolar latent dimension, which is defined as GENERAL CANONICAL MOTOR FACTOR. Analysis of the latent structure of the first pair of canonical one -dimensional structure and its significant maximal cross canonical loadings points to the following hypothetical cause-effect explanation of the linear correlations: if students achieve higher values in primary latent morphological dimensions (longitudinal dimensionality of the skeleton, transversal dimensionality of the skeleton, mass and volume of the body and subcutaneous fat tissue), they achieve better results in motor factors as well (explosive strength, flexibility, coordination of movement, dynamic arm strength, static arm strength, repetitive strength, balance and speed of the alternating moves; and vice versa); decrease in values in the system of predicative morphological variables proportional mirrors decrease in the results within criteria motor variables. Given results are hard to compare due to the great difference in composition of variable groups in recent research of multidimensional morphological and motor domains.

However, they should certainly be tested in a series of new empirical studies (on valid and randomly chosen subjects and with the representative samples of variables), which would be complement those whose results were hypothetical subject of this study. Having in mind that the relations between morphological-motor variables were rarely analysed under to canonical model of linear correlation analysis, here presented data represent the contribution of this study to the research in anthropological space in first grade students. Through this study and through adequate methodological treatment of data, we offer (with the high degree of certainty and required coefficient of reliability) a hypothetical model.

That is a model of understanding the complexity of canonical structure and interrelations between the both groups of analysed anthropological features and abilities. Conclusions presented in this study can be used as initial basis for better kinesiology diagnostics, successful planning and scheduling of class activities and transformational processes in PE classes, as well as model criteria for training processes in order to ensure positive effects on development of somatic features and motor abilities in first grade students.

References

Bala, G. (2007). *Merenje i definisanje motoričkih sposobnosti dece*. Novi Sad: Fakultet sporta i fizičkog vaspitanja.

Blašković, M. (1997). *Relacije između antropometrijskih i motoričkih dimenzija*. Doktorska disertacija, Zagreb: Fakultet za fizičku kulturu.

Blažević, S., Bilić, Ž., Bonacin, Da., Širić, V., & Bonacin, D. (2007). Identifikacija razvojnih procesa kod dječaka u prvom razredu osnovne škole na temelju promjene strukture distinktnih taksona pod utjecajem tretmana. *Acta Kinesiologica, 1*(2) 59-64.

Findak, V. (1999). Planinning, programming, implementation and control of the process of exercise. U D. Milanović, F. Prot (Ur.), *Proceedings Book of 2rd International scientific conference "Kinesiology for the 21st century", Zagreb, 1999*, (pp. 109-112), Zagreb: Faculty of Kinesiology.

Grbavac, N. (2007). *Promjene kanoničkih relacija morfoloških faktora i motoričkih sposobnosti kod učenika prvog razreda osnovne škole*. *Acta Kinesiologica, 1* (1), 84-88.

Gredelj, M., Hošek, A., Metikoš, D., & Momirović, K. (1975). *Model hijerarhijske strukture motoričkih sposobnosti*: 1. Rezultati dobijeni primenom jednog neoklasičnog postupka za procjenu latentnih dimenzija. *Kineziologija*, *5* (1-2), 7-82.

Ismail, A.H., & Gruber, J.J (1971). *Integratdevelopment-Motor appitude and intellectual perfomance*, Columbus: Charles E. Merrill Books, INC.

Mišigoj-Duraković, M. (1995). *Morfološka antropometrija u športu*. Zagreb: Fakultet za fizičku kulturu.

Kurelić, N., Momirović, K., Stojanović, M., Šturm, J., Radojević, Đ. & Viskić-Štalec, N. (1975). *Struktura i razvoj morfoloških i motoričkih dimenzija omladine*. Beograd: Institut Fakulteta za fizičko vaspitanje.

Malacko, J. (2002). Relations of coordination, morphological characteristics and motor abilities. U D. Milanović, F. Prot (Ur.), *Proceedings Book of 2rd International scientific conference "Kinesiology for the 21st century", Zagreb, 1999*, (pp. 291-295), Zagreb: Faculty of Kinesiology.

Malacko, J., & Popović, D. (2005). Relacije između sistema morfoloških i motoričko-funkcionalnih varijabli i njihov uticaj na aerobni kapacitet kod dece 5. razreda osnovne škole. *Homosporticus 8*(2), 6-10.

Malacko, J., & Rađo, I. (2004). *Tehnologija sporta i sportskog treninga*. Sarajevo: Fakultet sporta i tjelesnog odgoja.

Metikoš, D., Gredelj, M., & Momirović, K. (1979). *Struktura motoričkih sposobnosti*. Kineziologija, *9*(1–2), 15-25.

Mraković, M. (1994). *Programiranje i kontrola procesa tjelesnog vježbanja*. Zagreb: Fakultet za fizičku kulturu.

Širić, V., Manić, G. & Bonacin, Da. (2008) Promjene relacija morfoloških i motoričkih dimenzija dječaka uzrasta 7 godina pod utjecajem tretmana. *Sport Science, 1*(1) 18-22.

Tokić, P., & Prskalo, I. (1999). The relations between the system of anthromometric and motor-functional variables in croatian recruits. U D.Milanović, F. Prot (Ur.), *Proceedings Book of 2rd International scientific conference "Kinesiology for the 21st century", Zagreb, 1999*, (pp. 434-436), Zagreb: Faculty of Kinesiology, Univesity of Zagreb.

Viskić-Štalec, N., & Mejovšek, M. (1975). *Kanoničke relacije prostora koordinacije i prostora motorike*. Kineziologija, *5*(1-2), 83-112.

KANONIČKE RELACIJE MORFOLOŠKIH I MOTORIČKIH DIMENZIJA UČENIKA PRVOG RAZREDA OSNOVNE ŠKOLE

Sažetak

Na reprezentativnom uzorku od 164 ispitanika uzrasta od 7.5 godina iz Valjeva, primjenjen je sistem od ukupno 25 manifestnih varijabli i to 14 antropometrijskih mjera i 11 motoričkih testova. Obrada podataka i utvrđivanje relacija između morfoloških (prediktorskih) i motoričkih (kriterijskih) varijabli, izvršena je primjenom biortogonalnog linearnog modela kanoničke korelacijske analize. Algoritam ove multivarijantne metode ekstrahirao je samo jedan par značajnih kanoničkih funkcija. Nađeni standardizovani koeficijent kanoničke korelacije iznosi R=0.77, pozitivnog je smjera i ima relativno visok intenzitet na nivou statistike značajnosti (p < .01), dok izračunata vrijednost kanoničkog koeficijenta determinacije ili kvadrata kanoničke korelacije R^2 = 0.55 ukazuje na količinu od 55% objašnjenih informacija u odnosu na ukupnu varijancu analiziranih skupova varijabli. Ekstrahirana kanonička funkcija definisana je (na hipotetskoj razini) kao generalni kanonički morfološki faktor i generalni kanonički motorički faktor. Razmatranje kompleksne latentne strukture prvog para kanoničkih faktora i njihovih unakrsnih kanoničkih maksimalnih opterećenja ukazuje na slijedeću statističku interpretaciju linearnih korelacija: ukoliko ispitanici imaju veće vrijednosti u latentnim morfološkim dimenzijama ostvaruju bolje rezultate i u motoričkim faktorima (eksplozivnoj snazi, gipkosti, koordinaciji pokreta, statičkoj i dinamičkoj snazi ruku, repetitivnoj snazi, ravnoteži i frekvenciji pokreta), i obrnuto.

Ključne riječi*: morfološke karakteristike, motoričke sposobnosti, kanonička funkcija, koeficijent determinacije, varijanca, kanonički faktor*

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Correspondence to:
Assoc.Prof. Miroljub Ivanović, PhD.

College for professional education
Sremska Mitrovica, Serbia
Phone: +381(0)22 621 864
E-mail: marijava@verat.net