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The influence of increased physical activity on the level of somatic and functional development Polish children of methodological problems and state of research

by

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The research was conducted on 91 female and 143 male subjects, students of Academy of Physical Education aged from 21 to 23 years. They were performed in standard conditions, fulfilling the objectivism criterion (Chwala 1998). There were four groups of laboratory tests and field motor tests. In general, 110 predispositions were diagnosed, which were subjected to further analysis in order to reduce the number of variables and to determine the structure and "golden standards". Authors stated that there is no "optimal" dose of physical activity for children and youth. The results show that 10-12 hours of additional physical activity do not improve the level motor abilities. Probably, it is cause by improper organization and structure of physical education lessons (not enough general fitness exercises and too early specialization). The experiments on trainability show that results of properly conducted sport training are clearly visible.

Motor abilities are significantly, although in different degree, sensitive to training. Because of small durability of these stimuli, physical activity has to remain without interruptions during the entire life. In light of this notion the idea of "education to physical culture" (prosomatic attitude) appears to be very important. The proper level of motor abilities is one of the conditions of health. In that case it may be treated as proper scope of "health-related-fitness).

Keywords: *motor abilities, somatic and functional development*

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Introduction

The necessity of proper physical activity for development and functioning of human organism is undisputable. It is document by results of clinical research on the effects of hypokinesia (Hickson et al. 1985; Coyle et al. 1986; Pitts et al. 1989; Costill et al. 1991). Despite many research projects, the problem of “optimal” and “minimal’ determination of doses activity, necessary in different forms of life, still exists. The evaluation of the effects of increased physical activity, especially among children, also remains unsolved.

These problems overlap creating neutral area of common interest of many scientific disciplines i.e. physiology, biochemistry, medicine and mainly physical culture. It creates many difficulties because these, relatively young disciplines, do not have generally accepted and precise notions and concepts, as well as proper methodology. These problems are discussed in Poland for 10 years, ever since the journal “Antropomotoryka” has been published.

This work is directed at the presentation of contemporary knowledge in this area, to point out main methodological problems and describe actual state of the research on the influence of increased physical activity.

Theoretical problems: basic notions, structure of motor potential and its testing

The proper definition of used notions and their “hierarchization” (structure) in order to avoid inconsistencies with the general sciences is the main theoretical problem in the discussed area. It is possible to start considerations from the “highest” and most often researched, because of the seemingly simple evaluation, level i.e. fitness. Two general meanings of this notion exist:

1. Physical fitness – understood as general movement capacity (abilities and skills).
2. Motor fitness – understood as the degree of skills and abilities manifestation (potential motor area) in specific movement tasks (for example specific tests). This is a narrower notion, which allows for the diagnosis of the structure of physical fitness of particular subjects or a whole population. This way of interpretation of fitness does not allow generalizing and calculating average values. The results of such activities generate an (unfortunately very often) “empty set of variables” without any informative value.

The background of both mentioned above notions is related to structural and functional features of organisms defined as the potential side. The notion of so called motor features, defined as “organism ability to....” existed for many years if Polish (and not only) literature. They included, among others, strength, speed, endurance, agility, flexibility etc. General criticism of such an approach rose, underlining the baseless and improper defining, identifying and testing some aspects of these properties. Because of unjustified and useless ascription of biological sense they lost valid meaning and majority of scientists resigned to use them. Instead of motor features, the notion of motor abilities understood as the complex of predispositions integrated by common biological background and type of movement (time of duration, intensity, level of movement complication etc.), appeared. These abilities determine the functional state of organism, which obvious difficulties in of evaluation predispositions (diagnostic problems), the abilities compose basic “level” accessible for testing with the use of synthetic laboratory tests, as well as, indirect methods, what is simpler in large population studies.

The problem of identification and separation of motor abilities is difficult. First version of structure (strength, speed, endurance and coordination abilities) seems to be nowadays too general because of its complexity. Their complexity does not allow to diagnose them validly. It should be underlined that testing abilities (therefore the state of the organism) with the use of the fitness tests is characterized with such a large error, that the question what is diagnosed should be asked? The answer is practically impossible, because they are compilations of many components in undetermined proportions, sometimes completely not correlated. Using an analogy it is possible to compare such a procedures with body height evaluation, when measuring the shadow on the wall in different light.

At this point the question arises: is there a need for evaluation of abilities? Is it not sufficient to diagnose fitness? The answer seems to be simple, however not to all scientists. When someone wants to provide a biological analysis it has to be directed and based on biological features. The result in a 50 m run or a medicine ball throw is not a feature so it is impossible to describe their ontogenetical development or genetic determinants!

The structure of motor abilities

The problem of motor abilities structure is the scope of research since classical Fleishman work (1964) and experiments of physiologists (Astrand 1952; Margaria et al. 1965; Bar-Or et al. 1971) directed at synthetic measures of structural and functional features establishing physical fitness potentials. Such experiments are very difficult and demand multidimensional statistical analysis. In order to use such methods the “input” of large number of unintentionally chosen variables, which state real organism’s features is indispensable. Only the, it is possible to interpret the acquired factors (generally of higher level) as abilities, while their components – as predispositions. The features with higher factor loads may be referred to “golden standards”, which in the nest step may be related to the indirect tests determining their validity. It has to be stressed, that in many works, even well known EUROFIT or ICSSPFT test batteries, this conditions are not fulfilled, because the notion of reliability is identified with validity! In result, many new test batteries are produced, which include many similar tests diagnosing the same abilities – without others – accompanied by illogical, difficult to describe factors (see “EUROFIT”).

As it may be seen the determination of the “list” of motor abilities and “golden standards” are strictly related to each other, being at the same time the conditions of the validity of the tests. Such a procedure was used in the works focused on structure and validity of tested abilities (Szopa and Latinek 1997; Szopa et al. 1998). The research was conducted on 91 female and 143 male subjects, students of Academy of Physical Education aged from 21 to 23 years. They were performed in standard conditions, fulfilling the objectivism criterion (Chwala 1998). There were four groups of laboratory tests and field motor tests including:

1. The measurements of main aspects of muscular work (maximal of torque force time of Fmax development and force decrement) on 18 muscle groups of limbs and trunk, during isometric contractions (38 variables characterizing strength, speed and endurance predispositions).
2. The measurement of basic biomechanical variables characterizing the speed abilities during a vertical jump on a tensometric platform and during a 50 m run with sidographic registration (53 parameters).
3. Measurements of endurance abilities: fatigue resistance and aerobic capacity (9 variables).
4. Coordination predispositions: 12 test including simple and complex reaction time, eye-movement coordination, space orientation, kinesthetic sense (sense of force), movement memory and rate, stability and precision of motor learning.

In general, 110 predispositions were diagnosed, which were subjected to further analysis in order to reduce the number of variables and to determine the structure and "“olden standards”.

5. The last group included motor fitness tests (13) that validity evaluated the following motor abilities:

   a) Strength

   – medicine ball throw forward and backward,

- pull-ups,
- push-ups,
- sit-ups,
- dynamometry of handgrip strength.

b) Speed
- standing long jump,
- 50 m run,
- 300 m run.

c) Endurance
- 1500 m run (men) and 800 m run (women),
- shuttle run,
- “Coopers” test.

For all measured variables the statistical characteristics were calculated ($\bar{x}$, S) and transformed on scale Z. In order to establish the inner structure of a set of variables, two multidimensional analyses were performed (“step-by-step”): factor analysis in EFA exploratory version and Ward taxonomic method.

First phase determined 9 factors in male and female subjects in strength abilities, 15 factors in speed abilities and four in endurance and coordination. It allowed for the reduction of the set of variables to 28 analyzed with the use of the same method at phase 2 where 4, 5, 2 and 3 factors were respectively extracted.

Phase 3 appeared to be decisive in this experiment. In group of strength abilities 4 factors were extracted which showed in the Ward method (fig. 1, 2) a clear tendency to place in two groups with logical structure. It was: absolute and relative total power and local strength with slightly expressed sexual dimorphism. In the area of speed abilities (fig. 3, 4) 4 factors were extracted, which logically linked in two groups: maximal alactic anaerobic power (aMAP) and fast muscular mobility. Probably, because of the lack of longer tests, the third ability – maximal lactic anaerobic power (IMAP) – always identified in physiological experiments – was not extracted.

A very clear structure appeared in endurance abilities (no graphical illustration) where two factors were extracted: maximal oxygen uptake (VO_2max) and muscle resistance to fatigue. In the area of coordination two main groups appeared: space orientation (receptory-central abilities) and movement predispositions (central-interneuronal abilities).

According to above-mentioned results, authors acquired not 4 but at least 10 motor abilities describing the whole sphere of motor potential. All of them have strictly determined biological background and it is possible to evaluate them synthetically. It has to be stated that three of them: physiologists defined maximal alactic and lactic anaerobic power and maximal oxygen uptake – as abilities.

Evaluation of testing validity

Validity of the test requires, first of all, the determination of the matter of pattern (feature), which is supposed to be tested. This was never done, because such patterns (for example mentioned earlier motor features) never existed! Validity was recognized as internal validity or repeatability (reliability) of the results of similar tests (for instance runs) and the evaluation of their representativity (i.e. factor loadings). It was the representativity only for these groups of movement tasks, for which biological sense was groundlessly ascribed (it would allow to find plenty of "features" choosing some structurally similar tests).

In cited above research, for the first time, the list of the most representative features (patterns?) was determined. It allowed for the evaluation of validity (according to some validity criterion) of chosen tests as indirect measures of motor abilities. This analysis was also performed during two phases. In the first phase, the test results were placed in "space" of variables, which in the best way characterized specific abilities (extracted at third phase). Then, once again, factor analysis and Ward method were used. As the result of these calculations the specific structures were acquired. They group specific tests with proper functional parameters, however with large dispersion of factor loadings, what for validity evaluation is not beneficial. That was the reason for which in the second phase of marker analysis only one variable per specific motor ability as well as the results of test were taken into account. The results in both sexes were quite similar (tab. 1), then only data for men is presented. It can be seen, that only some of tests fulfill the requirements of validity. They include:

- Cooper test, shuttle run until exhaustion (EUROFIT) and 1500 m run as VO_2max tests,
- envelope run as a measure of muscular mobility,
- 300 m run as measure of LMAP,
- standing long jump as a measure of a MAP,
- push-ups and pull-ups as local upper limb strength test,
- medicine ball backward throw as absolute strength test.

Large dispersion and low factor loadings, therefore **low validity was presented for such tests as: figure eight run, sit-ups, medicine ball forward throw, hand grip strength. None of the tests appeared valid for coordination diagnosis**, what imposes the necessity of analytical testing. There were no valid tests for diagnosis of relative strength and muscle resistance to fatigue.

Table 1 Structure of extracted factors in individual age groups

	Gender (N)	FACOBL 1	FACOBL 2	FACOBL 3	FACOBL 4	FACOBL 5	FACOBL 6	FACOBL 7	FACOBL 8	FACOBL 9
11 years	Boys (141)	energy and co-ordination component	speed of simple movements	repetitive power of stomach muscles	flexibility of the hip joint	explosive power of the arm muscles	co-ordination of movement in rhythm	balance		
	Girls (207)	energy component	flexibility of the hip joint	speed of simple movements	repetitive power of stomach muscles	co-ordination of movement in rhythm	flexibility of the shoulder girdle	balance		
13 years	Boys (122)	agility	explosive power of the arm muscles	repetitive power of stomach muscles	flexibility of the hip joint	co-ordination of movement in rhythm	aerobic endurance	speed of simple movements		
	Girls (/216)	co-ordination and energy component	repetitive power of stomach muscles	speed of simple movements	flexibility of the hip joint	balance	explosive power	flexibility of the shoulder girdle	unnamed factor 1	unnamed factor 2

Table 2 Structure of extracted factors in individual age groups (cont.)

	Gender (N)	FACOBL 1	FACOBL 2	FACOBL 3	FACOBL 4	FACOBL 5	FACOBL 6	FACOBL 7	FACOBL 8	FACOBL 9
15 years	Boys (126)	aerobic endurance	speed of simple movements	explosive power of the arm muscles	repetitive power of stomach muscles	flexibility of the hip joint	co-ordination of movement in rhythm	co-ordination of movement of the arms	co-ordination of movement of the whole body	
	Girls (172)	agility	flexibility of the hip joint	speed of simple movements	explosive power of the arm muscles	repetitive power of stomach muscles	co-ordination of movement in rhythm	aerobic endurance		
17 years	Boys (128)	co-ordination of movement of the whole body	speed of simple movements in a particular rhythm	explosive power of the arm muscles	repetitive power of stomach muscles	flexibility of the hip joint	balance	endurance of the upper part of the body	speed endurance	co-ordination of movement of the arms in rhythm
	Girls (212)	agility	repetitive power of stomach muscles	flexibility of the hip joint	aerobic endurance	speed of simple movements in a particular rhythm	co-ordination of movement of the arms in rhythm	explosive power of the arm muscles	balance	

The conclusions from this research seem to be very important from a methodological as well as from a practical perspective. **First of all, it is improper to construct tests (and especially test batteries)** on the basis of unreal criterion. Secondly, motor abilities test batteries should “cover” the whole area of the motor potential. Third of all, there should be a clear distinction between reliability and validity because **second one needs the analysis of primary parameters**. This “sins” were committed not only during ICSPFT construction but also with the EUROFIT test battery.

A separate problem appears with the testing of coordination, including the so important element of motor preabilities. So far existing tests (Ozierecki, Johnson, Brace) diagnose in reality the skills – i.e. the result of motor abilities and process of motor learning. The research projects should be directed on learning of new movement sequences, which are unknown for the subject.

The influence of increased movement activity on somatic and functional development

The research on influence of movement stimuli on the level and dynamics of somatic and functional development should focus on three problems:

1. The evaluation of different amounts of movement stimuli (with different structure).
2. The determination of the different groups of features sensitivity (somatic, motor abilities) on the external influences (problem of trainability).
3. The evaluation of reactivity (sensitivity) of the organism to the movement stimuli in dependence to age and gender.

First problem was researched in many experiments conducted on sport groups. These groups are characterized with the enlarged amount of physical education (10-12 h per week) with different character (specific and general fitness exercises) starting with children aged 10-11 years and selected according to very differentiated criteria. The results of these research projects were very diversified: from the works stating large influence of mentioned above amount of physical exercises on somatic (including even body height!) and rate of maturation (Rarick 1973; Golebiowska et al. 1979) to works which did not determine any influence (Malina and Bielicki 1992; 1996; Malina et al. 1990). Unfortunately, it seems very simple to point out some **basic methodological errors**, which resulted in mentioned diversification:

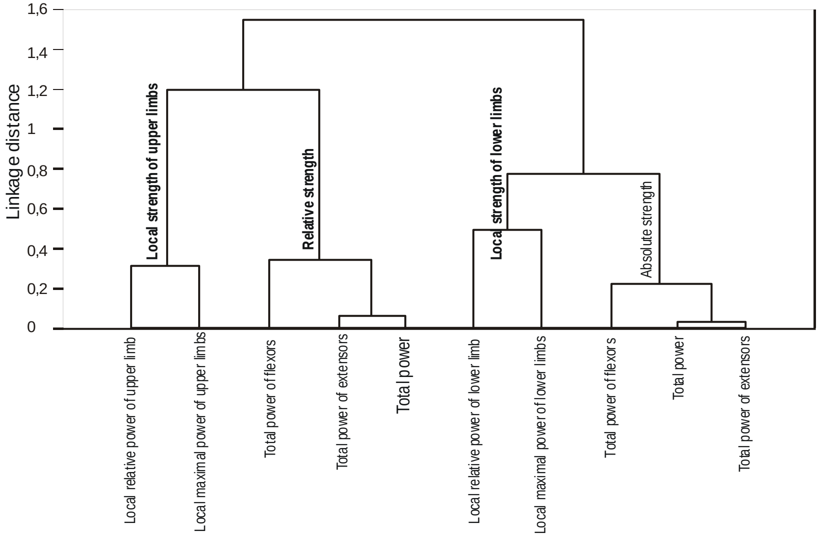

Fig. 1 Results of third phase of taxonomic analysis of strength abilities in men

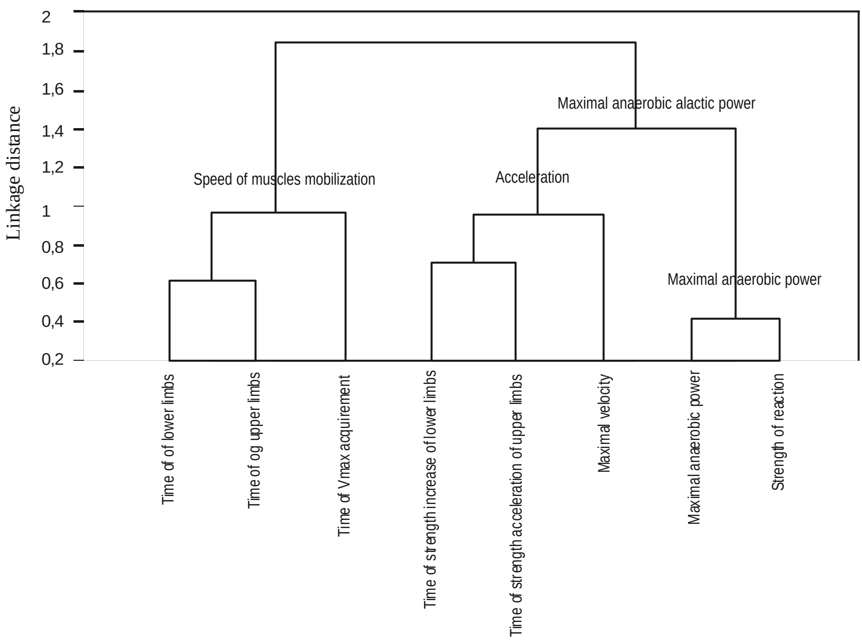

Fig. 2 Results of third phase of taxonomic analysis of speed abilities in men

1. Random coincidental selection of subjects, based in general, on simple motor fitness tests, regardless of fundamental and significant somatic predispositions and motor abilities.
2. Lack of separation of two main factors, differentiating the level of development, i.e. initial selection and physical activity. It was precluded by wrong selection of comparative groups (children from the same school; which were the basis for the selection to sport grades), and additionally in small quantity, so non-representative for the population. If some children in the initial selection were chosen because of early maturation (what was and is the principle), then the differences in the level and dynamics of development may not be the result of physical activity but different rate of maturation! If children chosen to sport grades poses a higher level of motor abilities at the start of research, it may be a result of genetic differences (the subjects presenting higher level of motor fitness as “homozygotic” are less reactive to the environment) as well as earlier physical activity (“movement experience”).
3. Cross-sectional character of material, precluding reliable evaluation of development dynamics and excluding genetic heterogeneity of consecutive age groups. Longitudinal studies are very rare (for example Komorowski 1983; Ziemilska 1987; Szopa and Srutowski 1990), and their results are ambiguous.
4. Lack of training documentation, which could allow to evaluate training loads and structure of movement stimuli (intensity, volume, loads).

The only attempt to fulfill the above-mentioned requirements in Polish literature was the longitudinal experiment of Szopa and Srutowski (1990) conducted on 25 girls and 31 boys in 1985-1988 in the 91st primary school in Cracow. Children specialized in track and field as well as handball and the measurements were taken every 6 month. The volume of training equaled respectively: 290, 360, 434 and 440 hours per year with the advantage of (53-70%) general fitness exercises. This volume of physical activity exceeded standard conditions by 4 to 6 times.

The selection to sport grades was performed under control of authors among 130 children, based on the following variables: body height, health state evaluation, and 4 fitness tests (sprint, agility run, Burpee test and eye-hand coordination test). The comparative material consisted of 137 girls and 151 boys from school of the same district measured simultaneously with sport grades (7 measurements) with the same methods.

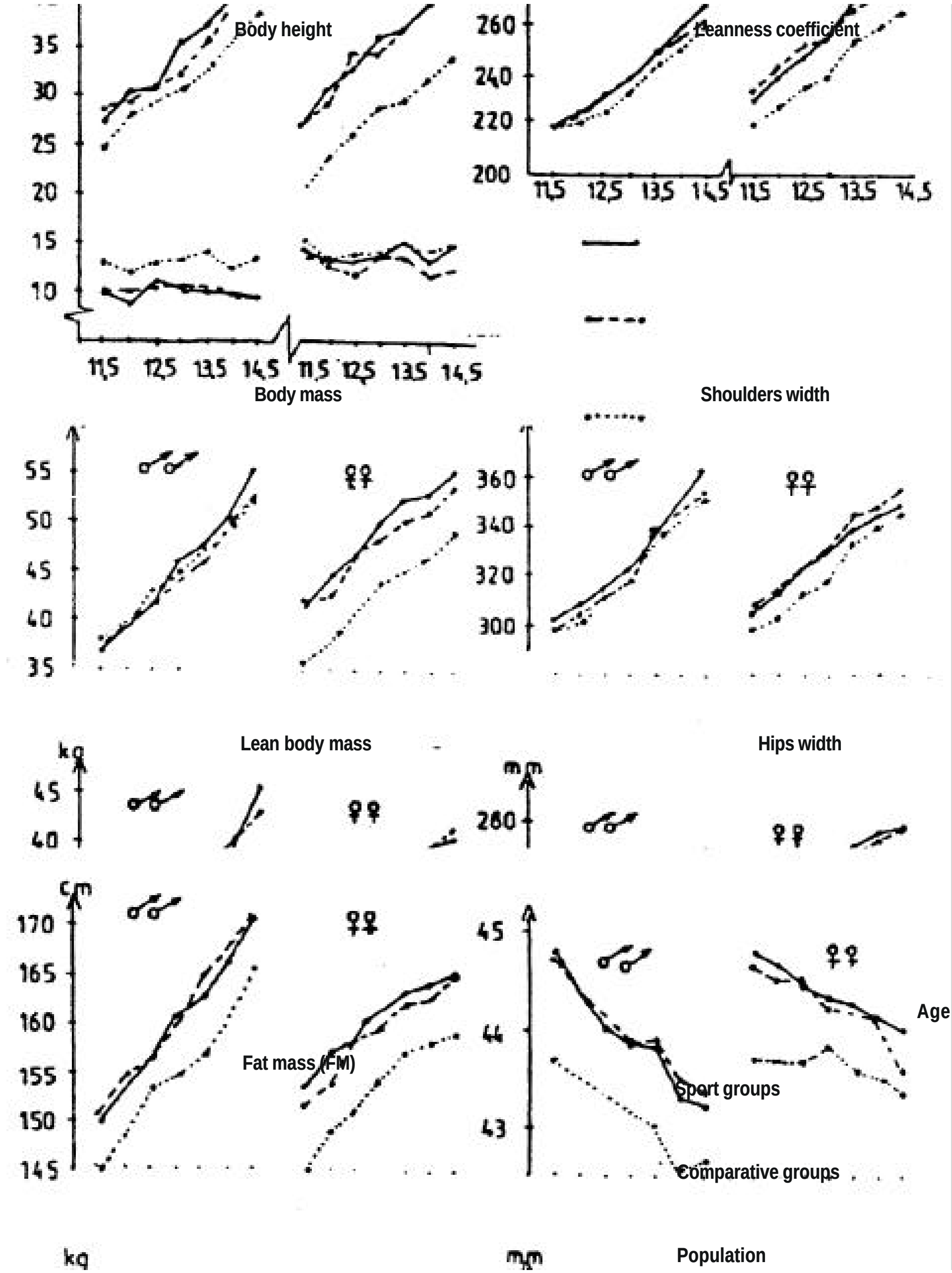

Fig. 3 The variability of somatic features level of development in consecutive measurements

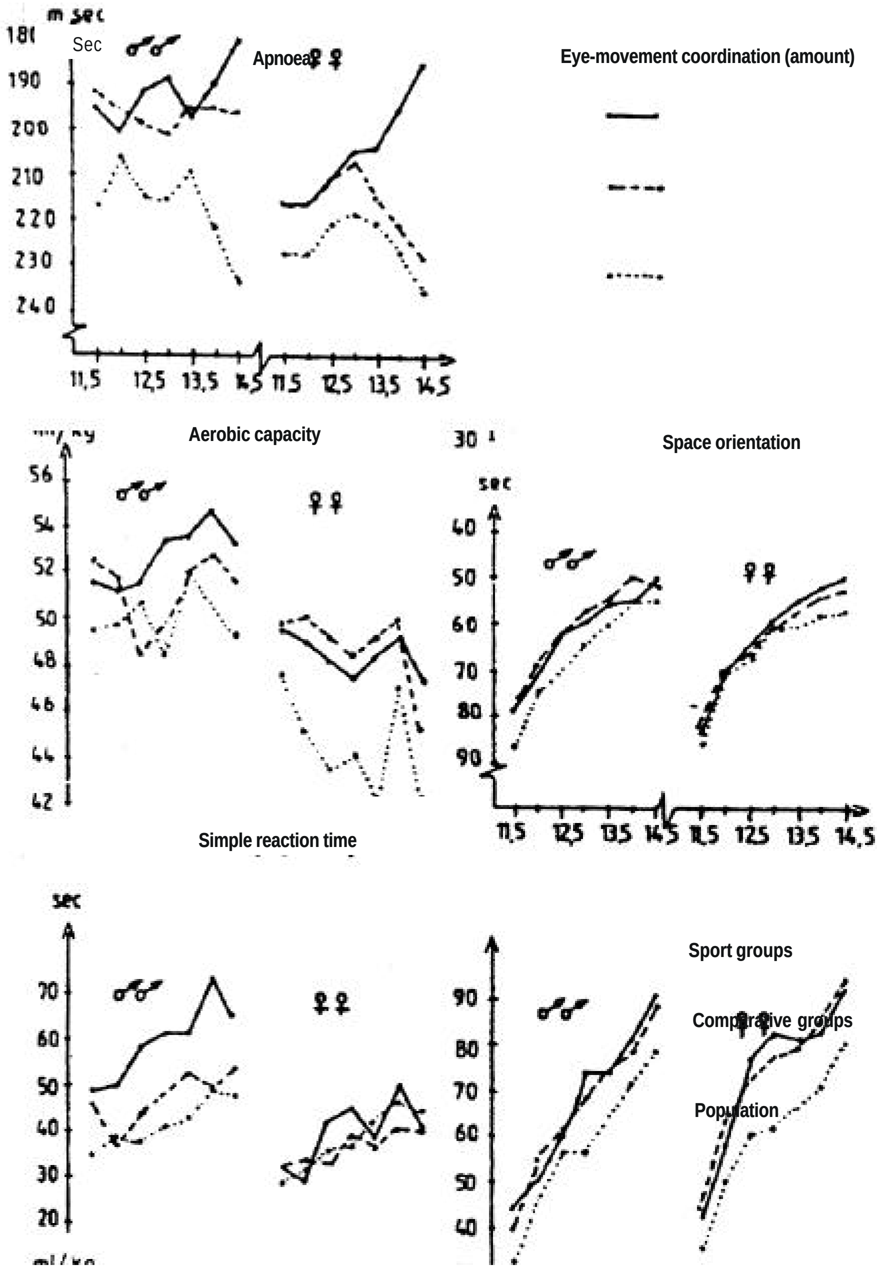

Fig. 4 The variability of functional features level of development in consecutive measurements

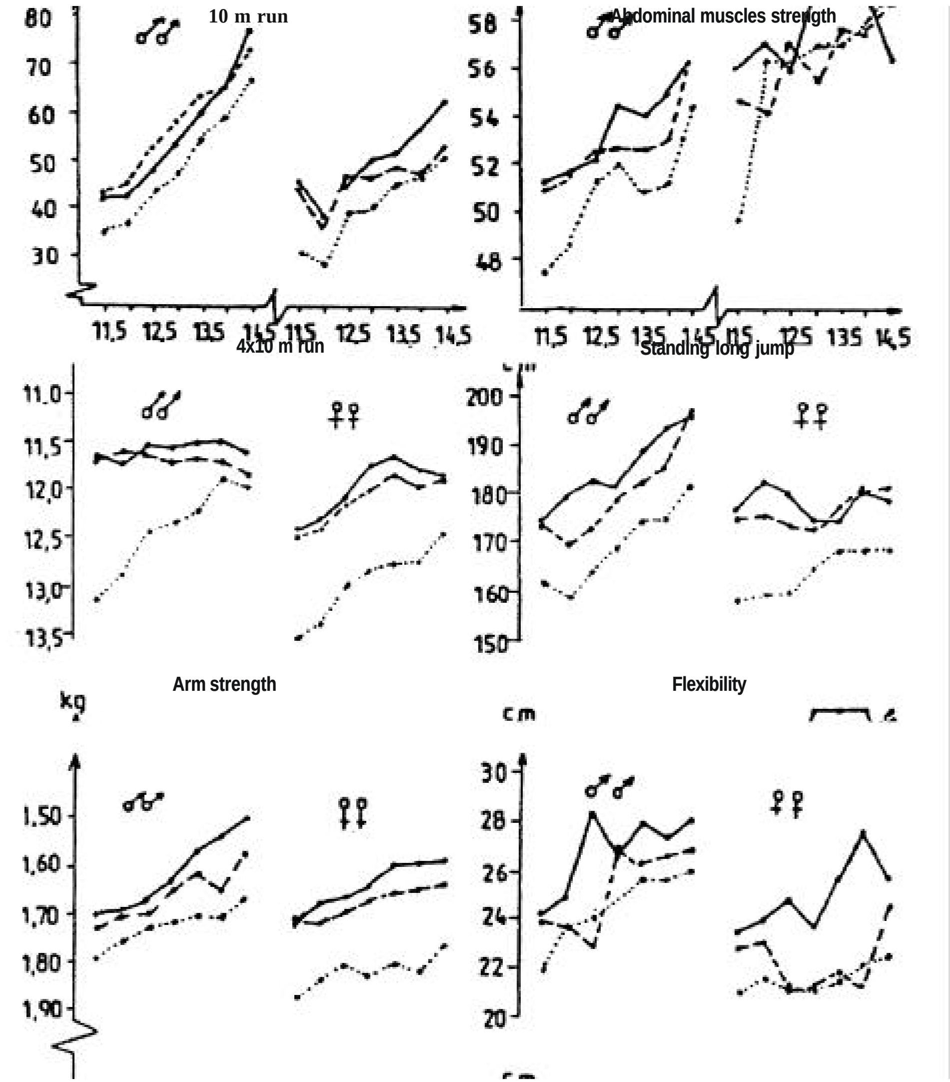

Fig. 5 The variability of motor fitness tests level of development in consecutive measurements

Statistical data ($\bar{x}$, SD, increments in % between measurements) of sport grades were compared to the entire population and comparative groups created through double selection of pairs for each measured variable (test) separately.

This choice was dictated by the fact that some features are inherited independently. For example some subjects with the same level of VO_2max may have (and very often have) different values of other variables. This method allowed to relatively "equalize" the genotypes (however it was impossible to exclude the differences in earlier movement experience), and continuing – elimination of differences caused by initial selection.

The results appeared to be very interesting. The differences between sport and comparative group 5 in relation to the entree population in area of somatic development (fig. 3) were statistically significant already at the time of selection, and reached highest values in body height (1,13 SD in boys and 1,65 in girls). The differences as well as development dynamics remained at a similar level in consecutive measurements. In "sport-comparative" groups there were no significant differences, even in so ecosensitive features, as fat mass or LBM. It testifies about only genetic, caused by initial selection, differences between somatic development of children from sport groups and population. The applied number of 10-12 hours of additional physical education classes has no influence even on body composition. It was confirmed by later work of Malina et al. (1990) and Malina and Bielicki (1992, 1996).

There was also no confirmation for thesis about greater masculinization of girls practicing sport disciplines. The differences in relation to population remained at similar level or even decreased.

A relatively small influence of increased movement activity was observed in relation to functional features (fig. 4). In both sexes significant improvement was observed simple reaction time, while in boys – to a small degree – also anaerobic capacity and apnea (toleration to acidosis).

Completely surprising were the results of motor fitness tests (fig. 5). Significant differences in relation to comparative groups appeared in the 10 m run and sit-ups in both sexes, while grip strength only in girls. Only these differences may be treated as the result of increased physical activity.

Generally, it may be stated that influence of increased physical activity (10-12 hours weekly) in very small. It only allows to maintain differences in the level of motor fitness in relation to the entire population, which was the effect of initial selection. This is one of the reasons why the amount of classes in sport grades should be increased to 20-24 hours weekly, with increased intensity of physical activity.

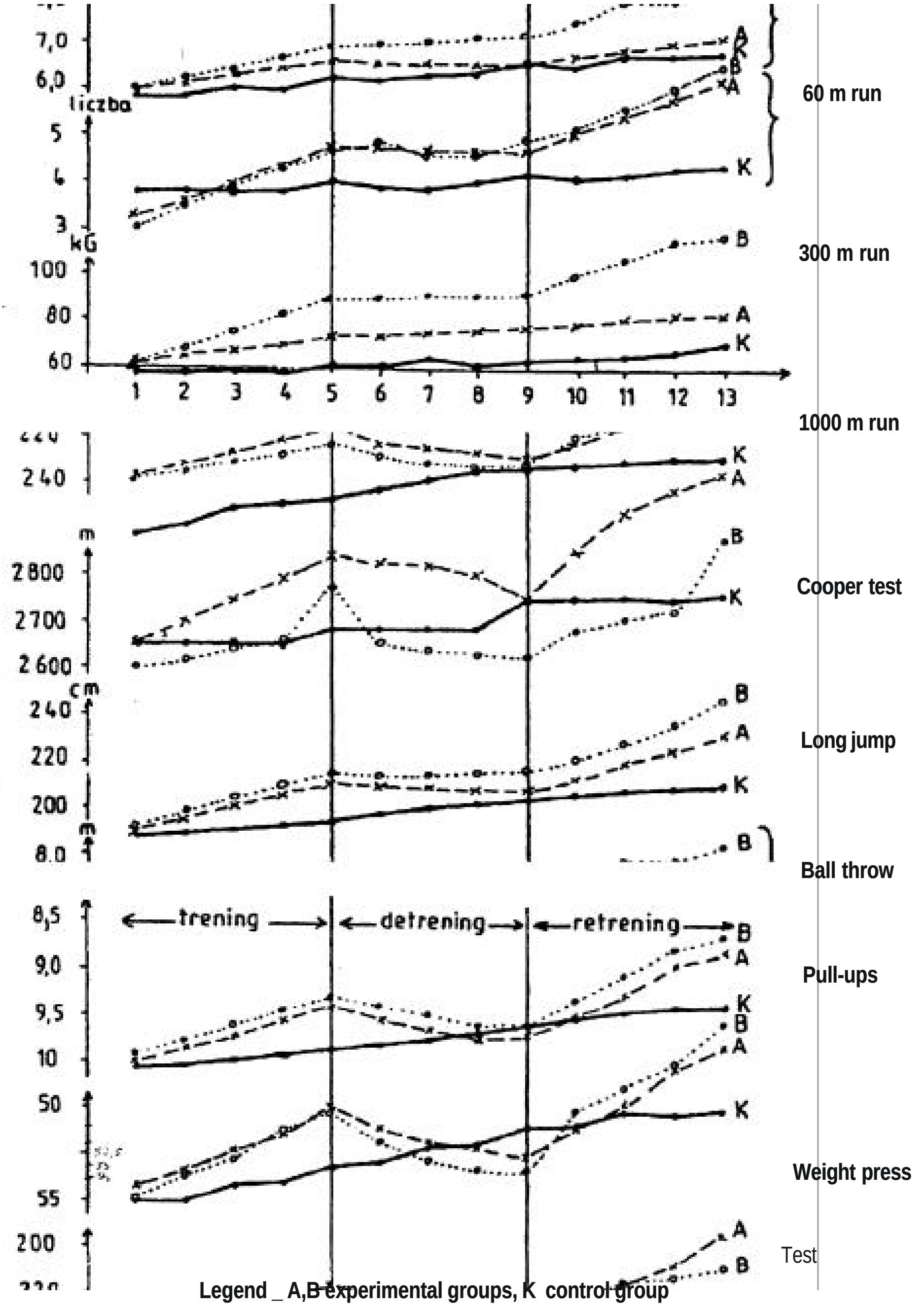

Fig. 6 The variability of specific motor abilities tests level of development in consecutive measurements

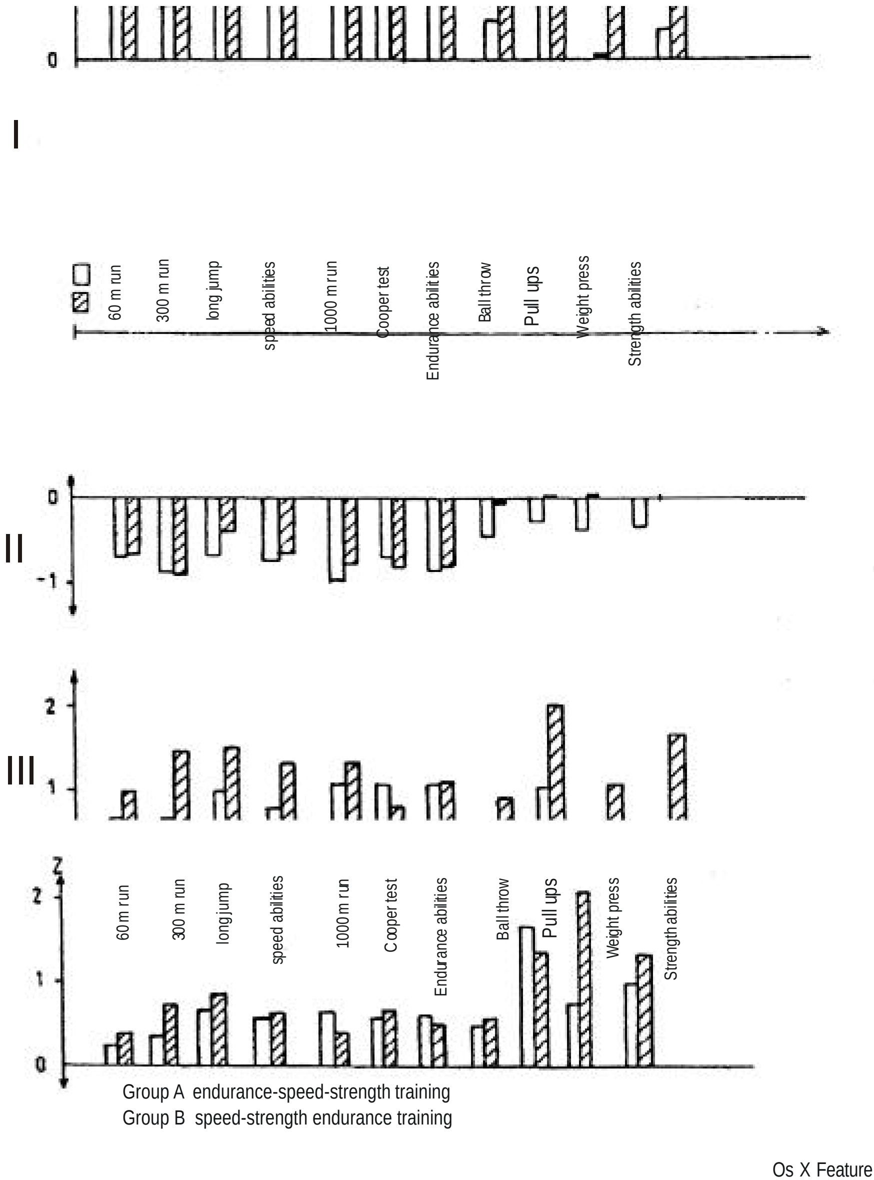

Fig. 7 Normalized intergroup differences in consecutive phases of experiment

A very important methodological conclusion also appears. Contemporary methods of increased physical activity evaluation do not allow exclude the initial selection factor, neither (because of lack of training structure registration data) the degree of sensitivity of specific motor abilities to environmental stimuli in different periods of ontogenesis.

The answers to these questions may be found only in properly planned and validly conducted research on trainability. Until now, there are a small number of such projects (for review see Bouchard et al. 1997), ant they show that trainability depends upon: type of ability (strength of genetic control), subject's genotype, as well as the intensity and volume of training stimuli.

In the Szopa and Prus (1997) experiment of conducted on 40 boys divided into two experimental groups (A and B) and 50 boys in control group (group K) aged 12 years, trainability was evaluated. Groups did not differ significantly at the preliminary measurement and experimental groups were subjected to strictly registered training protocols (tab. 2). The differences were:

a. group A realized endurance-speed-strength training while group B – speed-strength-endurance,
b. group A performed 12% more endurance exercises in comparison to group B, while less by 46% and 18% of strength and speed exercises,
c. control group practiced according to standard physical education program.

Experiment was conducted according to "training-detraining-retraining" schedule and lasted 3 years (3 cycles of 1 year each). The measurements were performed every 3 month and included 8 motor fitness tests:

– Speed abilities – standing long jump and 60 m run (alactic MAP) and 300 m run (lactic MAP),
– Strength abilities – medicine ball throw backwards, bench press (absolute strength) and pull-ups (relative strength),
– Endurance abilities – Cooper test (aerobic capacity) and 1000 m run (aerobic-anaerobic metabolism).

Basic statistics were calculated ($\bar{x}$, SD) and Z normalized intergroup differences for all measurements. The evaluation was made mainly for beginning and finish of each phase: training (measurement V-VI), detraining (IX-V) and retraining (XII-X), giving consideration to developmental tendency (group K).

The results of experiment are synthetically presented in fig. 6, while fig. 7 presents normalized to control group differences in consecutive periods. The control group shows relatively systematical development of all motor abilities (greater speed and strength abilities, then endurance). Physical activity in experimental groups caused changes in the level of motor abilities related clearly to time and structure of training.

In the first phase (i.e. training) significantly greater progression was observed. According to training, stimuli, higher improvement was observed in group A in endurance abilities, while in group B – in speed abilities. In both groups, strength abilities showed the highest increase. However training stimuli in both groups were not significantly different what shows undoubtedly, that physical activity factor is dominant in comparison to different genetic determinants of specific abilities.

Phase two (i.e. detraining) was focused on cessation of additional stimuli is characterized with significant decrease of both speed abilities (lactic and alactic MAP) and endurance (VO_2max), even to lower level than in the control group. These changes were not registered in case of strength abilities, where natural developmental tendencies (related to body mass) overreached the effect of decreased physical activity.

Phase three (i.e. retraining) was characterized a characterized by a very dynamic development of all abilities and clear differences between both experimental groups (structure of training). It was probably caused by “biochemical trace” in organism related to former training and higher sensitivity of boys aged 14-15 years (increase in muscle mass after the puberty spurt).

Figure 7, where normalized intergroup differences, with exclusion of developmental tendency are presented, allows for the resuming of results of the experiment. It is clearly visible that:

1. The scale of changes caused by retraining is significantly greater than effects of the training phase (in case of endurance and speed abilities almost twice greater).
2. The scale of regressive changes in detraining period is higher than training effects, especially in motor abilities dependent on circulatory and respiratory mechanisms, which are **so strongly related with health**. Such results were not confirmed in experiments with professional athletes (Coyle et al. 1984; Platonov 1986; Costill 1991). It should be mentioned, however, that the initial state, developmental phase and level were different, from which deadaptations started.
3. The experiment allowed to determine the differences in trainability of specific motor abilities: the highest occurred in strength abilities, while lower in speed and endurance ones. It was confirmed in genetic research (Simonean et al. 1986; Dionne et al. 1991; Meas et al. 1993; Bouchard et al. 1997), which allowed to formulate a thesis. On a population scale

trainability may be treated as a supplementation to genetic control of functional traits.

Conclusions

The presented above experiment results and theoretical background allow to formulate the following conclusion:

1. There is no “optimal” dose of physical activity for children and youth. The results show that 10-12 hours of additional physical activity do not improve the level motor abilities. Probably, it is cause by improper organization and structure of physical education lessons (not enough general fitness exercises and too early specialization). The experiments on trainability show that results of **properly** conducted sport training are clearly visible.
2. Motor abilities are significantly, although in different degree, sensitive to training. Because of small durability of these stimuli, physical activity has to remain without interruptions during the entire life. In light of this notion the idea of “education to physical culture” (prosomatic attitude) appears to be very important.
3. The proper level of motor abilities is one of the conditions of health. In that case it may be treated as proper scope of “health-related-fitness).
4. In research on the structure of motor potential, exploration for methods of testing and influence of physical activity, particular rules has to be followed:
   – the use of uniform and exact terminology,
   – the use of multidimensional statistical methods (variables choice, interpretation logic, complementarity of methods),
   – proper choice of comparative (control) groups,
   – precise registration of physical activity (load, volume and structure of stimuli etc.).

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