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QUANTITATIVE DIFFERENCES IN MOTOR ABILITIES OF PRE-SCHOOL BOYS AND GIRLS

KVANTITATIVNE RAZLIKE V MOTORIČNIH SPOSOBNOSTIH PREDŠOLSKIH DEČKOV IN DEKLIC

Abstract

The sample of 367 children, 223 boys and 144 girls, four to seven years of age, was measured with three anthropometric measures and seven motor tests. After the partialisation of motor test variables by children's age and body composition variables, the differences between boys and girls were analysed by the DISCP programme for canonical discriminative analysis in Mahalanobis' space. The obtained results point to the existence of "motor potential capacity" in which the quantitative differences show that the boys have significantly better results in motor tests for the estimation of explosive strength and functional coordination of primary motor abilities, whereas the girls performed better in flexibility tests.

Key words: motor abilities, differences, pre-school age

Izvleček

Vzorec 367 otrok, od tega 223 dečkov in 144 deklic, starih od štiri do sedem let, smo merili s tremi antropometrijskimi merami in sedmimi motoričnimi testi. Po procesu parcializacije spremenljivk motoričnih testov glede na starost otrok in njihovo telesno zgradbo smo razlike med dečki in deklicami analizirali s programom DISCP za kanonično diskriminantno analizo v Mahalanobisovem prostoru. Dobljeni rezultati kažejo na obstoj »motorične potencialne zmožnosti«. Kvantitativne razlike kažejo, da so v motoričnih testih dečki dosegli pomembno višje rezultate v ocenjevanju eksplozivne moči in funkcionalne koordinacije primarnih motoričnih sposobnosti, medtem ko so deklice dosegle višje rezultate na testih prožnosti.

Ključne besede: motorične sposobnosti, razlike, predšolska starost

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INTRODUCTION

On the basis of current experiences from work with pre-school children, it has been assumed that motor behaviour is qualitatively different from that at school age and even that at older ages. Unfortunately, until now the problem of structuring pre-school-children motor space has not been solved satisfactorily. According to the integrated development theory (Ismail & Gruber, 1971), it is easy to conclude that the solution to this problem is complex.

There is also evidence that motor development and motor behaviour of small children have a general character (e.g. Bala, 1981; Bala & Nićin, 1997). Such comprehension of motor behaviour of small children is in accord with Luria's studies (1976) which pointed out that the second and third zones of the brain cortex of small children are still not functionally formed. For this reason, the specific functioning of the central nervous system is not evident in pre-school children and has to be dealt with integrally.

On the other hand, there are some researches, especially those made by a group of authors from Slovenia, that pointed to the significant differentiation of motor abilities in motor behaviour in children (Planinšec, 1995; Rajtmajer, 1997a; Rajtmajer & Proje, 1990; Strel & Šturm, 1981; Videmšek & Cemić, 1991). Rajtmajer (1997b) compared the structures of motor abilities of small children as described in the above researchers and found out that there were similarities between them in terms of methodological approach, both in the sampling of children and motor variables (tests) and in data computation. It was established that there were differences in motor abilities of children already at the pre-school age, as well as statistically significant differences between boys and girls.

In one research of the structure differences in motor abilities of pre-school boys and girls (Bala, 2002b) a group of 220 boys and 220 girls, aged between four and seven, were measured with seven motor tests. Several criteria were used to analyse the differences and similarities of the correlation matrices as well as to compare their structures. The obtained results point out the existence of a general factor of motor behaviour, with some similarities between pre-school boys and girls, but not according to all of the applied criteria.

Morphological characteristics are the most noticeable anthropological dimensions and make the basis of growth and/or development of most of the remaining anthropological status dimensions. These characteristics manifest body composition and are assessed by anthropometric measurements. As is known, the morphological characteristics of adults are: a) longitudinal skeleton dimensionality, b) transversal skeleton dimensionality, c) body mass and voluminosity, and d) subcutaneous fat (Kurelić, Momirović, Stojanović, Šturm, Radojević & Viskić-Štalec, 1975; Momirović, 1970). In children, especially at pre-school age, there are no suitable models of morphological characteristics. It is worth mentioning that Bala (1981) in his research on a sample of 1564 boys and 1574 girls aged 6, 7, 8, 9 and 10 years in Vojvodina discovered two morphological characteristics in every age and sex: a) skeleton dimensionality and b) voluminosity of body and subcutaneous fat. The dominant anthropometric measures were: body height, body weight and upper arm (triceps) skinfold. These measures were later also included in the expert system for initial selection and orientation of children in different sports disciplines »Talent« in Slovenia (Leskošek, Bohanec, Kapus & Rajkovič, 1997).

The very simple model of fitness components in pre-school children measured by field tests consists of some motor abilities, body composition and cardio-respiratory fitness. For this research some motor abilities and some aspects of body composition are taken into consideration. Body composition is one of several fitness components and refers to the proportion of the different types of tissues that contribute to body weight. Fitness testing is most commonly performed by means of assessing the fat mass or adipose tissue. Body composition has almost become synonymous with body fat measuring. Body fat has received unique attention because it is mostly related to health problems and regarded as a potential health-risk, and as a success factor in physical activities and sports. The relative amount of fat in the body is by far the most common measure of body composition in adults, but less in children, because of the well-established relationship between fatness, fitness and athletic performance. There is not much information about the development of body composition in pre-school children and differences between boys and girls. Fatter children and children with obese parents are more likely to be fat as adults, so there is a need of assessing fatness in children, especially in selection for sport's activities and high athletic performance. This problem is very important because of children's physical activities that could lead to »children sports«, which is the first step to successful involvement in adequate sport or sports. However, selecting children for specific sports at a young age is a questionable procedure. There is low relationship between body composition (size and/or shape) and success in sports during childhood, so children and their parents can be given only advice about potential success in specific sports based on physical (body-build) characteristics.

Growth in stature and weight are frequently used as markers of health and nutritional status, as well as adjuncts to the evaluation of developmental progress. Strength, movement mechanics and control as well as physiological parameters can influence both absolute and proportional changes in specific body measures. Anthropometric tracking of such measures will provide information regarding the effects of training or detraining of children in addition to those changes normally anticipated with growth.

They all point to the fact that young children react with their entire bodies and minds, as well as with all their motor abilities. This concurs with the theory of "integrated development" of young children (Ismail & Gruber, 1971) which points to low but significant correlation between motor, intellectual and emotional development of young children. This correlation decreases with age, which indicates an enormous possibility to positively influence a child's intellectual and emotional behaviour through the development and enhancement of their motor behaviour.

The purpose of this paper is to analyse the quantitative differences of motor abilities in pre-school boys and girls after the partialisation by children's body composition (elementary morphological characteristics) and age. The results of this research could reveal the "pure" motor potential capacities of boys and girls at pre-school age (without the influence of morphological characteristics and age on their performance in motor tests, i.e. tests of motor abilities).

METHOD

Participants

This research was performed on the sample of 367 children, 223 boys (60.76%) and 144 girls (39.24%) aged between 4 and 7 (boys: M = 5.54 years, SD = 0.78 yrs; girls: M = 5.56 years, SD = 0.79 yrs). The sample was drawn from the population of children in kindergartens in the city of Novi Sad (Vojvodina, Serbia & Montenegro).

Instruments

The children's age (AGE) is presented in decimal years showing the period of time between the date of birth and the date every child was measured and tested, which is then transformed into a corresponding result according to the International Biological Programme.

Evaluation of anthropometric measures, these being important elements in evaluation of body composition, was carried out also in accordance with the International Biological Programme (Lohman, Roche & Martorell, 1988), and the sample consisted of these measures:

1) Body height (HEIGHT) - for longitudinal body dimensionality,
2) Body weight (WEIGHT) - for body voluminosity and
3) Upper arm skinfold (FAT) - for amount of subcutaneous fat.

The battery of seven motor tests used in this research was selected on the basis of experiences with adults, and was modified to suit small children (Bala, 1999a, 1999b, 2002a). These tests are used (for adults) to assess the effectiveness of the following functional mechanisms: movement structuring, tonus and synergetic regulation, regulation of excitation intensity and regulation of excitation duration (Gredelj, Metikoš, Hošek & Momirović, 1975; Kurelić, et al., 1975). The battery of motor tests included:

1) Obstacle course backwards (OBST) (to estimate Functional coordination of primary motor abilities),
2) Arm plate tapping (TAPP) (to estimate Frequency of simple movements),
3) Forward bend and touch on a bench (FORB) (to estimate Flexibility),
4) Standing broad jump (JUMP) (to estimate Explosive strength),
5) Crossed-arm sit-ups (SITUP) (to estimate Repetitive strength of the trunk),
6) Bent-arm hang (HANG) (to estimate Static strength of arms) and
7) 20 m dash (DASH) (to estimate Functional coordination of primary motor abilities).

Procedure

Every child was given an opportunity to rehearse the test before registering the results. In this way more adequate and reliable results were obtained.

1. *Obstacle course backwards* (OBST). The child has to walk backwards on all fours and cover the distance of 10 m, climb the top of Swedish bench and go through the frame of the bench. The task is measured in tenths of a second.
2. *Arm plate tapping* (TAPP). For fifteen seconds the child has to tap alternately two plates on the tapping board with his dominant hand, while holding the other hand in between the two plates. The result is the number of alternate double hits.
3. *Forward bend and touch on a bench* (FORB). The child stands on a bench and bows as deep as possible. A straight-angle ruler, which points down with the 40 cm mark at the child's foot and 40 cm below it, is next to him/her. The result is the depth of the reach measured in cm.
4. *Standing broad jump* (JUMP). The child jumps with both feet from the reversed side of Reuter bounce board onto a carpet, which is marked in cm. The result is the length of the jump in cm.

5. *Crossed-arm sit-ups* (SITUP). The child lies on his/her back with his/her knees bent and arms crossed on the opposite shoulders. He/she rises to a sitting posture and returns to the starting position. The instructor's assistant holds the child's feet. The result is the number of correctly executed rises to the sitting posture (no longer than 60 seconds).
6. *Bent arm hang* (HANG). The child under-grips the bar and holds the pull-up as long as he/she can (chin above the bar). The result is the time of the hold measured in tenths of a second.
7. *20 m dash* (DASH). The result is the time of the child's running of a 20 m distance from standing position at the start. The children run in pairs.

A more detailed description with the entire standardisation of tests can be found in the book "Sportska školica" (Sport School For Children) (Bala, 2002a). This battery of tests has been used for several years in the training process at "Sportska školica" in Novi Sad (Vojvodina) and it is very similar to the battery of tests used in the expert system "Talent" in Slovenia (Leskošek et al., 1997).

Consequently, these tests were a manifestation of a hypothetical functional mechanism of young people, which means that they could be virtually taken as primary latent motor factors. This approach was chosen to reduce the sample of motor tests because of significant organising and motivational problems that arise in testing procedures with pre-school children.

The results obtained from the measuring and testing procedures were analysed by the DISCP programme for canonical discriminative analysis in Mahalanobis' space with the partialisation by age and body composition variables, asymptotic tests and added identification structures (Version 1.0, Momirović, 2001). In other words, the determination of the correlations within the set of motor variables had first been removed after the components in these variables which were predictable from the set of age and body composition variables and then analyses were carried out.

RESULTS

Intercorrelation between the age and body composition variables in the entire sample of children is shown in Table 1. It is obvious that fat is not related to age but, of course, to height and much more to height of pre-school children. Certainly, height and weight are very strongly related to pre-school children's age.

Table 1: Intercorrelation between age and body composition variables

	AGE	*HEIGHT*	*WEIGHT*	*FAT*
AGE	1.000	**.749**	**.508**	.024
HEIGHT	**.749**	1.000	**.752**	**.164**
WEIGHT	**.508**	**.752**	1.000	**.620**
FAT	.024	**.164**	**.620**	1.000

Legend:
AGE – age in decimal years
HEIGHT - body height
WEIGHT - body weight
FAT - upper arm skinfold

Table 2 shows the correlation between age and body composition and motor variables. Age and height have a very significant and positive correlation with all motor variables, except with the one estimating flexibility (FORB). This motor variable is virtually independent of all body composition variables. Weight has significant and positive correlation with all motor variables, except with the variables estimating flexibility and static strength of arms. It is very interesting that fat has the highest and negative correlation with the motor variable that estimates static strength of arms, but weight has no such relation. It is evident that fat has virtually zero or negative correlation with all motor variables.

Table 2: Correlation between age and body composition variables and motor variables

	OBST	***TAPP***	***FORB***	***JUMP***	***SITUP***	***HANG***	***DASH***
AGE	**-.464**	**.545**	.039	**.498**	**.455**	**.276**	**-.542**
HEIGHT	**-.336**	**.434**	.001	**.461**	**.400**	**.146**	**-.433**
WEIGHT	**-.194**	**.306**	.048	**.288**	**.265**	-.051	**-.298**
FAT	**.114**	.010	.010	**-.140**	-.011	**-.241**	.072

Legend:

AGE – age in decimal years
HEIGHT - body height
WEIGHT - body weight
FAT - upper arm skinfold
OBST - Obstacle course backwards
TAPP - Arm plate tapping
FORB - Forward bend and touch on a bench
JUMP - Standing broad jump
SITUP - Crossed-arm sit-ups
HANG - Bent-arm hang
DASH - 20 m dash

The relation which points to the influence of age and body composition variables on the motor tests' performance is shown in Table 3, where the regression coefficients are, of course, somewhat different than the correlation coefficients. The elements in that regression matrix reveal a very high and significant influence of children's age on all motor abilities needed for performance of these motor tests, except the test for flexibility. It is apparent that the body composition variables have different influences than what could be concluded on the basis of correlation coefficients in Table 2. Height has much less influence than weight and fat. Nevertheless, it is very interesting that weight has a positive influence on a coordination of primary motor abilities (OBST and DASH), flexibility (FORB), and explosive strength (JUMP), but fat has a negative influence on the same motor abilities. This could be due to the fact that, even at pre-school age, children differ in muscle and fat tissues, which is why heavier children could have more active and effective (muscle) tissues which would help them perform the motor variables better.

Table 3: Regression matrix

	OBST	***TAPP***	***FORB***	***JUMP***	***SITUP***	***HANG***	***DASH***
AGE	**-.457**	**.501**	.094	**.307**	**.345**	**.326**	**-.476**
HEIGHT	.097	.009	**-.230**	.065	**.128**	.028	.084
WEIGHT	**-.167**	.076	**.237**	**.295**	.030	**-.131**	**-.265**
FAT	**.213**	-.051	-.102	**-.341**	-.059	**-.172**	**.235**

Legend (see Table 2)

After the partialisation, the intercorrelation coefficients of motor variables are shown in Table 4. Such motor space could be perceived as a “motor potential” of pre-school children, independent of their age and body composition (elementary morphological characteristics). Based on an examination of the elements in Table 4 a general conclusion may be drawn that the children’s motor abilities are significantly and positively intercorrelated.

Table 4: Intercorrelation of motor variables after partialisation

	OBST	***TAPP***	***FORB***	***JUMP***	***SITUP***	***HANG***	***DASH***
OBST	1.000	**-.293**	**-.173**	**-.461**	**-.332**	**-.229**	**.435**
TAPP	**-.293**	1.000	**.113**	**.311**	**.230**	**.122**	**-.281**
FORB	**-.173**	**.113**	1.000	**.181**	.079	**.149**	**-.129**
JUMP	**-.461**	**.311**	**.181**	1.000	**.401**	**.225**	**-.475**
SITUP	**-.332**	**.230**	.079	**.401**	1.000	**.312**	**-.319**
HANG	**-.229**	**.122**	**.149**	**.225**	**.312**	1.000	-.106
DASH	**.435**	**-.281**	**-.129**	**-.475**	**-.319**	-.106	1.000

Legend (see Table 2)

The centroides (the means in partialised space) of motor variables in both groups, boys (g1) and girls (g2), show that boys have better functional coordination of primary motor abilities (OBST and DASH) and explosive strength (JUMP) than girls. Girls achieved better results in the test which estimated flexibility (FORB). In fact, in other motor variables they have very similar results and, statistically, there are no significant differences between the results of boys and those of girls. Such conclusion was confirmed on the basis of the results of a univariate analysis of variance (see Table 6).

Table 5: Centroides of motor variables

	g1	***g2***
OBST	-.188	.292
TAPP	.001	-.002
FORB	-.162	.251
JUMP	.221	-.342
SITUP	.081	-.126
HANG	.008	-.012
DASH	-.176	.273

Legend (see Table 2)

Table 6: Results of univariate analysis of variance

	lambda	*etasq*	*eta*	*ftest*	*prob*
OBST	.945	.055	.235	21.251	.000
TAPP	1.000	.000	.002	.001	.974
FORB	.959	.041	.201	15.427	.000
JUMP	.924	.076	.275	29.814	.000
SITUP	.990	.010	.101	3.788	.052
HANG	1.000	.000	.010	.035	.852
DASH	.952	.048	.219	18.395	.000

Legend (see also legend of Table 2):
lambda – Wilks' Λ,
etasq – proportion of criterion variance explainable by the predictor variance
eta – Ficher's intergroup coefficient
ftest – Fisher-Snedecor test
prob – probability of error in rejecting the hypothesis that the means are equal

To achieve clearer differentiation between the group of boys and the group of girls in the entire sample, the distances between the groups are calculated in standardised (Fisher's) and Mahalanobis' space. The correlation coefficients between the standardised and Mahalanobis variables are shown in Table 7. From the main diagonal in this matrix, it is evident that the obtained and corresponding variables have high but not full correlation, which indicates a slightly unequal content of the two bases of differentiation between the boys and the girls. But the canonical correlation between the function in Mahalanobis' and standardised space shows a very significant statistical difference between these two spaces (see Table 8).

Table 7: Correlation between the standardised and Mahalanobis variables

	MOBST	*MTAPP*	*MFORB*	*MJUMP*	*MSITUP*	*MHANG*	*MDASH*
SOBST	**.938**	**-.119**	-.070	**-.198**	**-.131**	-.093	**.190**
STAPP	**-.119**	**.972**	.044	**.127**	.089	.042	**-.114**
SFORB	-.070	.044	**.990**	.074	.019	.066	-.047
SJUMP	**-.198**	**.127**	.074	**.926**	**.172**	.088	**-.212**
SSITUP	**-.131**	.089	.019	**.172**	**.953**	**.143**	**-.128**
SHANG	-.093	.042	.066	.088	**.143**	**.978**	-.023
SDASH	**.190**	**-.114**	-.047	**-.212**	**-.128**	-.023	**.942**

Legend (see also legend of Table 2):
S - Standardised variables
M - Mahalanobis variables

Table 8: Canonical correlation and Stojan's test of significance

	rho	*dtr*	*ftest*	*sig*
f1	.427	.183	81.595	.000

The dominant variables in the structure of function in Mahalanobis' space (Table 9) are explosive strength, flexibility and functional coordination of primary motor abilities, and much weaker is frequency of simple movements. The structure of standardised space (Table 9) is similar, with frequency of simple movements having no importance at all, but with repetitive strength of the trunk being an important variable. It seems that the structure of the function in Mahalanobis' space has a better solution. One reason for such opinion lies in the fact that repetitive and especially static strength is not characteristic of little children.

Table 9: Structure of the function in Mahalanobis' (fM) and standardised (fS) space

	fM	*fS*
OBST	**-.446**	**-.549**
TAPP	**-.147**	.004
FORB	**-.560**	**-.471**
JUMP	**.573**	**.643**
SITUP	.067	**.237**
HANG	-.045	.023
DASH	**-.363**	**-.512**

Legend (see Table 2)

The main results of the canonical discriminative analysis in Mahalanobis' space with the partialisation by age and body composition variables (see Tables 10 and 11) show that the boys (g1) achieved significantly better motor test results in estimation of explosive strength (JUMP) and functional coordination of primary motor abilities (OBST and DASH), while the girls (g2) had better flexibility (FORB) results.

Table 10: Standardised discriminative and cross-structural coefficients in Mahalanobis' space

	f1	*f1*
OBST	-.402	**-.235**
TAPP	-.267	.002
FORB	-.631	**-.201**
JUMP	.585	**.275**
SITUP	-.075	.101
HANG	-.077	.010
DASH	-.248	**-.219**

Legend (see Table 2)

Table 11: Centroids of groups on discriminative function

	f1
g1	.343
g2	-.532

Legend:
g1 – boys
g2 – girls

DISCUSSION

The obtained results point to a construct which could be referred to as "motor potential capacity" or "pure motor abilities", because the real manifestation of motor abilities in the motor tests was partialised from age and body composition of pre-school children. It could be very tricky and more of a theoretical than practical issue concerning motor behaviour of little children, but the determination of one's "motor potential capacity" should be an important task. There are many ways of influencing children's bodies, minds, abilities, etc. during their childhood. And all these influences can change, as well as children's bodies, minds, abilities, etc. Some "motor potential capacity" should be determined by eliminating as many influences as possible.

In order to better understand the role of body composition in the entire anthropological status and motor performance, it is important to distinguish between the terms growth, maturation, and development of children. Growth refers to an increase in the body size and results from an increase in the number of cells, increase in the size of cells or increase in intercellular substances. According to the results of this research the relationship between the size and most of the physiological attributes that are significant in physical activities during childhood is positive. Maturation is the process of attaining the mature state, noting that different body systems achieve mature state at a different time. Maturational rate does not necessarily parallel chronological age and is largely determined by biological inheritance. As we know, there is a positive correlation between physical performance and the level of maturity; children of pre-school age have not yet reached maturity because their central nervous system is still immature. Development is highly related to growth and maturation but it has a biological and behavioural context. Biological development involves differentiation of cells enabling them to perform specialised functions or to refine functions that already exist. Behavioural development relates to the evolution of intellectual, psychological and sociological attributes. Motor development could be defined as a progressive change in motor performance or, generally speaking, in motor behaviour, resulting from growth, maturation, and biological and behavioural development. This complex issue is even more complicated in little children, since one can talk about their growth and development, but not – or very carefully – about maturation, which is very important for the domain of motor abilities.

As the results of this research show quantitative differences between boys and girls, a suggestion could be made that a "motor potential capacity" of little children, which is "cleaned" from the influences of their body growth and age, is also characterised by differences between boys and girls in terms of structure. This indicates sex dimorphism among pre-school children in their motor abilities (the information and energy components of movement) or in their "motor potential capacity". At their age it is difficult to explain such phenomena only against the family background, different toys boys and girls play with, etc. It seems that differences between boys' and girls' motor abilities occur firstly due to their different "motor potential capacities" and subsequently due to other factors which help or prevent from the manifestation of such potential capacity.

After the partialisation of seven motor test variables of 223 boys and 144 girls, aged between four and seven, by the age and body composition, the results point to the "motor potential capacity" and to the existence of differences in the energy and information components of movement. Boys achieve significantly better results in tests for estimation of explosive strength and functional coordination of primary motor abilities, while girls have better flexibility results. Such results indicate a possibility that sex dimorphism exists in the motor domain even at pre-school age.

These findings should be interesting in a motor training process during entire motor activities of children, for example during physical education in kindergartens or at the early stages in the so-called “children sports”.

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