Correlation of physical characteristics and general endurance: A comparison of 7- to 19-year-old pupils between 1983, 1993 and 2003

Janko Strel
University of Ljubljana, janko.strel@fsp.uni-lj.si

ABSTRACT

The study examined the correlation between selected physical characteristics of pupils (body height, body weight, upper arm skin fold) and a general endurance indicator for 1983, 1993 and 2003. It was predicted that changes in physical and motor development observable in the last twenty years have altered also the magnitude and direction in correlation between certain physical characteristics and the results of a 600-metre run. Multiple correlation coefficients between the 600-metre run and certain morphological characteristics for 1983, 1993 and 2003 proved to be relatively high with pupils of all thirteen age groups. As expected, the highest values can be noticed in the period of adolescence with morphological characteristics influencing the 600-metre run result by up to 25%. The average multiple correlation coefficient between the 600-metre run and all three morphological characteristics was for all age groups of pupils the lowest in 1983 but it grew in every following decade.

KEYWORDS: morphological characteristics, general endurance, correlation, boys

Introduction

Genetically determined factors and environmental effects represent the basis for the development of people's abilities and characteristics. Genetically determined factors can be manipulated in different ways, with various contents and with different degrees of success in each developmental phase. The effects of such manipulation are never restricted to one area, instead they have an impact on the entire bio-psycho-social image of children and youth (Strel & Kovač 2004). Researchers from different fields aim to recognise the essence and reasons of the correlations between individual abilities, characteristics and qualities in a systematic, holistic and objective way. They also strive to identify what kind of influence individuals and the environment have on each other.

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For several years, the stagnation or even regression of some motor development indicators has been noticed in the period of late adolescence. This phenomenon is particularly noticeable in the results of tests measuring general endurance (Brettschneider & Naul 2004; Jurak et al. 2003; Kondrič 2000; Kovač 1999; Strel, Kovač & Rogelj 2005).

The modern information consumer society offers very different possibilities for active and passive lives; the supply of information activities significantly exceeds the time on hand, which is available to children after they finish their compulsory school tasks. The influx of various technological novelties, usually of an entertainment character such as mobile phones, computer, video and audio technology, represents a challenge for children and youth, however, it keeps them away from a healthy way of life (Strel, Kovač, Jurak 2004). Therefore, children and youth are being alienated from their family, school and peer environments and particularly from sports and other activities of a physical nature. Such a lifestyle has various impacts on children's development; often the effects on physical and motor development are negative and alter the structure of correlations between physical characteristics and motor abilities.

Physical education is one factor which could tip the scale and reduce the negative effects of a modern lifestyle and ensure a balance in children's physical and mental development (Brettschneider & Naul 2004; Strel, Kovač & Jurak 2004). Sports activity has an impact on the biological, mental and social parts of the human personality (Strel et al. 2003). Therefore, the physical education process needs to be carefully planned and supported with research efforts studying the status and changes in the motor, morphological and health parameters of children and youth. At the same time, physical education has to assure an individual approach to work with young people in order to allow them to develop their own potential.

Characteristics of physical and motor development

It must be recognised that a greater volume of physical education in schools cannot per se replace insufficient motor activity in everyday life. EU countries approach the sports education of 6-18 year-old children in different ways (Hardman & Marshall 1999). Sports education should mainly encourage medium to high intensity physical activity. The capability levels of cardio-respiratory systems of children and youth have to be stimulated by medium to high intensity sports activity, which has to be practiced regularly e.g. at least three times a week (Simons-Morton et al. 1988).

The very broad effects of sports activity on the bio-psycho-social dimension require knowledge about the fundamental rules of a child's growth and development. Further, the formation of suitable teaching plans and their high-quality realisation is needed; this depends on the education level of physical education teachers, material conditions and enlightenment of the social environment. The teaching process has to be planned in a way that stems from and considers the abilities, knowledge, needs, motivation and distinctiveness of all pupils.

Girls in Slovenia are taller than boys between the ages of eleven and thirteen, while between the ages of twelve and thirteen they are also heavier (Strel et al. 2003). Adolescence starts in girls one or two years earlier than in boys, around the ages of ten to twelve. The deferred start to adolescence allows boys to carry on growing for two years longer than girls. Therefore, men are taller and have longer extremities than women (Chumlea 1982). In Slovenia, an apparent increase of height acceleration has been noticed between the ages of eight and thirteen for girls and between the ages of eight to fifteen for boys (Strel et al. 2003). In men, muscular mass and to some extent also the amount of body fat on the stomach and breast area increases during adolescence (Roemich & Rogol 1995; Tanner 1962).

The growth rate for boys increases at the age of twelve and reaches its peak of twelve centimetres per year at the age of fourteen; afterwards, it gradually slows down until the age of seventeen, when growing comes to a halt (Roemich & Rogol 1995; Rolland-Cachera 1995). Strel et al. (2003) found that the biggest increase in body height for the population of girls occurs at the age of twelve—6.7 centimetres in one year, whereas for boys it happens at the age of fifteen—when they grow by 7.3 centimetres.

Prior to adolescence, girls have more body fat than boys (Abernethy et al. 1997; Dezenberg et al. 1999; Ferrante et al. 1993). During adolescence their weight increases by up to 8.5 kilograms per year for girls aged thirteen, whereas in boys the greatest increase is at the age of fourteen with 9.5 kilograms. Afterwards, the weight increase slows down for both genders and for 15-year-old girls amounts to just one kilogram per year, while the same value is noticed for boys at the age of seventeen (Roemich & Rogol 1995; Rolland-Cachera 1995). Body weight rises in line with age and increased body height, mainly as a result of growth and increased muscular mass rather than increased body fat (Abernethy et al. 1997; Parizkova 1996; Rolland-Cachera 1995).

The proportion of body fat increases slightly in boys in the period of early adolescence ands afterwards it decreases between the ages of ten and eighteen at a rate of 1.1 percent a year (Roche 1992). The accelerated gain in body weight, which starts at the age of 8 and ends at 13 for girls and 15 for boys, has been very characteristic for Slovenia in the last decade (Strel et al. 2003). The biggest weight gain happens at the age of twelve for girls with 4.9 kilograms and at the age of fifteen for boys with 6.6 kilograms (Strel et al. 2003).

Kondrič and Šajber Pincolič (1997) researched the developmental trends of certain physical characteristics and motor abilities of Slovenian pupils of both genders from 1988 to 1995. The results showed positive changes in the physical characteristics of both genders as the children were getting taller and heavier, whereas the proportion of their body fat was decreasing. Already prior to adolescence, there are slight yet constant differences between genders; they become more apparent during adolescence. The motor task results produced better results in those variables which display an information component of movement. In contrast, the results of variables representing the energetic component of movement had stagnated. The researchers also warned about the trend of growing differences in motor abilities between genders, which were most apparent at the age of thirteen.

Šturm and Strel (2002) analysed the motor and physical development of primary school pupils between 1970/71 and 1983. They came to the conclusions that the differences in the physical and motor development of young people between individual regions have decreased; positive steps in those motor abilities displaying the information component of motor efficiency are noticeable; the results of motor tasks of an energetic type, requiring a large mobilisation of energy, indicate a significant positive change; the results of motor efficiency tests requiring a long-term continuous effort are stagnating or even regressing; changes in physical characteristics are all positive, the most noticeable is the gain in body height; and there is a tendency of a decrease in body fat.

The study *Certain morphological, motor, functional and health parameters of children and youth in Slovenia between 1990-2000* (Strel et al. 2003) examined the status, magnitude and direction of changes in these parameters in the 1990s. The findings did not present any significant changes in physical characteristics. The gain in body height was smaller than in the previous decade, however, the parameters body weight and upper arm skin fold had significantly increased, particularly in the period prior to the age of thirteen. According to the comparison of results between 1990 and 2000, motor abilities showed a positive developmental trend, while changes between the genders were also smaller as the girls were catching up with the boys. Motor endurance had declined prior to the age of eleven; afterwards, positive developmental trends of motor endurance could be seen up to the age of fifteen. The population of high school pupils had progressed the most since in that decade girls increased their motor endurance by four percent.

Strel, Kovač and Rogelj (2006) found in an ongoing study of the population of Slovenian children and youth aged 6-19 an increase in fat tissue of 5% between 2000 and 2005 and an additional increase of 2% in 2006. The authors warned about a very negative trend (the strongest since 1970), which could have long-term consequences. A comparison of the average value index of motor abilities (eight tests) showed positive changes in girls (+.52%) and negative changes in boys (-.26%) between 2000 and 2005. For girls, positive changes are less noticeable than in the 1990-2000 decade, whereas in boys a moderate positive trend has turned into a negative one in the last five years.

The abovementioned research findings indicate that morphological dimensions have strong effects on motor dimensions, which can be seen in the results of individual motor tasks. Morphological dimensions generally have a positive influence on motor abilities; in certain cases the correlation between the dimension of motor abilities and morphological characteristics is also negative. Most often, body fat has a negative influence on motor abilities.

Correlations between physical and motor development

Many correlations between various dimensions of psychosomatic status have been proven and tested several times. In the transformation process of certain dimensions the effects are not limited as they affect the entire system of psychosomatic status due to the mutual connection of dimensions (Šturm & Strojnik 1994).

First studies of physical characteristics and motor abilities of children and youth in Slovenia were carried out by Božo Škerlj in the beginning of the 20th century (Štefančič et al. 1996). Physical and motor development is often a topic for many researchers, however, there is significantly less research studying their correlation. The status, development and mutual connection of physical characteristics and motor abilities forms an entity which helps to understand and plan the continuation of positive changes and to change the negative ones.

Research findings about the status, development and mutual connection of physical characteristics and motor abilities are quite often not in agreement but different or sometimes even opposing. The differences are most often a result of unrepresentative samples of measured pupils from different social and cultural environments, the systematic provision of physical education, eating habits and health and sports awareness of the social environment. Reasons for the discrepancies can also be found in differences between chronological and biological ages which cause problems in the valuation and interpretation of results.

The different numbers and types of tests also cause many problems. In North America the Youth Fitness test, Fitnessgram and Physical Best Package is applied, whereas in Europe a Eurofit test is used to measure motor abilities (Jürimäe & Jürimäe 2000). In Slovenia, experts have been following the physical and motor development of children and youth for more than 20 years with the help of the Sports-educational chart developed at the Faculty of Sport (Strel, Kovač & Rogelj 1996) which is recognised as one of the best sets of tests for motor abilities (Jürimäe & Jürimäe 2000).

In Slovenia, several researches examining the correlation between morphological characteristics, motor abilities and other bio-psycho-social dimensions have been carried out on representative samples or the entire population of children and youth. In the last ten years there have been significant and diverse changes in the physical and motor development of children and youth (Strel et al. 2003). Therefore, it is sensible to look for correlations between the morphological and motor dimensions and to test if the relationship between the dimensions has changed and, if so, in which direction.

Šturm (1975) examined correlations between physical strength and certain morphological and motor characteristics in manifested and latent space. The sample included 433 men and 422 women aged seventeen. A general positive correlation in men between anthropometrical variables and indicators of regulation mechanisms for the intensity of excitation was found, whereas the general correlation between anthropometrical variables and measures of regulation mechanisms for the duration of excitation proved negative. In women, correlations between anthropometrical variables and measures of relative strength were negative, only the relations between anthropometrical variables and measures of total strength were proven to be positive. In both genders, a negative correlation between body fat and tests performed with parts of the body containing large amounts of body fat was found.

Regression analysis showed a significantly characteristic correlation between the volume of body and manifested variables of physical strength of a dynamic type and dynamometry. There is also a negative correlation between the amount of body fat and all the strength measures. Anthropometrical measures significantly influence the latent dimension of physical strength. The mechanism for regulating the intensity of excitation is correlated with those variables which define an athletic type of body constitution and with body volume. A significant positive correlation exists between body volume and the mechanism for regulating the duration of excitation.

In one of his studies called *Changes in the relations between certain anthropometrical and motor characteristics between the ages of eleven and fifteen*, on the sample of 946 measured pupils of male gender Strel (1976) found that the proportion of total variance of both psychosomatic status dimensions increases with age. Body weight and upper arm skin fold have a decisive influence on motor abilities at the age of eleven. Both are in a negative correlation with motor activities where energetic components of movement and relative physical strength are dominant. Body height has a positive influence on power and fast locomotion tasks. The negative influence of the upper arm skin fold on all motor variables, except forward bench fold and hand drumming, is also noticeable at the age of thirteen. A high correlation between motor and morphological dimensions can also be seen in fourteen-year-old boys, reaching its culmination at the age of fifteen. At the age of fourteen, body height has a positive influence on the results of those tests of motor dimension which have the character of powerful and forceful movement, and a negative influence on tests where endurance in strength is needed. At the age of fifteen, body height only has a negative influence on test chin-up lifts in mixed hang.

Kondrič, Mišigoj-Duraković and Metikoš (2002) examined the correlations between morphological characteristics and motor abilities on a sample of 200 seven-year-old and the same number of 9-year-old boys. Fifteen tests were used to evaluate morphological characteristics and twenty-four tests were applied to evaluate motor abilities. An extremely high and strong correlation between both dimensions was found. The energy regulation mechanism has a significant correlation with both the manifested and latent space of morphological characteristics. A positive correlation was also found between morphological variables and those results of motor tests which depend on the mechanism for regulating the intensity of excitation (broad jump, medicine ball put), whereas a negative correlation was found between morphological variables and those results of motor tests which depend on the mechanism for regulating the duration of excitation.

Aims of the research

Slovenian teaching curricula for primary and high schools (Kovaè & Novak 1998) list symmetric physical development and general fitness as important goals. Therefore, the correlation between the 600-metre run, which describes the level of general fitness, and selected physical characteristics of pupils at primary and high schools will be examined. Certain physical characteristics which often have an important influence on motor efficiency can be changed through suitable programmes; therefore, understanding the magnitude and direction of mutual correlations provides the fundamental information needed for preparing and realising appropriate sports programmes.

Sample

The sample of measured pupils included primary and high school pupils aged 7 to 19. In 1983, 10% of the total population (29.230 pupils) was measured. In 1993 the percentage rose to 93.58% (148.291 pupils) of the total population, while in 2003 86.51% (120.830 pupils) were measured. All pupils were measured in April within the framework of measurements for the *Sports-educational chart*, following the standard procedure (Strel 1996). In 1983, only selected schools participated in the measurements whereas in 1993 and 2003 all schools in Slovenia were included. Only pupils who at the time of the measurements were healthy, not exempt from physical education lessons due to health reasons and whose parents had in 2003 given their written consent were included. In 1983 and 1993 the parents were not asked to give their consent as the regulations of the Ministry of Education have only required the obtaining of consent for measurements of physical characteristics and motor abilities within the *Sports-educational chart* database since 1996 (Strel 1996).

Sample of variables

The sample included three anthropometrical tests (body height, body weight and upper arm skin fold) and a test for measuring general endurance—the 600-metre run. All the tests have suitable measuring characteristics and have been used in Slovenia since 1970 (Šturm and Strel 2002), from 1986 onwards they have been used annually on the population of children and youth, ever since the measurements for the *Sports-educational chart* commenced.

Data analysis methods

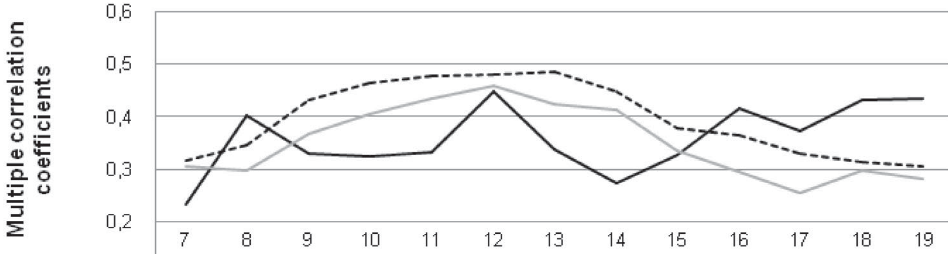
The data were analysed at the Faculty of Sport of the University of Ljubljana using the SPSS statistical package. Simple (descriptive) statistics were calculated; a regression analysis was used to measure the correlation between the variables.

Results and discussion

Due to the large volume of statistical data, correlation coefficients of the multiple regression analysis between the 600-metre run and all three measures of physical characteristics in 1983, 1993 and 2003 will be presented first. Afterwards, beta coefficients between the 600-metre run and body height, body weight and upper arm skin fold for each age group in all of the observed periods will be presented.

The previous analysis of simple statistical data (due to their volume they are available from the author) confirmed the already expected significant differences in the results of individual tests between different age groups of children and youth. Also very important are the differences between children and pupils who were measured in different time periods (1983, 1993 and 2003). The largest differences can be seen in the increase of body weight and the worst results in the 600-metre run.

As the samples of measured pupils were extremely large (in 1993 and 2003 they can be considered as the population), all the regression analyses were statistically significant at the level of $p = .000$ and are not presented separately.



	7	8	9	10	11	12	13	14	15	16	17	18	19
1983	0,234	0,404	0,331	0,325	0,334	0,449	0,338	0,274	0,328	0,416	0,372	0,433	0,434
1993	0,306	0,299	0,367	0,405	0,434	0,459	0,425	0,413	0,336	0,294	0,256	0,298	0,283
2003	0,316	0,346	0,433	0,466	0,478	0,48	0,487	0,448	0,378	0,364	0,33	0,313	0,305

Age

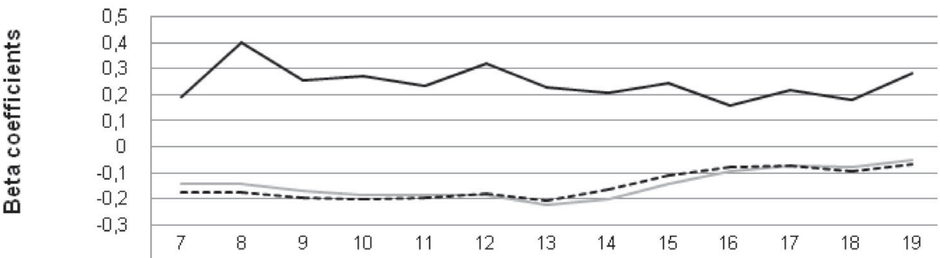
Fig. 1: *Correlation between the 600-metre run and body height, body weight and upper arm skin fold in pupils aged 7 to 19 in 1983, 1993 in 2003 (multiple correlation coefficients)*

By using regression analysis (as a criterion the result of the 600-metre run was considered a representative measure of general endurance, predictive variables were body height, body weight and upper arm skin fold) the coefficients of multiple correlation were calculated, thereby explaining the degree of mutual correlation. Multiple correlation coefficients between the test 600-metre run and some morphological characteristics (body height, body weight and upper arm skin fold) in 1983, 1993 and 2003 are for pupils from all age groups relatively high with values of between .243 and .487. The highest values were, as expected, in the period of adolescence as the 600-metre run results have an impact on the morphological characteristics of up to 25%. The average multiple correlation coefficient was for all age groups lowest in 1983 (.336), in 1993 it was higher (.351) and it reached its highest value in 2003 (.395). The influence of morphological characteristics on the result of the 600-metre run has risen in two decades from 11.3% in 1983 to 15.6% in 2003.

Figure 1 shows the correlation between the 600-metre run and physical characteristics, which is quite diverse according to the age of the measured pupils, while the structure of the correlation also changes according to the year of measurement. In 1983, the multiple correlation coefficients were highest for 8- and 12-year-old pupils and for pupils older than 16, and significantly lower in all other age groups. In 1993 and particularly in 2003 the multiple correlation coefficients increase from the age of 7 (.316) up to the age of 13 (.487), when the biggest gain in height is noticeable (7.3 centimetres); afterwards the values gradually fall until the age of 19 when they are nearly at the same level as in 7-year-old pupils (Strel et al. 2004).

The table shows significant changes in the multiple correlation coefficients which have occurred over the period of twenty years between the correlation of the 600-metre run and the three morphological characteristics. In 1983, there were no significant differences in the multiple correlation coefficients between primary and high school pupils. In 1993 and 2003 the coefficients for primary school pupils are significantly higher than for the high school pupils. In the last decade, the unfavourable morphological structure of primary school pupils has had a significant impact on the declining results of the 600-metre run (Strel, Kovač & Rogelj 2006).

Teachers and parents have not paid enough attention to changes in living conditions which have contributed to the reduced physical activity of children and youth (Strel, Kovaè & Jurak 2004); simultaneously, eating habits which influence a different morphological structure are changing. As the influence of various morphological characteristics on success in the 600-metre run is presumably different, the impacts of body height, body weight and upper arm skin fold will be explained separately. The interpretation of results and discussion will focus on the magnitude of beta coefficients, which represent the best measure to define a degree of mutual correlation of criterion and predictive variables.



1983	0,193	0,401	0,256	0,273	0,235	0,321	0,231	0,206	0,244	0,159	0,218	0,179	0,286
1993	-0,14	-0,14	-0,16	-0,18	-0,18	-0,18	-0,22	-0,20	-0,14	-0,09	-0,07	-0,07	-0,05
2003	-0,17	-0,17	-0,19	-0,2	-0,19	-0,18	-0,20	-0,16	-0,11	-0,07	-0,07	-0,09	-0,06

Age

Fig. 2: *Correlation between the 600-metre run and body height of boys aged 7 to 19 in 1983, 1993 and 2003 (beta coefficients)*

With the use of regression analysis, where the 600-metre run represented a criterion variable and body height, body weight and upper arm skin fold were predictive variables, beta coefficients were calculated for each of the morphological characteristics and for each year of measurement (1983, 1993 and 2003) for the age groups 7 to 19. Beta coefficients values are graphically presented in the Figures 2, 3 and 4. In the 600-metre run a lower result (measured in seconds) is also a better result; consequently, the negative or positive value of the beta coefficients needs to be changed in order to see realistic values of the mutual correlation.

Beta coefficient values between the 600-metre run and body height are for pupils from all age groups not particularly significant in 1993 and 2003. The values are between -.05 and -.224 and show a positive correlation which decreases with age and was at the age of 19 just -.05 in 1993 and -.069 in 2003. Yet the correlation between the 600-metre run and body height in 1983 differs considerably. The values of beta coefficients are between .159 and .40, indicating a negative correlation between the variables. According to the results, taller pupils had worse running results, particularly high values of the beta coefficient are noticeable at the ages of 8 (.401) and 12 (.321) when the annual gain in height is also the largest.

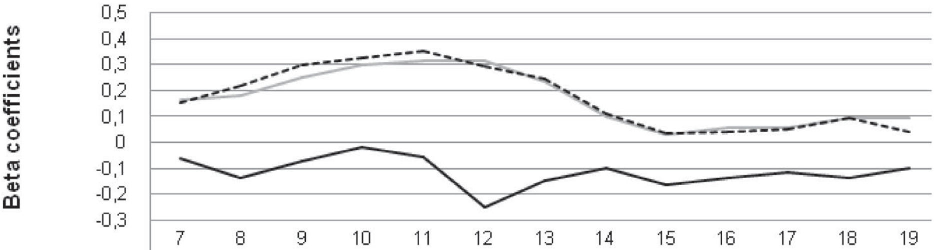
The review of results in Figure 2 shows some surprising beta coefficient values as significant changes have occurred in the correlation of the 600-metre run and body height in the last 20 years. In 1983, the correlation between the 600-metre run and body height was negative (it is more noticeable for primary school pupils) which is in line with the findings of Kurelić (1974), Šturm (1975) and Strel (1976). In 1993 and 2003, the correlation is lower, however, it is also positive with an apparent tendency of a reduced mutual correlation with the age of the measured pupils.

There are some arguments supporting the change of effects of body height on the result of the 600-metre run, nevertheless, they will need to be additionally studied in future research. In the last twenty-five years, some crucial changes have happened in the development of children and youth and particularly in the volume, type and quality of sports programmes in the education system and in the course of sport in free time.

In the mentioned period, the acceleration of body height increase stopped; there are no significant changes in the population or samples of Slovenian children and youth in comparison with 1983 (Štefančič et al. 1996; Strel, Kovač & Rogelj 2006). Simultaneously, the volume of physical education in the education system has been increased by approximately 30%; the material conditions have improved considerably (modern built and equipped facilities in primary and high schools); the number of pupils in groups has been reduced by 50%; while the teaching curricula for primary and high schools have been reformed twice. Pupils with above-average body height are more successful in physical education and particularly in sports activities which schools organise after school hours. Better-educated teachers are presumably better considering the particularities of physical development and, as a result, pupils in the period of accelerated growth have less problems in those activities requiring the co-ordination of movement, flexibility, strength and endurance.

The abovementioned quantitative and qualitative factors have presumably influenced a higher level of sports skills and a more balanced motor development of children and youth. This is also apparent from the better results achieved in the 600-metre run by individuals of an above-average height who have developed a running technique where their higher centre of gravity results in a biomechanical advantage.

Reasons for the positive correlation between the 600-metre run and the body height of pupils can also be found in the changed living conditions. Different nutritional possibilities and other effects of the environment have probably more influenced developed physical and functional development (cardiovascular and respiratory abilities).



	7	8	9	10	11	12	13	14	15	16	17	18	19
1983	-0,06	-0,13	-0,07	-0,01	-0,05	-0,24	-0,15	-0,09	-0,16	-0,13	-0,11	-0,13	-0,09
1993	0,165	0,183	0,254	0,299	0,315	0,318	0,238	0,101	0,028	0,056	0,058	0,095	0,093
2003	0,152	0,218	0,299	0,328	0,356	0,295	0,244	0,109	0,034	0,04	0,051	0,094	0,04

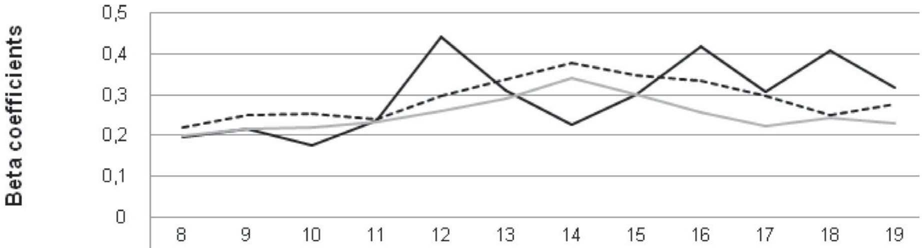
Fig. 3: *Correlation between the 600-metre run and body weight of pupils aged 7 to 19 in 1983, 1993 and 2003 (beta coefficients)*

Beta coefficients describing the degree of correlation between the 600-metre run and body weight are for pupils from all age groups not particularly significant in 1983; the values are between - .017 and - .248 and show a low positive correlation. The most positive influence of body weight on the result in the 600-metre run can be seen with 12-year-old pupils, although the beta coefficient does not exceed the - .25 level. The correlations between the 600-metre run and body weight in 1993 and 2003 differ significantly. Beta coefficient values are between .028 and .356. The correlation between the variables is negative; heavier pupils achieved worse results. Particularly high values of beta coefficients are noticeable with eleven-year-old pupils (.356), when the body is preparing for accelerated growth. Table 3 also shows very low values of beta coefficients between the ages of 13 to 19, indicating an insignificant influence of body weight on the 600-metre run results.

The results in Figure 3 show significant changes in the last twenty years in the correlation of the 600-metre run and body weight. In 1983, the correlation of the 600-metre run and body weight was positive and more apparent for primary school pupils. In 1993 and 2003, the correlation is significantly higher yet negative, with a clear tendency of a reduced mutual correlation with the age of the measured pupils.

Findings about the negative effect of body weight on the 600-metre results are surprising and unexpected since Šturm (1975) and Strel (1976) found a positive effect of body weight (muscular mass) on the 600-metre run. In the last 20 years almost identical important changes in physical development have been found on the samples and population of Slovenian children and youth. In this period, the body weight of same age pupils has increased by 10% (Strel, Kovač & Rogelj 2006). Up-to-date researches also reveal that for primary school pupils the increase in body weight is due to increased muscular mass, as well as due to a higher amount of body fat. For high school pupils, the amount of body fat did not have a significant influence on the increase of body weight.

Despite the important positive changes in the physical education process presented in the section on the positive correlation between the 600-metre run and body height, the negative influence of body weight on the 600-metre result is only partly surprising. As a result of an increased volume of body fat in the last 20 years, body weight has also changed, particularly in pupils under the age of 12. Passive body weight understandably has a negative influence on the results of the 600-metre run.



	8	9	10	11	12	13	14	15	16	17	18	19
1983	0,196	0,217	0,177	0,236	0,442	0,312	0,227	0,301	0,42	0,306	0,41	0,318
1993	0,201	0,215	0,219	0,235	0,259	0,291	0,343	0,3	0,256	0,222	0,242	0,231
2003	0,219	0,249	0,254	0,241	0,296	0,337	0,377	0,348	0,336	0,296	0,252	0,278

Age

Fig. 4: *Correlation between the 600-metre run and upper arm skin fold of boys aged 8 to 19 in 1983, 1993 and 2003 (beta coefficients)*

Beta coefficient values describing the correlation of the 600-metre run and upper arm skin fold in 1983, 1993 and 2003 for pupils from all age groups are between .117 and .442. Expectedly, these values are high (Šturm 1975; Strel 1976). Upper arm skin fold explains success in the 600-metre run to a larger degree than body height or body weight. In 2003, the results of the 600-metre run were, particularly for the primary school pupils, subjected to a slightly larger negative effect of the upper arm skin fold compared to 1983, whereas in 1993 the correlation was the least obvious. A negative effect of the upper arm skin fold on the results of the 600-metre run is expected and in line with up-to-date findings (Kondriè 2000; Kurelič 1974; Strel 1976; Šturm 1975). The magnitude of the negative correlation of the upper arm skin fold and success in the 600-metre run was to be expected.

The most noticeable was the negative effect of the upper arm skin fold on the results of the 600-metre run of 12-year-old boys in 1983. The outstanding value of the beta coefficient (.442) is surprising and unexpected, nevertheless, certain circumstances which could have influenced the ability of the 12-year-old pupils need to be mentioned. 1983 was a year of a serious economic crisis, there was shortage of material goods, food etc., and the choice of them was also minimal. In progress was an education reform with new academic subjects, curricula and additional professional training of teachers. Norms calling for a significantly lower number of children in groups for physical lessons were put in place for 11-year-old pupils. The so-called 'Portorož articles' brought new strategic directions for sport, directing the focus to more professional work for the purposes of elite sport, particularly for children aged 5 to 11. These reasons could have influenced the specific status of the 12-year-old pupils.

The beta coefficients in Table 4 indicate an increase in negative effects of the upper arm skin fold on the results of the 600-metre run in 2003 compared to 1983. The increase is noticeable for all primary school pupils, apart for the already mentioned 12-year-old children. The findings are in line with the gain in skin fold values between 1983 and 2003 (Strel 2003). Changes in high school pupils have an opposite correlation, showing a smaller negative effect of the upper arm skin fold on the results of the 600-metre run in 2003 in comparison with 1983.

The negative influence of body fat on motor efficiency, particularly on general endurance, is a problem which, despite the positive changes in physical education in schools, has not been reduced; it has actually increased in some age groups. There are several reasons for this. The modern lifestyle includes excessive food of insufficient quality and is a predominant factor. Physical education is not effective enough as the particularities of each pupil are still only considered in theory instead of becoming an ingredient of everyday professional work in practice.

Conclusion

The status of fitness abilities holds a special place in school. As a result, the correlation of a 600-metre run, which describes the level of general endurance, and selected physical characteristics such as body height, body weight and upper arm skin fold was examined. Some physical characteristics which often have an important effect on motor efficiency can be changed through suitable programmes. Therefore, knowledge of the direction and magnitude of the mutual correlations is fundamental in order to prepare and realise suitable sports programmes.

As the samples of measured pupils are sufficiently large they can be considered to be population samples at least in 1993 and 2003. All the correlations are statistically significant at the level of .000. Multiple correlation coefficients between the 600-metre run and body height, body weight and upper arm skin fold in 1983, 1993 and 2003 are for pupils from all age groups between .243 and .487. The highest values are, as expected, in the period of adolescence when the morphological characteristics influence the results of the 600-metre run by up to 25%. The average multiple correlation coefficient between the 600-metre run and all three morphological characteristics for all age groups of pupils was the lowest in 1983 (.336), in 1993 it increased (.351) and in 2003 it was significantly higher (.395). The effect has increased in two decades from 11.3% in 1983 to 15.6% in 2003.

In 1983 there were no significant changes in the multiple correlation coefficients between primary school and high school pupils. In 1993 and 2003, the coefficients of primary school pupils are considerably higher than for high school pupils. An unsuitable morphological structure for the 600-metre run has been formed in the last ten years, mainly in primary school pupils, and has significantly influenced a decline in general endurance.

Beta coefficients between the test 600-metre run and body height are not significant in 1993 and 2003 for pupils from all age groups. Values are between - .159 and - .206 and show a positive correlation, which lessens with age. At the age of 19, the value of beta coefficients was - .05 in 1993 and - .069 in 2003. The correlation between the 600-metre run and body height in 1983 differs considerably. The values of beta coefficients are between .159 and .401, indicating a negative correlation—taller pupils achieve poorer results.

In the studied period, significant changes also occurred in correlation between the 600-metre run and body weight. In 1983 there was a positive correlation between the results in the 600-metre run and body weight, which was more obvious for the primary school pupils. In 1993 and 2003 the correlation is significantly higher, however it is negative and has an apparent tendency of a decreased mutual correlation with the age of the measured pupils.

In 2003, the negative effect of the upper arm skin fold on the results of the 600-metre run increased for primary school pupils in comparison with 1983. This finding is in line with the changes in skin fold gain between 1983 and 2003 (Strel, 2003). The changes for the high school pupils move in the opposite relation as the negative influence of the upper arm skin fold on the results of the 600-metre run is less in 2003 than in 1983.

The predominantly negative effect of body weight and upper arm skin fold on motor efficiency, particularly on general endurance, which despite the positive changes in physical education in schools has not in fact been reduced; actually, it has increased in some age groups. There are several reasons for this. The modern lifestyle includes excessive food of insufficient quality and is the principal factor. Physical education is not effective enough as the particularities of each pupil are still only considered in theory instead of becoming an element of everyday professional work in practice. Parents and teachers need to be encouraged to focus even more on correct nutrition while, at the same time, the volume and quality of planning and realisation of suitable physical education should be ensured.

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POVZETEK

Študija proučuje povezanost nekaterih telesnih značilnosti učencev (telesna višina, telesna teža, kožna guba nadlahti) in kazalcev splošne vzdržljivosti v letih 1983, 1993 in 2003. Predvidevali smo, da so se spremembe v telesnem in motoričnem razvoju, ki smo jim priča v zadnjih letih, odrazile tudi na spremembi moči in smeri povezanosti med nekaterimi telesnimi značilnostmi in rezultati teka na 600 metrov. Korelacijski koeficienti med tekom na 600 metrov in telesnimi značilnostmi učencev v omenjenih letih so pokazali na visoko stopnjo povezanosti med njimi in sicer v vseh trinajstih starostnih kategorijah. Po pričakovanju, so se najvišje vrednosti korelacijskih koeficientov pokazale v obdobju adolescence, saj so v tem obdobju telesne značilnosti vplivale na rezultat teka na 600 metrov kar v višini 25%. Povprečni korelacijski koeficient je bil v vseh trinajstih starostnih skupinah najnižji v letu 1983, nato pa se je vsako desetletje zviševal.

KEYWORDS: morphological characteristics, general endurance, correlation, boys