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THE RELATIONSHIP BETWEEN CHILDREN'S PHYSICAL FITNESS AND GENDER, AGE AND ENVIRONMENTAL FACTORS

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ABSTRACT

The main aim of the research was to determine how children's physical fitness development is related to age, gender, and certain environmental factors at the onset of puberty. The research was carried out on a representative sample of 897 children (47.9 % females and 52.1 % males) aged eleven and fourteen. Twelve tests were used to assess their physical fitness. Based on the duration of the physical activities, the children were divided into four categories: inactive, occasionally active, active and highly active. In the case of paternal education and maternal education, the children were classified into three categories: low, average and high. Considering their school grades in mathematics, the children were divided into three groups: less successful, successful and very successful. In the case of their place of residence, the children were divided into three groups: urban, suburban and rural. A component model of factor analysis was used to identify their basic coordinate system of physical fitness. To solve the problem of the integration of physical fitness into environmental factors, age and gender, a factorial analysis of variance was used. The results show that most of the differences in physical fitness can mainly be explained through age and gender. We can conclude that the significant factors to physical fitness development are growth, development and the maturation rate of individuals, which are predominantly hereditarily determined. Place of residence, physical activity, school grades and parental education have less influence on physical fitness development and serve only as an additional impulse to further stimulate or inhibit the physical development of children.

Keywords: *physical fitness development, environment, factorial analysis of variance, effect size.*

POVEZANOST GIBALNE UČINKOVITOSTI OTROK S SPOLOM, STAROSTJO IN OKOLJSKIMI DEJAVNIKI

IZVLEČEK

Osnovni cilj raziskave je bil ugotoviti, kako je gibalna učinkovitost otrok povezana s starostjo in spolom ter z nekaterimi okoljskimi dejavniki na začetku pubertetnega obdobja. Raziskava je bila opravljena na reprezentativnem vzorcu 897 otrok starih enajst in štirinajst let. Za oceno gibalnih sposobnosti je bilo uporabljenih 12 testov. Merjenci so bili na osnovi časa, ki ga namenjajo športni dejavnosti, razdeljeni v štiri kategorije: nedejavne, občasno dejavne, dejavne in zelo dejavne. Na osnovi izobrazbe očeta in matere so bili merjenci razvrščeni v tri kategorije: nižja, srednja in višja. Na temelju ocene pri matematiki so bili merjenci razdeljeni v tri skupine: slabši in povprečni, dobri, zelo dobri. Na osnovi kraja bivanja so bili merjenci razdeljeni v tri skupine: mestno, primestno in podeželsko. S komponentnim modelom faktorske analize smo v prostoru gibalnih sposobnosti opredelili bazični koordinatni sistem. Za reševanje problema povezanosti gibalnih sposobnosti z okoljskimi dejavniki, starostjo in spolom je bila uporabljena večfaktorska analiza variance. Glede na dejstvo, da največji del razlik v gibalnih sposobnostih merjencev pojasnjujeta starost in spol, lahko ugotovimo, da so ključni dejavniki razvoja gibalnih sposobnosti rast, razvoj in hitrost zorenja posameznika, ki so pretežno dedno determinirani. Kraj bivanja, športna dejavnost, učna uspešnost in izobrazba staršev imajo na gibalno učinkovitost bistveno manjši vpliv in predstavljajo le dodatni impulz, ki dodatno spodbudi ali zavira gibalno učinkovitost otrok.

Ključne besede: *razvoj gibalnih sposobnosti, okolje, večfaktorska analiza variance, velikost učinka*

INTRODUCTION

The health of the adult population is closely related to health in childhood, and the health of children depends on their physical activity, physical fitness, and motoric skills, while mental health also depends on physical and motoric self-concepts (Jürimäe & Jürimäe, 2001; Eisenmann, Wickel, Welk, & Blair, 2005; Janssen & LeBlanc, 2010). A high level of physical fitness is a positive criterion of health level, while regular physical activity of appropriate intensity, frequency, type, and duration increases physical fitness (Mišigoj-Duraković, 2003). Through play and physical activities, children learn the limits of their physical fitness and improve their motoric efficiency.

The development of children and adolescents occurs integrally, dynamically, con-

tinuously, and according to certain rules. It depends on the hereditary predispositions, the environment we live in, and one's physical activity. Physical activity is one of the key stimuli of children's growth and development in the period before puberty (Jürimäe & Jürimäe, 2001; Malina, Bouchard, & Bar-Or, 2004; Brettschneider & Naul, 2007). Delemarre-van de Waal (1993) claims that growth and development depend on hereditary and environmental factors that are complexly intertwined into a grid. Environmental factors can be understood as the physical and social environment that is related to the person (Stokols, 1992). Environmental factors include geographic, climate, social, economic, cultural, family, and nutritional factors as well as lifestyle and physical activity. They are interrelated and affect a person's growth and development (Pařízková, 2010). Genetically conditioned factors and environmental influences present the basis for the development of a person's abilities and characteristics. We can influence the genetically conditioned factors in different ways and by the application of different contents, whereas we have to be aware that the influence is never divided and it integrally influences the bio-psychosocial image of the child and adolescent (Strel & Kovač, 2004).

Researchers from different fields are trying to uncover the essence of and causes for the connection between individual abilities, characteristics, and features as systematically, integrally, and objectively as possible as well as attempting to establish how an individual and their surroundings influence each other. An individual's behavior is influenced by intrapersonal factors (biological, psychological), interpersonal factors (social, cultural), organizational factors, social community, physical environment, and politics (Sallis, Owen, & Fisher, 2008; Van Tuyckom, 2011). Most features of today's information-consumer society deter children from healthy lifestyles and physical activity. Children are most susceptible to the various technological novelties that chiefly enable a comfortable lifestyle in front of computers and televisions (Bar-Or et al., 1998; Jurak, 2006), while simultaneously alienating children from their environment and physical activity. In Slovenia, according to the HBSC1 data from 2001 and 2002, more than half of boys and girls aged eleven through fifteen were insufficiently physically active (Janssen et al., 2005). One of the factors that can tip the scale, decrease the negative influence of the modern lifestyle, and ensure the balance of psychical and physical development of children is physical education class in school in combination with other extracurricular and leisurely sports activities. Sports activities, which stand out from other physical activities due to its higher intensity and target orientation towards improving well-being, health, physical fitness, and physical components, influences the biological, psychical, and social components of an individual's personality (Strel et al., 2003). The system of a person's psychosomatic dimensions can be understood as an organized, open, and dynamic system composed of subsystems that are intertwined in continuous co-dependency.

There have been several researches conducted globally in the field of physical fitness and motoric development in primary school children (Bouchard & Shepard,

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1994; Baunen & Malina, 1996; Jürimäe & Jürimäe, 2001; Malina, Bouchard, & Bar-Or, 2004). The connection between physical fitness and physical activity, the children's social status, and success in school has been studied somewhat less, whereas the findings of the researchers often differ (Jürimäe & Jürimäe, 2001; Malina, Bouchard, & Bar-Or, 2004). The main reason definitely lies within the complexity and intricacy of the individual areas and the connections between them. Additional reasons can also be found in the fact that, in the case of children, there is a gap between chronological and biological age, which causes extreme difficulty in the evaluation and interpretation of the results, as for some, this is still a period of pre-puberty and, for others, a period of puberty. Non-harmonized measuring procedures for determining physical fitness also cause significant problems (Jürimäe & Jürimäe, 2001). Until now the research concerning the correlation between physical fitness and physical activity, social status, and success in school (in boys and girls) has not been conducted, therefore it is reasonable to research the relationships between physical space and the aforementioned environmental factors, age and gender.

The basic purpose of this research is to determine in what way motoric development is related to age, gender, and certain environmental factors, namely in the case of sports activities, paternal education, maternal education, success in school and place of residence during the period of slower growth and at the onset of puberty.

METHODS

Participants

Female and male individuals who turned 11 and 14 in the six months before or after October 1, 2003 were included in the research. The actual sample includes 897 children, of which 467 are boys and 430 are girls. There are 450 children in the age group of eleven-year-olds and 447 children in the age group of fourteen-year-olds. The assessments were performed only on those pupils who were healthy on the day of the assessment. The subjects' parents gave their written consent for their children to be included in the research. The entire sample was divided according to regions and selected randomly within regions. The chosen schools were from larger and smaller towns (Metlika, Trebnje, Žalec, Trbovlje, Ormož, Ljubljana, Izola, Tolmin, Jesenice, and Ravne na Koroškem) where the assessments had been performed since 1970.

Measurments

Physical fitness assessment. The selection of the group of tests for physical fitness assessment of the studied sample of subjects was based on the hypothetical model by Strel et al. (1992). Hypothetically, the tests belong to nine different latent dimensions of physical fitness space. The research included 12 tests: hand plate tapping for

20 seconds, standing broad jump, 60-meter run, hands drumming, shoulder flexibility, forward bend, flamingo balance test, sit-ups in 60 seconds, bent arm hang, polygon backwards, 20-meter endurance shuttle run, and 600-meter run. We decided to use only the tests that, according to the previous researches (Kovač, 1999), are representative for individual motoric dimensions. The subjects performed two repetitions of energetically less demanding tests, whereas the second repetition was used in data analysis. Only one repetition of energetically more demanding tests was performed.

Physical activity assessment. Other methods of physical activity assessment might be more accurate (Jürimäe & Jürimäe, 2001), but the use of a questionnaire enables working with larger samples. For assessing physical activity, the adopted questionnaire of Strel et al. (1992), was used. Based on the duration of moderate to vigorous physical activity, we divided the subjects into four categories: inactive (up to 3 hours/week), occasionally active (from 3 to 6 hours/week), active (from 6 to 9 hours/week), and highly active (more than 9 hours/week).

Social status assessment. Social status of children can be defined in several ways and considering numerous parameters, but it is frequently the education of the "dominant" parent that is the base for determining a child's social status (Malina, Bouchard, & Bar-Or, 2004). Based on paternal and maternal education, the subjects were classified in three categories: low (unfinished primary school, primary school), average (vocational school, 4-year secondary school), and high (bachelor's degree or more).

*Academic achievement assessment. T*here are numerous methods for determining academic achievement: standardized national tests for academic achievement, literacy, knowledge of arithmetic, reading skills, subjective knowledge assessments by the subjects, subjective assessments by the teachers or principles, grade average, general academic achievement, and mathematics grade (Trudeau & Shepard, 2008). Reading skills and especially the knowledge of mathematics in the early educational period are the most reliable indicators of a general academic achievement, i.e. school performance in the higher grades (Duncan et al., 2007). For this reason, in our research we also decided to define the general academic achievement based on the grade in mathematics. Based on the grade in mathematics the subjects were divided in three groups: less successful (grades 1, 2, or 3), successful (grade 4), very successful (grade 5).

Residence. Based on the place of residence the subjects were divided in three groups: urban (Ljubljana, Ravne, Trbovlje, Jesenice), suburban (Žalec, Izola, Trebnje), and rural (Metlika, Ormož, Tolmin) as was defined in previous researches (Strel, 1992).

Research design

The assessments were performed at primary schools in September and October 2003. The parents of all the subjects were acquainted with the purpose and the course of assessment and gave written consent prior to the assessment. At the end of the 2002/03 school year all the schools included in the sample were informed of the purpose and the performance of the assessment. No later than ten days before the start of the assess-

ment, they received the instructions and the assessment program; after that an interview with the coordinator was conducted at each school and the course of the assessment was harmonized. The assessment took place in favorable weather conditions and normally in good material conditions. It was performed in indoor and outdoor school facilities at the temperature between 16 and 24 °C. The assessment took place outdoors only if there was no rain or strong wind. The order of motoric tests was precisely defined and subjects had no systematically organized warm-up between individual assessments. However, they were allowed a practice run of individual tasks before the assessment. The subjects were divided into smaller groups to perform the motoric tests and they stayed in these groups during the whole assessment. Prior to performing the tasks, the subjects received detailed instructions from the examiners on how to perform the individual tasks. During the task performance, the examiners did not encourage the subjects. In case of an incorrectly performed task the subject had to repeat it. The assessments took place between 8 a.m. and 5 p.m. and only exceptionally before and after that period. The assessments took two or three days at an individual school. All the physical fitness assessments were completed on the first day, except the long distance run that was performed on the second day. An overall assessment time for each child was not longer than one hour.

Data Analyses

Before carrying out data analyses, screening procedures tested the parametric tests assumptions (normality, linearity). The Kolmgorov-Smirnov test showed that the distributions of hand plate tapping for 20 seconds, standing broad jump, 60-meter run, hand drumming, shoulder flexibility, forward bend, flamingo balance test, sit-ups in 60 seconds, bent arm hang, polygon backwards, 20-meter endurance shuttle run, and 600-meter run values statistically significantly deviate from normal distribution, therefore the transformation of data was performed. In the physical fitness space we separately defined the basic coordinate system with the component model of factorial analysis. Firstly, the Bartlett test was conducted to establish if the correlations between the variables are high enough to present a good basis for component analysis. And secondly, the Kaiser-Mayer-Olkin (KMO) measure was determined, and the variables communalities were calculated. With the Principal Component Analysis method we determined the component eigenvalues and the percentages of the explained variance. We limited the extraction to one component presenting the condensation of all variables in one dimension which carries most information we could gain from this set of variables. After determining the principal component, we analyzed the factor saturations of manifest variables vectors with the first main component of the physical fitness space. To solve the problem of physical fitness integration with some environmental factors, gender and age, we chose the multifactor analysis of variance. We limited the interpre-

tation of statistically significant interactions of environmental factors (sports activities, paternal and maternal education, place of residence, and academic achievement), gender, and age with the first principal component in the physical fitness space to two factors. Statistical significance was set at the α level of 0.05.

RESULTS

Principal Components of the Physical Fitness Space

The value of Kaiser-Mayer-Olkin (KMO) measure is 0.885, which points to the justified use of the component analysis in the physical fitness space. The value of Bartlett test is statistically significant (p = 0.000) which points to the fact that the correlations between the variables are high enough to present a good basis for the component analysis. Based on the component analysis there were twelve components extracted in the physical fitness space, but only the first component eigenvalue (λ = 4.580), the second component eigenvalue (λ = 1.388), and the third component eigenvalue (λ = 1.132) were higher than one. Given the fact that the first component explains 38.165 % of physical fitness variance and the second and third only 11.563 % and 9.431 % respectively, we decided to keep only the first extracted component, which we named **physical fitness component**.

Table 1: Final parameters of physical fitness space factorization.

Factors	h^2	λ	%
1	.374	4.580	38.165
2	.711	1.388	11.563
3	.634	1.132	9.431
4	.183	.838	6.985
5	.000	.765	6.379
6	.062	.674	5.619
7	.183	.565	4.709
8	.411	.543	4.527
9	.375	.473	3.941
10	.581	.399	3.324
11	.561	.376	3.136
12	.505	.267	2.221

h^2 = comunality; λ = eigenvalue; % = percentage of the explained variance

Table 2: Saturation of physical fitness variables with physical fitness component (F1).

Physical fitness tests	F 1
Standing broad jump	.843
60-meter run	–.796
Polygon backwards	–.762
20-meter endurance shuttle run	.749
600-meter run	–.711
Sit-ups in 60 seconds	.641
Bent arm hang	.612
Hand Plate tapping for 20 seconds	.611
Hands drumming	.427
Flamingo balance test	–.427
Forward bend	.249
Shoulder flexibility	.017

Table 2 shows the saturation of physical fitness manifest variables with the extracted physical fitness component. The values present the correlation of an individual variable with the physical fitness component. Given the fact that all the values of factor saturation, except the lowest two are higher than 0.40, we can determine that the extracted component represents the whole physical fitness space well. Only in the forward bend and shoulder flexibility variables the values of saturation with the physical fitness component are lower. Given the fact that the tests are representative for flexibility assessments it is possible to conclude that the physical fitness component provides the least information on flexibility.

The relation of age, gender, and environmental factors to the physical fitness space

The presumption of the homogeneity of variances is justified, which is pointed out by the values of Leven test ($F = 0.816$; $p = 0.983$). Therefore, the use of variance analysis is justified.

Table 3: Statistically significant diferences in physical fitness component regarding environmental factors, gender, and age, separately (ANOVA) and the measure of effect size.

Variable		Mean (SD)	ANOVA		
			F	p	η^2
Physical activity	Inactive	–.066 (.154)	1.505	.212	.006
	Occasionally active	.033 (.156)			
	Active	.167 (.157)			
	Highly active	.157 (.156)			
School grade	Less successful	–.097 (.157)	1.758	.173	.004
	Successful	.011 (.143)			
	Very successful	.303 (.211)			
Place of residence	Rural	.080 (.145)	3.017	.050	.007
	Suburban	176 (.150)			
	Urban	–.038 (.144)			
Paternal education	Low	.149 (.246)	0.077	.926	.000
	Average	.079 (.056)			
	High	–.010 (.323)			
Maternal education	Low	–.008 (.317)	.174	.840	.000
	Average	.061 (.085)			
	High	.166 (.193)			
Gender	Male	.284 (.136)	27.538	.000	.033
	Female	–.139 (.144)			
Age	Eleven	–.424 (.142)	145.890	.000	.152
	Fourteen	.570 (.139)			

η2 = effect size

Table 3 shows that the differences in *physical fitness component* between the urban, suburban, and rural children are statistically significant ($F = 3.017$; $p = 0.050$). The children from the suburbs reach the highest values, while the urban children reach the lowest values. More interesting is the fact that the place of residence explains only 0.7 % variance of physical fitness of children. The probability of the proof of statistically significant differences that are not practically important (as shows η^2) increases with

the sample size. Table 3 shows that the differences in the *physical fitness component* with regard to the age are statistically significant ($F = 145.890$; $p < 0.001$). The fourteen-year-old children have higher values than the eleven-year-old ones. The extremely high relation of age and the *physical fitness component* should be pointed out as it explains 15.2 % of the variance of children's physical fitness ($\eta^2 = 0.152$). As the results of the variance analysis show in Table 3, the difference in the *physical fitness component* with regard to gender is statistically significant ($F = 27.538$; $p < 0.001$). The boys have higher values. It must be pointed out that the relation of gender and the *physical fitness component* is substantially lower than the relation of age in spite of the same level of statistical significance and it explains 3.3 % of children's physical fitness variance ($\eta^2 = 0.033$).

DISCUSSION

The findings of our research show that regarding the environmental factors (place of residence, maternal education, paternal education, academic achievement, and sports activity) the subjects differ in the physical fitness with statistical significance only with regard to the place of residence. The children from the suburbs reach the highest values, while the urban children reach the lowest values. More interesting is the fact that the place of residence explains only 0.7 % variance of physical fitness of children. The probability of the proof of statistically significant differences that are not practically important (as shows η^2) increases with the sample size. The share of the explained variance of subjects' physical fitness is extremely low for all the environmental factors and does not exceed 0.7 % (Table 64). In other words, this means that the relation of individual environmental factors (place of residence, maternal education, paternal education, academic achievement, and sports activities) and the differences in the subjects' physical fitness is negligible. The results of our research show that the living conditions in the Slovenian countryside and in the cities are uniformed to the extent that they practically do not generate differences in physical fitness between the urban and rural children. It is frequently presupposed (Sallis, McKenzie, & Alcaraz, 1993; Mountjoy et al., 2011) that sports activity is connected with the level of physical fitness, thus the children more active in sports have a higher level of physical fitness, but the results of this research do not support this. Maline et al. (2004) came to similar findings, namely, that in children and adolescents the connection between the regular sports activity and the physical fitness is relatively low. The quality of planning and teaching the sports activity is also of great importance in the development of physical fitness (Starc & Strel, 2012). Therefore, we speculate that this is also the main reason why our research did not find the differences in physical fitness regarding the amount of physical activity, since we were asking, not only about the organized but also about the voluntary and non-organized physical activity.

The findings of our research show that the subjects' age and gender explain the differences in physical fitness with statistical significance, which is in accordance with the findings of numerous other authors (Strel et al., 2003; Malina et al., 2004; Starc, Strel, & Kovač, 2010). The age thus explains 15.2 % of variance of subjects' physical fitness (Table 3). As expected, the physical fitness component in eleven-year-old subjects is less pronounced than in the fourteen-year-olds. Even though the gender explains the differences in the physical dimensions with statistical significance, it explains only 3.3 % physical fitness variance (Table 3). As expected, the physical fitness component in girls is less pronounced than in boys. The influence of genetically conditioned factors on the physical fitness is higher than the environmental factors influence, whereas it is necessary to point out, same as with the physical characteristics, the influence of age and the differences in the subjects' physical fitness (Matejek, 2013). Pařízková (2010) finds that the children of better-educated fathers have higher endurance and that there is a trend of better results in 500-meter run and standing broad jump, while children do not differ in physical fitness with regard to maternal education, but the results of our research do not confirm this. Tomkinson et al. (2007) found that the weak connections of the different economic status indicators and the amount of physical education with the level of physical fitness suggest that the accessibility of means is not a key factor that influences the level of physical fitness. These findings coincide with the findings from our research which also show that parental education as a measure of socio-economic status as well as the time children spend doing sports activities are not the key generators of the differences in physical fitness.

Given the fact that the majority of differences in subjects' physical fitness is explained by the age factor, we can conclude that the key factors of physical fitness development are growth, development, and the maturation rate. This means that the level of physical fitness changes regardless of whether children receive the incentive from the environment or not. It is the homogeneity of the environment and thus the uniformity of the environmental factors in Slovenia (Atkinson, Marlier, Montaigne, & Reinstadler, 2010; Vrabič Kek, 2012), i.e. relatively small differences in social environments in which children and adolescents grow up, that is of key importance in understanding and interpreting the findings. Therefore, the differences in the various lifestyles of children are not important to the extent that they generate the differences in the motoric development.

CONCLUSIONS

Understanding the significance of genetically determined factors in the motoric development of adolescents and children is one of the main contributions of this research. However, the results must be viewed in a broader context. It is a fact that the Slovenian environment is relatively homogenous. The findings of the European Commission (Atkinson et al., 2010) and the Statistical Office of the Republic of Slovenia (Vrabič Kek, 2012) also point this out, establishing that among all the EU countries Slovenia

has one of the lowest risk of poverty rate as well as one of the lowest inequalities of income distribution among households. This is also due to Slovenia's social aspect with its redistribution function that uses different forms of social transfers to alleviate the distress of households with insufficient incomes. It is the homogeneity of the environment and thus the uniformity of the environmental factors in Slovenia (Atkinson et al., 2010; Vrabič Kek, 2012), i.e. relatively small differences in social environments in which children and adolescents grow up, that is of key importance in understanding and interpreting the findings. Appropriate healthcare, a good education system that includes a sufficient amount of physical education, appropriate diet, and natural goods are accessible to all children and adolescents in Slovenia. All the aforementioned factors are equally available to children from urban, suburban, and rural areas as well as to children of parents with low, average, or high education. Therefore, it is possible to claim that the influence of genetically conditioned factors is predominant as the environment, in which the children grow up, is homogenous enough not to generate further differences in the motoric and physical development. This is a fundamental finding of our research that is becoming even more important in the time of recession and in the context of diminishing social rights. By diminishing the social rights and lowering standards in education and healthcare the differences between certain environments and social groups will increase, which will also influence the physical and motoric development of an individual. The socially underprivileged children that at this point get enough support from the education and healthcare systems in order to adequately develop their genetic potential will be marginalized and will neither be able to follow the privileged peers nor be equally included into society. These findings require additional consideration about the sensibility and justification of the spending cuts at the expense of children's health and development. To a great extent, the results are surprising as they offer a new view of the discussed space, and confirm the claims of Pařízkova (2010) that due to the change of environmental factors and in relation with individual factors resulting from a continuous development, their importance and influence on the individual's growth and development are also changing.

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