A CONTRIBUTION TO UNDERSTANDING RELATIONS BETWEEN MORPHOLOGICAL AND MOTOR CHARACTERISTICS IN 7- AND 9-YEAR-OLD BOYS

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Abstract:

Relations between morphological characteristics, assessed by 15 morphological measures, and motor abilities, assessed by 24 motor tests, were investigated on the total cross-sectional sample of 400 male participants from Slovenia (200 boys of 7 and 200 boys of 9 years). Associations between these two groups of variables were determined by the Hotteling's biorthogonal canonical correlation analysis and, consequently, a large number of significant canonical pairs were obtained. In the present study only the first pair of canonical dimensions obtained has been interpreted because of limited space, and because the first pair exhausted the largest portion of variability due to the method applied. The remaining dimensions, although important to the explanation of the entire common covariability, probably represent the structure of the highly specific parts of variances of particular groups of variables, pertaining to either single variables, or to single pairs. Association between blocks of morphological and motor variables in boys is strong, well differentiated and very high. Significant relations have been determined between the energy regulation system and morphological variables in both the latent and manifest space. General positive relations were determined between utilized morphological variables and the motor variables saturated predominantly by the measures of dimensions of the excitation intensity regulation mechanism (horizontal jump, throwing the medicine ball, grip strength), whereas negative relations of anthropometric dimensions occur with regard to the measures assessing dimensions of the excitation duration regulation mechanism (600m running, endurance shuttle run, sit-ups in 60 sec). The influence of longitudinal body dimensions and ballast body mass is greater in 9-year olds.

Key words*: anthropometric measures, motor abilities, primary school, relations, boys*

BEITRAG ZUM VERSTÄNDNIS DER BEZIEHUNGEN ZWISCHEN MORPHOLOGISCHEN UND MOTORISCHEN EIGENSCHAFTEN BEI DEN 7- UND 9-JÄHRIGEN JUNGEN

Zusammenfassung:

Die Beziehungen zwischen morphologischen Eigenschaften und motorischen Fähigkeiten wurden auf einer Stichprobe von 400 slowenischer Jungen (200 7-jährig und 200 9-jährig) untersucht. Morphologische Eigenschaften wurden mittels 15 morphologischen Maßen und motorische Fähigkeiten mittels 24 motorischen Tests bewertet. Die Beziehungen zwischen diesen zwei Variablengruppen wurden mit Hilfe der Hotellingschen biorthogonalen kanonischen Korrelationsanalyse festgestellt, die eine große Zahl bedeutender kanonischer Paare ergab. In dieser Studie wurde wegen Platzbegrenzungen nur das erste erworbene Paar der kanonischen Dimensionen erklärt. Außerdem, erschöpfte dieses erste Paar wegen der angewendeten Methode auch den höchsten Teil der Varianz. Obwohl für die Erklärung der gesamten gemeinsamen Kovarianz wichtig, beziehen sich die übrigen Dimensionen wahrscheinlich auf die Struktur hochspezifischer Teile der Varianz bestimmter Variablengruppen, die enweder die Variablenstichprobe oder auch einzelne Paare betreffen. Die Verbindung zwischen den Gruppen morphologischer und motorischer Variablen bei den Jungen ist stark, gut differenziert und sehr hoch. Bedeutende Beziehungen wurden zwischen dem System zur Energieregulation und den morphologischen Variablen im latenten sowie im manifesten Raum festgestellt. Allgemeine positive Beziehungen wurden zwischen den gebrauchten morphologischen Variablen und denjenigen motorischen Variablen festgestellt, die vorwiegend mit den Werten der Dimensionen des Mechanismus zur Regulation der Aufregungsintensität (horizontales Springen, Medizinballwerfen, Händedruckfestigkeit) gesättigt waren. Die negativen Beziehungen anthropometrischer Dimensionen entstehen im Bezug auf die Messverfahren zur Bewertung von Mecha-

nismen zur Regulation der Aufregungsdauer (600 m Laufen, Shuttle-Ausdauerlaufen, Aufsitzen in 60 sec). Der Einfluss der longitudinalen körperlichen Dimensionen und der ballasten Körpermasse ist größer bei den 9-jährigen Jungen.

Schlüsselwörter: *anthropometrische Werte, motorische Fähigkeiten, Grundschule, Beziehungen, Jungen*

Introduction

Anthropometric and motor attributes of school-age children undoubtedly have a significant contribution in explaining pupils' entire psychosomatic status, and may highly influence the development of other human dimensions. Hence, the developmental level of both dimensions seems to play a very important role in the process of unique and integrated personality growth and maturity. The issue is one of the crucial considerations of education in general and of physical education (PE) in particular.

Tendencies to accelerated and more pronounced changes in body measures of youngsters have become conspicuous in the second half of the last century from all aspects and in any phase of growth and development. Up-to-date Slovenian research studies, particularly those performed in the last five years, confirmed the continuation of the general trend of accelerated somatic development of children (Karpljuk, 1999; Mišigoj-Duraković et al., 1998; Kondrič and Šajber-Pincolič, 1997; Štefančič et al., 1996; Strel et al., 1995, among many others). Reasons for the well documented tendency may be numerous – among them one should firstly highlight improved nutrition (dietary habits), better living conditions, enhanced social (environmental) influence and the higher quality of children's health care. Many examples have so far shown a greater acceleration in the development of recent generations of boys than of the previous ones (Beunen et al., 1988; Malina and Bouchard, 1991; Kondrič and Štihec, 1999; Kondrič, 2000). Physical educators are particularly interested in the issue. Namely, disproportion in either the development or the interrelations between the morphological characteristics and motor abilities, especially in the period of the most intensive growth, may cause a lot of problems in PE teaching planning and delivery. In order to provide timely and adequate adjustments of PE classes curricula and syllabuses, the somatic characteristics and motor abilities of children and teenagers should be continuously qualitatively assessed and monitored.

Research methods

The research study focused on the determination of the structural characteristics of associations between the morphological and motor variables that occur in boys 7 and 9 years of age. The data on which this work is based have been collected within the framework of the research project "Analysis of developmental trends of motor abilities and morphological characteristics and their relations to the psychological and social dimensions of Slovenian children and young people 7-18 years of age in the period 1970 – 1983 - 1993" (Strel et al., 1992; 1996).

The participants, 400 male pupils, aged 7 and 9 years, were randomly sampled from the lower grades of the Slovenian primary schools. Each cross-sectional age group embraced 200 examinees.

The sample of variables consisted of two groups: the first included 15 morphological measures (selected in such a way as to be the best representatives of the latent dimensions which had been determined and tested in many previous research studies), whereas the second group, the group of motor variables, consisted of 24 measures of good metric characteristics, which had been also tested many times on various samples of examinees.

The somatic, morphological measures were: body height (ABH), leg length (ALL), arm length (AAL), hip (bicrystal) breadth (AHB), shoulder (biacromial) breadth (ASB), wrist breadth (AWB), knee diameter (biepicondylar breadth) (AKD), ankle diameter (bicondylar breadth) (AAD), body mass (ABM), thigh circumference (ATC), forearm circumference (AFC), abdominal (suprailiac) skinfold (AAS), subscapular (back) skinfold (ASS), upperarm (triceps) skinfold (AUS), and biceps skinfold (ABS).

The employed motor tests were: endurance shuttle run (MESR), 600 m run (MR600), sit-ups in 20 sec. (MSU20), sit-ups in 30 sec. (MSU30), sit-ups in 60 sec. (MSU60), bent arm hang (MBAH), throwing the medicine ball (MMBT), horizontal jump (MHJ), grip strength (MGS), external arm circumduction with a bar (MCB), sit

and reach (MSR), forward bend on a bench (MFBB), arm tapping in 20 sec. (MAT20), leg tapping (MLT), 60m run (MR60), low beam balance (MLBB), flamingo stand (MFS), polygon backwards (MPB), run in a figure-of-eight with ducking (MR8D), climbing up and down (MCUD), running-rolling-crawling (MRRC), arm drumming (MAD), arm and leg drumming (MALD), and running around stands (MRAS).

The collected data were processed by the SPSS 8.0 for Windows statistical software.

The basic statistical parameters were first computed separately for the morphological and motor variables in each age group: arithmetic mean (Mean), standard deviation (SD), the minimum (MIN) and maximum results (MAX). Further, the interrelations, precisely the cross-correlations for the anthropometric space and the motor space were calculated, as well as the intercorrelation matrix for both spaces.

Relations between the utilized groups of morphological and motor variables were determined by Hotelling's biorthogonal canonical correlation analysis. On the basis of the cross-correlations of manifest dimensions it maximizes covariances among corresponding pairs of lineary combined intergroup variables. The number of significant canonical factors was determined on the basis of the Chi-square test according to Bartlett's algorithm (1941). All the variables were scaled in the same direction prior to multivariate canonical analysis procedure. Therefore, all correlation coefficients in all the correlation matrices have their real plus or minus signs.

Results and discussion

Anthropometric and motor measurements, and adequate data processing methods enable the determination of relationships between the somatic development and motor efficiency in pupils of 7 and 9 years of age. Mean comparison of anthropometric measurement scores the 7 and 9 year-olds achieved in the tests (Table 1) indicated, as expected, that boys of 9 years of age were taller and heavier than the 7 year-olds, that they had longer extremities and, distinctly expressed, more subcutaneous fat tissue. They were on average taller by as much as 11.8 cm, and larger longitudinal values of their arms and legs were in congruence with the body height gain. In 9-year old boys a relatively large increase was registered in body weight and subcutaneous fat tissue The finding suggests that they had more ballast body mass along with more lean muscle mass. The differences in transversal measures were less pronounced (Table 1)

Table 1. Basic statistical parameters regarding the sample of the 7- and 9-year-old participants.

	Seven-year-old boys					Nine-year-old boys			
Var	MEAN	SD	Min	Max		MEAN	SD	Min	Max
ABH	124.66	5.54	108.8	140.3		136.41	5.74	121.8	153.5
ALL	68.59	4.24	51.1	79.2		76.72	4.19	64.3	87.7
AAL	53.52	2.87	45.5	60.8		59.00	3.17	50.4	67.5
AHB	15.30	1.16	12.5	19.1		16.61	1.34	13.2	22.3
ASB	26.95	1.59	20.4	30.7		29.34	1.77	24.7	39.1
AWB	4.25	0.28	3.6	5.1		4.49	0.31	3.7	5.2
AKD	7.64	0.39	6.5	9.0		8.15	0.51	6.0	9.8
AAD	5.83	0.37	4.8	6.9		6.24	0.39	4.5	7.6
ABM	25.24	4.02	18.3	42.8		32.46	6.78	21.7	53.1
ATC	37.30	4.16	23.0	57.0		41.91	5.26	31.8	58.0
AFC	18.22	1.34	15.0	23.7		19.61	1.74	15.5	25.3
AAS	6.90	4.98	2.8	36.8		10.75	10.49	3.0	48.0
ASS	6.35	3.00	3.6	30.8		9.39	7.78	3.7	41.6
AUS	8.90	3.00	4.8	24.0		10.47	5.07	4.6	35.0
ABS	5.34	2.04	2.9	16.6		6.80	4.07	2.7	25.4
MESR	2.12	0.80	1	5		3.33	1.58	1	7
MR600	198.98	25.11	144	301		170.72	22.90	136	263
MSU20	7.36	3.24	0	15		11.58	2.61	0	18
MSU30	10.54	4.58	0	20		16.43	3.81	0	25
MSU60	19.87	7.04	0	40		29.35	6.73	7	48
MBAH	18.69	16.97	0	107		27.92	24.41	0	149
MMBT	185.59	36.65	70	265		270.08	44.99	170	450
MHJ	114.51	17.40	65	160		139.20	18.62	81	179
MGS	79.13	31.44	10	154		101.80	43.53	10	236
MCB	70.56	13.66	30	113		82.22	16.26	44	121
MSR	20.30	5.55	5	48		19.01	5.29	5	30
MFBB	41.62	6.45	15	55		42.52	5.74	27	55
MAT20	18.10	3.54	9	30		26.12	4.45	11	47
MLT	16.59	2.28	9	24		20.16	2.66	10	31
MR60	130.65	12.27	109	183		115.84	12.55	89	182
MLBB	80.31	78.13	12	646		119.40	108.83	10	666
MFS	25.74	5.83	9	30		20.55	7.10	5	30
MPB	263.79	68.16	129	500		185.03	47.40	110	353
MR8D	121.55	17.29	91	232		103.41	10.94	80	153
MCUD	361.72	105.88	192	800		253.98	60.56	148	599
MRRC	290.44	63.22	179	600		210.70	37.74	138	384
MAD	4.39	2.55	0	13		7.99	3.31	0	16
MALD	4.36	2.43	0	11		7.03	29.98	0	15
MRAS	93.41	10.22	75	164		82.12	6.71	67	103

The 9-year-olds achieved, in general, much better results in motor tasks, which was particularly obvious in the measures of spatial dexterity, i.e. coordination of moving through the space (MPB, MR8D, MCUD and MRRC), and in the test procedures assessing the energy component of movement (MBAH, MGS, MMBT, MHJ, MSU60). Organized, compulsory physical education in schools, as well as the natural course of growth and development have a considerable influence on progress in basic motor abilities (coordination, balance, speed, strength, endurance), which is followed by subcutaneous fat tissue reduction and muscle mass enlargement. The results (mean values) obtained in the motor tests of the present study are comparable to those obtained by Malina and Bouchard (1991), except for the poorer scores in measures of flexibility (MCB, MSR, MFBB), which can be attributed to a considerable enhancement of longitudinal skeletal measures.

Multiple and significant relationships were obtained between the anthropometric morphological and motor groups of variables. In the space of morphology only 15 measures were selected from the IBP, whereas 24 motor measures were applied – this imbalance in the number of variables undoubtedly influenced the results obtained in the study. The greater number of variables might have caused lower canonical correlations, but a higher number of connections.

Relationships between morphological characteristics and motor abilities in boys 7 years of age

The statistical significance of correlation coefficients was determined according to the tables for assessing borderline values in such a way that each coefficient equal or higher than 0.181 was considered significant at the level of reliability of 0.01 (1%) and 200 degrees of freedom.

Table 2 reveals that low and insignificant correlations prevail in general. Nevertheless, it is obvious that certain motor variables have built multiple significant, either positive or negative, relations with morphological variables, or that they simultaneously have positive and negative connections. High positive values of correlation coefficients were registered between morphological variables and the following motor variables: throwing the medicine ball, external arm circumduction with a bar and grip strength. Positive correlation coefficients occurred in all versions of sit-ups, and in running-rolling-crawling. Negative relationships were manifested in the 600m run, horizontal jump, bent arm hang, and polygon backwards. In the 60m run both the positive and negative relations occurred.

Table 2. Matrix of cross-correlations among the anthropometric and the motor variables obtained in the 7-year-olds' sample.

	MAT20	MLT	MHJ	MMBT	MSU60	MPB	MCUD	MR8D	MRRC	MRAS	MFBB	MSR	MSU20	MSU30	MCB	MAD	MALD	MGS	MLBB	MFS	MBAH	MESR	MR60	MR600
ABH	.087	.016	.127	.427	.068	-.111	.065	.037	.173	.029	-.066	-.096	.075	.118	.286	.013	-.018	.182	-.102	-.045	-.070	.021	.155	-.026
ALL	.022	-.043	.071	.319	.070	-.173	.007	-.039	.093	-.027	-.081	-.096	.106	.147	.302	.045	-.023	.132	-.074	-.022	-.042	.022	.133	.011
AAL	.092	.035	.118	.378	.067	-.075	.069	-.001	.158	.006	.003	-.044	.133	.169	.270	-.022	-.045	.210	-.117	-.010	-.003	-.008	.193	-.051
ASB	.022	.005	.099	.410	.184	-.049	.069	.105	.140	.033	.051	.0 29	.110	.137	.253	-.003	.008	.221	-.010	.006	.026	.006	.155	-.011
AHB	.002	-.112	-.008	.224	.118	-.026	.070	.005	.052	.068	-.013	-.018	.107	.129	.201	.034	-.080	.334	-.003	-.080	-.071	.098	.086	-.027
AWB	.129	-.002	.145	.444	.281	.107	.143	.096	.157	.029	.103	.064	.188	.195	.233	.052	-.003	.202	-.007	.009	.095	-.040	.199	-.032
AKD	-.024	-.071	.108	.427	.179	-.063	.113	.084	.196	.016	.126	.049	.111	.132	.258	-.070	-.064	.054	-.038	-.095	-.019	.002	.178	-.077
AAD	-.032	-.054	.111	.415	.141	.085	.176	.049	.187	.022	.109	.056	.081	.102	.102	-.001	-.014	.110	-.010	-.022	.001	.083	.283	-.002
AFC	.027	-.111	.023	.350	.244	.004	.065	.089	.115	-.047	.112	.168	.097	.126	.142	-.103	-.083	.146	-.111	.017	-.044	-.019	.045	-.130
ATC	.062	-.049	-.057	.244	.121	-.047	-.017	.054	.127	-.070	.049	.080	.065	.098	.082	-.061	-.111	.059	-.121	-.017	-.078	-.029	-.019	-.159
ABM	.062	-.048	.024	.440	.124	-.111	.046	.041	.180	.000	.111	.090	.070	.102	.207	-.002	.008	.143	-.131	-.045	-.117	-.038	.056	-.210
AUS	.020	-.105	-.194	.088	-.014	-.227	-.094	.006	-.032	-.108	.048	.050	-.077	-.072	.095	.035	.002	.100	-.159	-.039	-.246	-.121	-.287	-.273
ABS	.020	-.103	-.189	.068	-.013	-.177	-.077	-.017	-.016	-.068	.086	.057	-.078	-.072	.060	.021	.013	.146	-.134	-.045	-.211	-.144	-.266	-.280
AAS	.006	-.094	-.145	.167	-.055	-.169	-.094	-.037	.069	-.054	.136	.140	-.090	-.076	.086	-.003	.036	-.015	-.146	-.052	-.177	-.081	-.154	-.229
ASS	.045	-.072	-.136	.129	.019	-.196	-.037	-.030	.076	-.072	.119	.064	-.064	-.043	.145	-.000	.027	.109	-.098	-.046	-.193	-.107	-.256	-.265

Relations between the utilized groups of morphological and motor variables were determined by Hotelling's biorthogonal canonical correlation analysis. On the basis of cross-correlations of manifest dimensions it maximizes covariances among corresponding pairs of lineary combined intergroup variables. In the 7-year-olds sample canonical correlation was obtained betweent three pairs of canonical dimensions.

Table 3. Basic parameters of canonical correlation analysis in the space of anthropometric morphological and motor variables in the 7-year-olds sample.

	Can Cor.	Sign	Sq. Cor
7-year old	0.713	0.000	0.509

On the basis of the obtained values of correlations among canonical factors formed in the space of morphological anthropometry and motor abilities (0.713) and 51% of their common variance, it is feasible to assertain that in boys of 7 years of age, as opposed to the 9-year-olds, where almost 70% of common variance has been explained, the relations between the analysed spaces are considerably lower.

All the measures of anthropometric dimensions have significant positive relations with the first canonical factor which is to a great extent similar to the general factor of anthropometric space, determined also by Kurelić and associates (1975).

The conspicuously highest projection (0.896) on the first factor was registered, as expected, for body mass (Table 4). This anthropometric dimension is a linear combination of almost all morphological characteristics (Momirović et al., 1975; Kurelić et al., 1975). The measures of longitudinal and transversal skeletal dimensionality had rather high projections on this factor, except for the measure of bicristal breadth which showed a lower projection. The variables assessing subcutaneous fat tissue established the weakest associations with the first canonical factor in the anthropometric space.

In the first canonical dimension of the morphology space correlations of the measures of tranversal skeletal dimensionality with the respective dimensions were considerably higher than the relations of body fat indicators and the same factor. It is feasible to consider this dimension a carrier of information primarily about the development of skeletal and muscle system and, to a lesser extent, about the variability of subcutaneous fat tissue.

Table 4. The structure of the first pair of the significant canonical dimensions obtained in the 7-year-olds sample.

Variable	1	Covariate	1
ALL	.660	MALD	.008
AAL	.749	MAD	-.036
ABS	.329	MGS	.154
ASS	.480	MSU20	.163
AUS	.380	MSU30	.226
AAS	.498	MSU60	.251
AFC	.698	MFS	-.041
ATC	.565	MLBB	.127
AKD	.769	MR8D	.073
AAD	.669	MPB	-.071
AWB	.687	MFBB	.124
AHB	.433	MSR	.101
ABM	.896	MHJ	.205
ABH	.803	MESR	.033
ASB	.690	MMBT	.746
		MRAS	.040
		MR60	.260
		MR600	-.148
		MLT	-.009
		MAT20	.128
		MRRC	.367
		MBAH	-.053
		MCB	.370
		MCUD	.155

The test throwing the medicine ball (MMBT) had the highest projection on the positive pole of the first canonical dimension, formed in the group of motor variables (Table 4). The authors suppose that such a high position of the variable is in direct relation with the body mass and relatively high values of measures assessing longitudinal and transversal skeletal dimensionality. In that way muscles of the shoulder region, in well developed boys with pronounced muscle mass, are in a favourable position to activate the upper arm, which enhances the angular speed. A relatively high position of the variable *wrist diameter* (AWD) should not be disregarded in this case either, because hand activation in the final phase of throwing adds a lever to the whole movement. Considerably lower, but still significant correlation coefficients define the position of the tests *external arm circumduction* and *running-rolling-crawling,* which are aimed at assessing flexibility (0.370) and coordination (0.367), respectively. Performance of these tasks is under the control of mechanisms for regulation of synergists and antagonists and of movement structure. In a decreasing sequence

came the tests of energy component of moving, assessing dynamic and explosive power, which had positive, but low correlations with the first canonical dimension.

The negative pole of the dimension was defined by the tests: 600m running, flamingo stand, polygon backwards, bent arm hang, leg drumming and leg tapping, which had low and insignificant relationships from the aspect of statistics and interpretation. To summarize, it seems that in the background of the canonical connection between the morphological and motor variables in 7-year-old boys there was only a strong positive influence of skeletal and muscular development on absolute power motor task performance.

Morphological characteristics had low or no influence on other motor activities, which can be attributed to a favourable and harmoniuos pattern of morphological dimensions in boys 7 years of age.

Relationships between morphological characteristics and motor abilities in boys of 9 years of age

The cross-correlation matrix in 9-year olds displayed at the manifest level a considerably larger variety of established relationships than in the 7-year-olds. In the manifest space positive correlations were obtained with the tests: *throwing the medicine ball, grip strength and external arm circumduction with a bar,* and somewhat lower correlations with the test *arm* and *leg drumming.*

Negative correlation with the highest correlation coefficients was determined in *polygon backwards, bent arm hang, horizontal jump* and in all the running tests. In the manifest space of the subcutaneous fat tissue latent dimension this negative relation was more conspicuous in the variables that hypothetically covered the energy component of moving.

Table 5. The matrix of cross-correlations among the anthropometric and the motor variables obtained in the 9-year-olds' sample.

	MAT20	MLT	MHJ	MMBT	MSU60	MPB	MCUD	MR8D	MRRC	MRAS	MFBB	MSR	MSU20	MSU30	MCB	MAD	MALD	MGS	MLBB	MFS	MBAH	MESR	MR60	MR600
ABH	.149	.023	-.015	.469	-.042	-.274	-.062	-.001	.003	-.040	-.072	-.083	.011	.024	.122	.078	.089	.158	-.092	-.114	-.163	-.018	-.021	-.154
ALL	.107	.049	-.000	.405	.029	-.304	-.031	-.012	-.033	-.040	-.123	-.135	.010	.030	.113	.060	.099	.138	-.044	-.070	-.150	.001	-.024	-.130
AAL	.053	.042	.045	.461	.018	-.249	-.056	-.004	.017	-.064	-.025	-.046	.079	.104	.138	.054	.082	.282	.029	-.083	-.129	-.025	-.001	-.146
ASB	.086	.093	-.067	.471	-.058	-.243	-.055	-.012	.060	-.062	.023	.018	.015	.020	.191	.051	.158	.247	-.010	.047	-.191	-.162	-.089	-.233
AHB	.005	.013	-.130	.380	-.065	-.260	.086	-.117	-.010	-.129	-.030	-.096	-.052	-.105	-.001	-.032	.042	.078	.028	-.095	-.246	-.129	-.035	-.156
AWB	.007	.021	.059	.481	.040	-.075	.077	-.007	.130	.001	.014	.081	.044	.001	.104	-.006	.037	.300	.045	.022	-.109	-.006	-.116	-.134
AKD	.069	-.093	-.089	.469	-.081	-.263	.037	-.094	.068	-.102	-.043	-.045	-.049	-.101	.101	.058	.074	.099	.016	-.159	-.227	-.101	-.081	-.319
AAD	.079	-.112	.017	.433	-.050	-.108	.113	-.002	.054	-.011	-.044	-.001	.000	-.034	.155	.036	.003	.234	.051	-.013	-.156	.002	-.085	-.155
AFC	-.044	-.055	-.266	.496	-.122	-.393	-.102	-.191	.007	-.150	-.004	-.020	-.131	-.157	.135	-.021	.123	.177	-.103	-.182	-.365	-.257	-.224	-.457
ATC	.011	-.102	-.327	.369	-.155	-.449	-.183	-.223	-.066	-.215	.000	-.011	-.164	-.162	.112	-.057	.131	.045	-.159	-.230	-.397	-.283	-.230	-.502
ABM	.013	-.063	-.279	.483	-.143	-.466	-.142	-.190	-.012	-.176	.026	.004	-.139	-.147	.158	-.005	.158	.144	-.148	-.207	-.380	-.259	-.194	-.476
AUS	-.050	-.093	-.450	.286	-.216	-.474	-.196	-.331	-.121	-.257	-.047	-.067	-.249	-.257	.104	-.094	.103	.052	-.181	-.202	-.424	-.392	-.345	-.559
ABS	-.097	-.064	-.448	.229	-.184	-.463	-.192	-.316	-.064	-.234	.036	.012	-.214	-.227	.096	-.096	.124	.101	-.174	-.207	-.415	-.373	-.350	-.564
AAS	-.066	-.018	-.432	.215	-.197	-.523	-.199	-.258	-.059	-.221	.060	.003	-.195	-.200	.054	-.025	.164	.036	-.173	-.234	-.405	-.340	-.227	-.572
ASS	-.080	-.016	-.414	.263	-.125	-.496	-.144	-.228	-.033	-.204	.046	-.001	-.162	-.185	.058	-.026	.194	.132	-.130	-.183	-.359	-.376	-.224	-.547

The relationship obtained in the 9-year-olds' sample between the canonical dimensions of the first pair was considerably high (0.836), whereas the size of common variance was 69.9% (Table 6). It is obvious, then, that variety of morphological dimensions has a rather stronger influence on motor efficiency of boys 9 years of age than of 7-year-olds.

Table 6. Basic parameters of canonical correlation analysis in the space of anthropometric morphological and motor variables in the 9-year-olds' sample.

	Can Cor.	Sign	Sq. Cor
9-year olds	0.836	0.000	0.699

As is obvious from Table 7, all the anthropometric measures have contributed to the first canonical dimension, but with varying proportions, which is obvious from the size of orthogonal projections of variables ranging from .458 to .971. In this linear combination body mass also had its predominant position, even more conspicuous than in comparable canonical dimension in 7-year-olds. Still, the first canonical dimension is here composed in quite a different way. Body mass is followed, in order of descending significance, by the other two circular measures, and then, with slightly lower projections, by all the measures assessing subcutaneous fat tissue.

Measures of transversal and longitudinal skeleton dimensionality had considerably lower values of correlations with the dimension. Certain transversal measures, in which a notable amount of fat tissue in the vicinity of the measuring points may "distort" the obtained scores, like shoulder breadth (ASB), or knee diameter (APK) in particular, had somewhat higher orthogonal projections than the other skeletal measures.

The first canonical dimension obviously had typical taxonomic characteristics in the space of morphology. On its extremely negative pole of distribution it described the group of 9-year old boys whose total body mass was not only remarkably above average, but it was predominantly defined by a substantial amount of subcutaneous fat tissue. Descriptive parameters of anthropometric measures (Table 1) revealed that the number of such persons is higher in the 9-year-olds sample than in the sample of 7-year-old boys – the comparison made it obvious that the means of 9-year-olds were higher in all the measures of subcutaneous fat, the minimum results were practically the same, whereas the maximum scores were substantially higher with higher standard deviations.

Table 7. The structure of the first pair of the significant canonical dimensions obtained in the 9-year-olds' sample

Variable	1	Covariate	1
ALL	-.528	MALD	-.196
AAL	.512	MAD	.004
ABS	.858	MGS	-.146
ASS	.890	MSU20	.201
AUS	.886	MSU30	.223
AAS	.899	MSU60	.212
AFC	.914	MFS	.249
ATC	.902	MLBB	-.175
AKD	.746	MR8D	.263
AAD	.480	MPB	.587
AWB	.458	MFBB	-.043
AHB	.577	MSR	-.009
ABM	.971	MHJ	.407
ABH	-.581	MESR	.360
ASB	-.612	MMBT	-.513
		MRAS	.231
		MR60	.266
		MR600	.642
		MLT	.066
		MAT20	.009
		MRRC	.012
		MBAH	.480
		MCB	-.164
		MCUD	.168

The first canonical dimension in the motor space was bipolar, as expected. The positive pole of the dimension was determined by the measures of endurance and power of a relative type (600m running - MR600, endurance shuttle run - MESR, and bent arm hang - MBAH). The variable *polygon backwards* (MPB), measuring coordination, was associated to this group with a relatively high projection.

The negative pole of the first canonical dimension in the motor space was primarily defined by the absolute explosive power test – *throwing the medicine ball* (MMBT). Some other motor tests, with various objects of measuring, had negative relations to this dimension, but their contribution was insignificant because the size of associations was simply too small.

The essence of relationship between the anthropometric measures and results in motor tests of boys 9 years of age lies, in fact, in the powerful negative influence of total body mass, defined primarily by subcutaneous fat tissue, on motor manifestations of endurance and power of a relative type, on the one hand, and at the same

time, in the positive influence of such a body built on manifestations of absolute power. The same logic is applicable in the case of interpreting the negative effect the described morphological structure had on efficiency and accuracy of motor performance in the test *polygon backwards* MPB) - large ballast mass is probably the principal restrictive factor of speed of movement.

The comparison with the results of 7-year-old boys clearly indicates that anthropometric characteristics variously influence motor efficiency during the period of growth and development. In the 9-year-olds the influence of anthropometric characteristics on motor output was stronger. One of probable causes is a high percentage of ballast body mass and high variability of measures of the subcutaneous fat tissue in the observed age category. Total body weight strongly influenced motor outputs – negatively, the measures of relative power and endurance, and positively, the measures of absolute strength.

Conclusion

The significant relationships were determined between the anthropometric characteristics, both the manifest variables and latent dimensions, and the motor abilities in boys of both age groups.

The cross-correlation matrix in 9-year-olds displayed, at the manifest level, greater variety of established connections than in 7-year-olds. In the latter age group general prevailance of low and insignificant correlation associations was noticeable. On the basis of the obtained values of correlations among canonical factors formed in the space of morphological anthropometry and motor abilities (0.713) and 51% of their common variance, it is feasible to assertain that in boys of 7 years of age, as opposed to the 9-year-olds, where almost 70% of common variance was explained, the relations between the analysed spaces were considerably lower. In the 9-year-olds sample a considerably high interrelationship (0.836) was obtained in the first pair of canonical dimensions. It is obvious, then, that variability of morphological dimensions had a greater impact on motor efficiency in 9-year-olds than in boys of 7 years of age.

Further, the results suggest that the development of motor abilities is more pronounced than the development of morphological characteristics. Organized, compulsory physical education classes in schools, as well as the natural course of growth and development have considerable influence on progress in basic motor abilities (coordination, balance, speed, strength, endurance). The results obtained in the present study are similar to the ones documented in Malina and Bouchard (1991). The assessment instruments pertaining to the informational component of moving were of a higher complexity, therefore the examinees achieved lower values, whereas higher scores were obtained in tests depending on the energy component of moving.

Positive influence on motor efficiency was registered for the transversal and longitudinal skeletal dimensions, and for body mass. The latent dimensions, that are under the control of the excitation intensity regulation mechanism, are under positive influence of the morphological variables that define the athletic body constitution type. Body voluminosity, as the latent dimension in the observed sample, presents active body strength. Skinfold measures have negative influence on motor efficacy, and subcutaneous fat tissue negatively influences direct connections with dimensions and variables of the energy regulation mechanism. In the measures that are under the control of the energy regulation mechanism, influence of the manifest anthropometric variables and morphological latent dimensions is higher. In the measures that depend on the information component of moving the influence of the anthropometric variables is lower.

The research suggests that morphological attributes have, in principle, significant, very often even considerable influence on the structure and the level of motor abilities. The development level and the structure of morphological characteristics may, with regard to the biomechanical demands of a motor task assessing motor abilities, either facilitate or inhibit accomplishments in the task performance. Getting an insight into the nature of these relationships in children within heterogeneous groups is crucial for physical education quality planning and programming. The findings of the present study highlight a necessity to analyse the morphological characteristics along with each motor efficiency analysis. Therefore, the analysis of the morphological space is an indispensable component of work of PE educators and other kinesiologists.

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PRILOG POZNAVANJU RELACIJA MORFOLOŠKIH I MOTORIČKIH OBILJEŽJA 7- I 9-OGODIŠNJIH UČENIKA

Sažetak

Uvod

U sustavu tjelesnog odgoja, sporta i vježbanja značajan je udio antropometrijskih i motoričkih karakteristika u objašnjenju cjelokupnog psihosomatskog statusa školske djece. Ta obilježja sasvim sigurno utječu i na razvoj drugih dimenzija. Tako su stupanj razvijenosti i međusobni odnosi antropometrijskih i motoričkih dimenzija vrlo važni za razvoj cjelovite učenikove osobnosti.

U drugoj polovini 20. stoljeća svjedoci smo izrazitih promjena tjelesnih mjera mladeži, koje su u svim svojim razvojnim promjenama najuočljivije. Istraživanja provedena u Sloveniji tijekom poslijednjih pet godina ukazuju na nastavak ubrzanog tjelesnog razvoja djece. Uzroci tome mogu se prije svega tražiti u boljoj i kvalitetnijoj prehrani, višem životnom standardu, snažnijem utjecaju socijalne sredine te u boljoj zdravstveno-higijenskoj zaštiti djece. Brojni primjeri potkrepljuju tvrdnju da se današnji dječaci razvijaju znatno brže nego generacije prije njih.

Za nastavu tjelesne i tdravstvene kulture stoga se postavljanju novi zahtjevi da pravodobno i kvalitetno prati morfološke karakteristike i motoričke sposobnosti djece i mladeži kako bi se nastavni programi i sadržaji vježbanja uskladili i planirati primjereno potrebama djece. Nejednakomjeran razvoj pojedinih morfoloških karakteristika i motoričkih sposobnosti te njihovi neusklađeni odnosi, pogotovo u periodu najintenzivnijega rasta i razvoja, u mnogočemu otežavaju rad nastavnika TZK.

Ispitanici i metode

Cilj je istraživanja bio utvrditi strukturne karakteristike relacija morfoloških i motoričkih varijabli sedmo- i devetogodišnjih dječaka. Podaci uporabljeni u ovom istraživanju, prikupljani su u okviru projekta: »Analiza razvojnih trendova motoričkih sposobnosti i morfoloških karakteristika te njihove relacije s psihološkim i sociološkim dimenzijama slovenske djece i mladeži u dobi od 7. i 18. godine u razdoblju 1970. – 1983. – 1993.« (Strel i suradnici, 1992, 1996).

Uzorak ispitanika činilo je ukupno 400 učenika slučajno odabranih iz populacije učenika nižih razreda osnovnih škola Republike Slovenije, u dobi od 7 i 9 godina, po 200 dječaka za svaku dob. Uzorak varijabli činilo je 15 morfoloških varijabli izabranih tako da najbolje reprezentiraju latentne dimenzije koje su bile utvrđene i više puta provjeravane u mnogobrojnim dosadašnjim istraživanjima. Uzorak motoričkih varijabli činila su 24 mjerna postupka dobrih metrijskih karakteristika, koji su također već bili provjereni na raznolikim uzorcima entiteta.

Za svaku dobnu skupinu najprije su izračunati osnovni deskriptivni statistički parametri morfoloških i motoričkih varijabli. Nadalje su izračunati međuodnosi, odnosno kroskorelacije za prostor antropometrije, za prostor motorike te je izračunata interkorelacijska matrica za oba prostora. Odnosi između skupova upotrebljenih morfoloških i motoričkih varijabli utvrđeni su Hottelingovom biortogonalnom kanoničkom korelacijskom analizom. Broj značajnih kanoničkih faktora utvrđen je na osnovi Hi^2 testa za ocjenu značajnosti kanoničkih faktora po Bartlettovom algoritmu. Mora se posebno istaknuti da su sve varijable, prije nego što su podvrgnute multivarijatnoj kanoničkoj analizi, skalirane u istom smjeru, tako da svi korelacijski koeficijenti u svim matricama imaju realne predznake.

Rezultati i rasprava

Primjenom antropometrijskih i motoričkih mjerenja i odgovarajućom obradom podatka mogu se utvrditi relacije između tjelesne razvijenosti i motoričke učinkovitosti učenika u dobi od sedam i devet godina. Usporedba srednjih vrijednosti antropometrijskih mjera sedmo- i devetogodišnjaka pokazuje da su devetogodišnjaci viši i teži od sedmogodišnjaka, da su dužih ekstremitete i, što je jasno izraženo, da imaju i više potkožnog masnog tkiva. Devetogodišnjaci su u prosjeku viši čak za 11,8 cm, a sukladno s time povećava se i duljina ruku i nogu. U devetogodišnjaka dosta je veliko povećanje tjelesne mase, ali i potkožnog masnog tkiva, što znači da osim veće količine mišićne mase, imaju i više balasne mase. Promjene u transverzalnim mjerama su u usporedbi sa sedmogodišnjacima nešto manje.

U motoričkim zadacima devetogodišnjaci u pravilu postižu puno bolje rezultate, a najbolje se to vidi u testovima za procjenu sposobnosti koordinacije kretanja u prostoru (MPB, MR8D, MCUD i MRRC) te mjernim postupcima koje spadaju u prostor energetske komponente kretanja (MBAH, MFGF, MMBT, MHJ, MSU60). Organizirana nastava tjelesnog odgoja i sama priroda rasta i razvoja djece u tom razdoblju utječu na razvoj osnovnih motoričkih sposobnosti (koordinacije, ravnoteže, brzine, snage i izdržljivosti), a taj razvoj prati redukcija potkožnog masnog tkiva i povećanje mišićne mase. Usporedba srednjih vrijednosti rezultata motoričkih testova pokazala je da su devetogodišnjaci postigli slabije rezultate u testovima za procjenu fleksibilnosti (MCB, MSR, MBFB), što se može pripisati dosta velikom povećanju longitudinalnih mjera skeleta.

Na temelju veličine dobivene korelacije između kanoničkih faktora formiranih u prostoru morfološke antropometrije i motorike (0.713) i 51% njihove zajedničke varijance može se tvrditi da su kod sedmogodišnjaka, za razliku od devetogodišnjaka, gdje je objašnjeno čak 70% zajedničke varijance, relacije između analiziranih prostora relativno niske. Kod devetogodišnjaka je dobivena veza između prvog para kanoničkih dimenzija izrazito visoka (0,836), dok je veličina zajedničke varijance čak 69,9%. Očito je, dakle, da varijabilitet morfoloških dimenzija znatnije utječe na motoričku učinkovitost devetogodišnjaka nego sedmogodišnjaka.

Suština odnosa između antropometrijskih mjera i testova motoričkih sposobnosti devetogodišnjaka nalazi se u, s jedne strane, snažnom negativnom utjecaju ukupne tjelesne mase, definirane prvenstveno potkožnim masnim tkivom, na motoričke manifestacije izdržljivosti i snage relativnog tipa, a s druge strane u istodobnom pozitivnom učinku takve morfološke građe na manifestacije apsolutne snage. Usporedba sa sedmogodišnjacima jasno pokazuje da se tijekom rasta i razvoja mijenja utjecaj različitih antropometrijskih karakteristika na rezultate istih motoričkih zadataka. Kod devetogodišnjaka znatno je jači utjecaj antropometrijskih karateristika na motoričke izlaze, a jedan je od razloga za to visoki postotak balasne mase i visoka varijabilnost mjera potkožnog masnog tkiva u tom godištu. Ukupna tjelesna masa najviše utječe na motoričke izlaze kako u pozitivnom tako i negativnom smislu. Pozitivno utječe na mjere apsolutne snage, a negativno na mjere relativne snage i izdržljivosti.

Zaključak

Na osnovi dobivenih rezultata utvrđena je značajna veza između antropometrijskih karakteristika, kako manifestnih varijabli tako i latentnih dimenzija, te motoričkih sposobnosti. Utvrđeno je da je međusobna ovisnost motoričkih sposobnosti i morfoloških karakteristika vrlo značajna za obje dobne skupine.

Rezultati su pokazali znatno izraženiji razvoj motoričkih sposobnosti nego morfoloških karakteristika. Organizirana nastava tjelesne i zdravstvene kulture, kao i sam rast i razvoj djeteta u tom razdoblju utječu osobno na razvoj osnovnih motoričkih sposobnosti (koordinacije, ravnoteže, fleksibilnosti, brzine, snage i izdržljivosti).

Ovo istraživanje govori u prilog činjenici da morfološka obilježja imaju u pravilu važan, a često i znatan utjecaj na strukturu i razinu motoričkih sposobnosti. Rezultati ovog istraživanja ukazuju na to da se u svakoj analizi motoričkog prostora nužno mora analizirati i morfološki prostor.

Ključne riječi: *antropometrijske mjere, motoričke sposobnosti, osnovna škola, relacije, dječaci*

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