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A RELATIVE EVALUATION OF THE DEVELOPMENT OF FLEXIBILITY IN BOYS AT THE AGES BETWEEN 8 AND 15

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Abstract. On the basis of a continuous research on 162 boys from Cracow, at the ages of 8-15, an analysis of the dynamics of flexibility development was carried out according to the absolute and relative approach. The obtained results confirmed the hypothesis that the flexibility measurement by the EUROFIT battery of tests (range of the sit-and-reach test in a simple squat) is conditioned to a large extent by proportions of the longitudinal sections of the body. In this paper, an application of relative measurement of flexibility was suggested, in which the influence of this somatic factor is controlled. It was found in the conclusion that the methods applied to evaluate the relative flexibility give a diametrically different picture of the ontogenetic development of boys than the traditional method (EUROFIT test).

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Key words: Flexibility - Relative evaluation - Boys - Period of maturation

Introduction

Flexibility is a feature of the body treated in the research on motor behaviour in a marginal way. The most controversial is its interpretation, measurement and localisation in the structure of motor capacity. This refers, first of all, to the verification of the argument whether it can be regarded as an independent factor that occurs simultaneously with other elements determining human kinetics [4,8,11,12,16,19,25]. There also appears a question to what degree it is a specific feature of the body build [7,21,20] and to what degree it is the function of the

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body. Flexibility is traditionally defined as an ability to achieve a maximal range of movements [1,13,16,21,22] - in this sense; it is thus an anatomical and functional feature. Such a solution is not fully satisfactory.

In research on human populations, the importance of flexibility measurement is connected thus with the definition of so-called “health-related fitness” [2], while in highly qualified sport it is associated with the technique with which movements are performed.

In practice, the simplest way to evaluate flexibility is to measure the range in the sit-and-reach test forward in the sitting position [6,11]. It should be stressed that the results obtained in this way do not correspond in general with the results of research that determine movement range of other joints [4,5,15,24]. Furthermore, their interpretation is complex and raises some doubts because this measurement is error-prone, which results from the changing proportions of the body in particular periods of the ontogenesis. As it was shown in the previous studies [28], the longitudinal indices of the somatic features significantly correlate with the effects achieved by children and adolescents in the traditional flexibility test. This concerns a peculiar phase of pubertal onset and it manifests itself by a disturbance in the proportions between the length of the trunk and that of lower extremities. A quicker increase in the length of lower extremities in this period is indicated by all ontogenetic studies. Consequently, a question should be asked what great influence on the obtained results is exerted by the proportions of the length of the trunk and those of the lower and upper extremities? A greater range of the upper extremities, for example, may compensate the “losses” caused by an increased length of the lower extremities.

The purpose of the study is an answer to the question whether and in what degree a measurement of flexibility, determined during body bend forward is conditioned by the changing body proportions during a progressive development. We examined also the influence of age on the dynamics of flexibility development both in the traditional approach and in relative approach when a growth spurt of the body height appeared.

A hypothesis was formulated that the universally applied measurement of flexibility [6,11], to a large degree, is error-prone, which is due to the changes in the proportions of the body during the ontogenesis. The relativisation of results should allow a more accurate assessment of the range of movements, devoid of an influence of the somatic factor.

Materials and Methods

The longitudinal research involved 162 children from the primary schools (No. 11, 12 26, 91, 130) which were selected from particular districts of the City of Cracow. The measurements of the somatic characteristics as well as motor abilities were carried out every year between 1992-1999.

In accordance with the assumptions of this study, the following length characteristics of the body were taken for the evaluation of flexibility: the body height (vertex), trunk length (suprasternale - symphysion), length of lower extremities (symphysion), length of upper extremities (acromion - dactylion) as well as the range of the sit-and-reach forward test in the sitting position (Fig. 1).

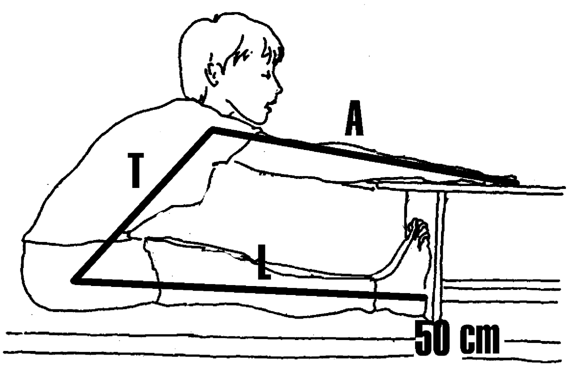

Fig. 1
Body stance in the flexibility test (modified according to 6); the best result out of the three executed trials was taken for the calculation

The following methods were applied in this research:
1. The evaluation of the dynamics of development on the basis of arithmetic averages of flexibility in absolute values [6] and relative ones (flexibility index), which were calculated according to the equation:

$$FI = \frac{results\ of\ flexibility\ measured\ in\ the\ sit-and-reach\ forward\ test\ (in\ cm)}{length\ of\ upper\ extremities + trunk\ length - length\ of\ lower\ extremities + 50\,cm} * 100$$

2. The assessment of the speed of development of flexibility in absolute and relative values in three groups of boys divided according to their age when their growth spurt of body height appeared. The following division was applied: group “W” (n=32) was formed from the boys who evinced adolescent spurt between 12 and 13 years of age. Group “N1” (n=62) was created from the subjects with

pubertal onset at the ages of 13-14 as well as Group “N2” (n=68) that was characterized by even later period of pubertal onset, i.e. at the ages of 14-15.
3. The verification of significance of the following factors: a simple effect which results from a split of the population according to the criterion of the age when the growth spurt in body height appeared (3 levels) as well as to the time factor (8 levels) connected with a natural development of boys at the ages from 8 to 15, with the application of a statistic variance analysis during a repeated measurement.

Results

In Table 1, the ANOVA results were juxtaposed in the flexibility test of boys at the ages of 8 to 15.

Table 1
The results of ANOVA analysis in the flexibility test with an inclusion of the occurrence of the pubertal onset factor (Spurt) and the natural development factor (Age) during repeated measurements

The source of variability	df Effect	MS Effect	df Error	MS Error	F - value	p - level
1-Adolescent Spurt	2	43.7063	159	212.5795	0.20560	0.814375
2-Age	7	435.6830	1113	8.4669	51.45710	0.000000
	14	10.4648	1113	8.4669	1.23597	0.242445

The simple effect, resulting from the split of the group according to the criterion of pubertal onset, was not statistically significant (F=0.21; p=0.814). In the group with an earlier observed pubertal onset – “W”- the mean result of the flexibility measurement amounted to $\bar{x}$=52.64 cm, in group with the normal occurrence of the spurt –“N1”- it was respectively $\bar{x}$=51.92 cm, whereas, in the group with the later spurt –“N2”- the mean result achieved equalled $\bar{x}$=52.10 cm.

The time factor connected with a natural development of boys at the ages from 8 to 15 was mainly responsible for an increase in flexibility level during the EUROFIT test (F=51.46; p<0.001). The average result in this test in the case of eight-year-olds amounted to 49.75 cm, while in fifteen-year-olds – 55.58 cm. The group's average of the flexibility measurement in eight-year-old boys was statistically significant in relation to all the older age categories (in Tukey test p<0.001). At the ages of 14 and 15 distinct differences were observed, which indicated an increase in their flexibility level in relation to the group of thirteen-year-old and younger boys (Tukey test p<0.001).

The results of the flexibility test in nine-year-olds were similar as in those of 10-,11-,12- and 13-year-olds, while the Tukey test showed that those were homogeneous groups (p>0.05).

No expected interaction was found between age factors and the moment of pubertal onset (F=1.23; p=0.242), although Fig. 2 may indicate a slight superiority of Group "W" over Groups "N1" and "N2", which was present in the majority of those age categories.

No matter when the growth spurt occurs, the results of flexibility measurements in school children indicated an intensive increment of this feature during the first year of school education and a certain stagnation at the ages of 10,11 and 12, and then again an increase in mobility ranges were observed during the flexibility test at the ages from 13 to 15, which in Group "N2" began one year later than in groups "W" and "N1".

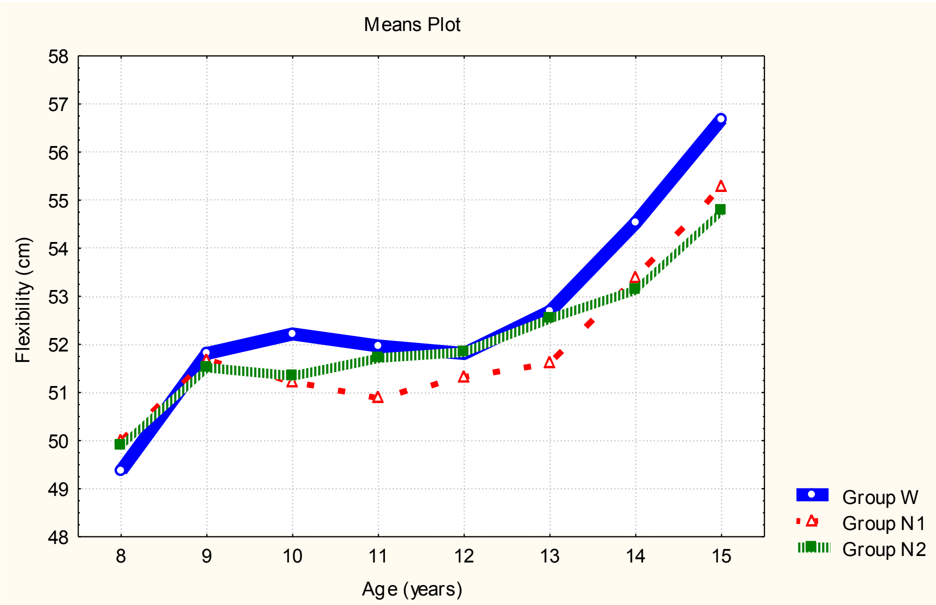

Fig. 2
The graph of the average results of the flexibility test with an inclusion of the occurrence of pubertal onset factor in boys at the ages from 8 to 15

The results of ANOVA analysis of flexibility index were presented in Table 2.

Table 2
The results of ANOVA analysis in the flexibility test with an inclusion of the occurrence of pubertal onset factor (Spurt) and natural development factor (Age) in repeated measurements

The source of variability	df Effect	MS Effect	df Error	MS Error	F - value	p - level
1-Adolescent Spurt	2	55.6927	159	224.2884	0.24831	0.780421
2-Age	7	379.4294	1113	8.0298	47.25254	0.000000
	14	6.7371	1113	8.0298	0.83901	0.626572

It was demonstrated that the value of the flexibility index did not differentiate significantly the groups of boys divided according to the moment when their growth spurt occurred (F=0.248; p=0.780). However, the variance analysis proved some influence of the age factor on the level of relative flexibility (F=47.25; p<0.001). No interaction was found between the factors of pubertal onset and that of age (1 * 2; F=0.84; p=0.63).

The values of the flexibility index in the group of eight-year-olds were significantly different than in the older age categories, starting with eleven-year-olds, in whose case these were significantly lower (Tukey test when p<0.001). The group of ten-year-olds also demonstrated a superiority over the older boys in this respect (p<0.01).

The boys at the ages of 13-15 were in terms of statistics different from those aged 9 to 11 as far as the flexibility index was concerned (p<0.05). At the same time, in this age bracket there was a steady decrease in the relative level of their flexibility expressed by means of FI from 51.5 to 48.8%).

The age categories between 13 - 15 years of age formed a homogeneous group in terms of their level of the flexibility index (p>0.05). At that moment, there also occurred an increase in the values of the flexibility index, especially in Group W (Fig. 3).

After the evaluation of flexibility was standardised, the natural time factor was perceived to be acting differently. In this approach, Group " N2 " had slightly higher values of the flexibility index than Groups "W" and " N1 ", in the majority of age categories.

Fig. 3
The graph of "FI" average values with an inclusion of the occurrence of pubertal onset factor in boys at the ages of 8 to 15

In the results of flexibility measurements of EUROFIT test, a upward trend was observed (compare Fig. 2), whereas in the case of the flexibility index a decrease was duly documented of this feature as the physical development continued in boys at the ages of 8 to 15.

The inclusion of the body size brought about a change in the evaluation of flexibility level in boys at the ages of 8 - 15.

Discussion

The issues concerning the ontogenetic variability of selected somatic parameters for the analysis of flexibility is - from point of view of the main objectives of this paper - of a primary importance. The question of interpretation of the mechanisms that condition the changes within the results of the verified test is complex and lies, among others, in the morphological structure of the human body. The most significant in this regard seem to be to longitudinal characteristics, especially their proportions.

Clarification of the differences during the formation of the developmental lines of flexibility with the application of the traditional and relative method of its measurement requires reminding of a number of the most important generalizations concerning the development of ontogenetic characteristics of body length. From the previous studies [3,16,26,28] it follows that relative increases between different age groups in the length of the upper and lower extremities are, in general, stable and grow accordingly from the age of 8 to the moment of pubescence. They are greater in the length of the lower extremities than those of the upper ones. After this phase of development, the general tendency manifests itself in a slower and slower incremental development of these features. At the beginning, the differences are levelled out; in the majority of later age groups there occurs a more dynamic increase in the length of upper extremities than lower ones. All these phenomena, - obviously - have to exert an essential influence on the size of the inter-extremity factor. As it follows from the previous studies (quoted above), the formation of its value indicates a downward trend with age up to the period of pubescence and a stabilization in the further stage of development on more or less the same level. Other developmental lines indicate some values describing the variability of the trunk-leg factor [16,28]. Particularly interesting appears to be a drop of this index during pubescence. This phenomenon is undoubtedly related with a different formation of dynamics of the longitudinal development of the trunk, which in comparison with the increments in the length of lower extremities up to the period of pubescence is typified by a slower and more homogeneous progress. The greatest increases in the length of the trunk take place during maturation. After this period, the values of the described index return to the level observed during the younger school age [28]. It was already Tanner that drew our attention to a periodic and more intensive growth of the length of lower extremities than that of the trunk [18]. Szopa [16] associates these facts with a different type of body build and the growth of the spinal cord (development of the spongious substance of bones). A similar opinion was also represented by Skibińska [14].

Generally, it can be said that if, in terms of the length of upper and lower extremities, the direction of changes may be regarded as similar and resulting from the identification of these features with the body size factor, then in regard to the length of anterior wall of trunk this phenomenon loses its momentum [16].

It is obvious that the above-mentioned phenomena have to result in grave consequences in respect of the functional biomechanical capacities of the tested boys, especially in terms of the results obtained during the flexibility test.

The variability of flexibility results in the relative approach retains a considerably specific character and disproportions in comparison with the findings of the research on movement range by means of the traditional test. The obtained effects in terms of “relative flexibility” tally with our expectations and are characterised not only by a lower dynamics of development in the older age groups (13 between 15), but also by a considerable regress in the age bracket between 9 and 13. This strong regression deserves our particular attention (greatest one in the group of boys who mature the earliest) during the period preceding the adolescent spurt of body height. The inter-fractional differences during the studied development of flexibility are actually statistically insignificant, but they indicate certain dissimilarities especially in the group of boys, in whom the adolescent spurt occurred at the very latest. It is also worthwhile to draw attention to the fact that in spite of “the elimination“ of the body proportion factor in the phase following pubertal onset and partly during its progression, there occurs a slight improvement in the results of tests. It may foreshadow a considerable increase in flexibility in the further stage of the ontogenesis. At this point it should be stressed that the " spurt " in terms of the length of the spinal cord always occurs later than it is in the case of the length of extremities. This phenomenon is explained by some authors as an increased flaccidity of muscles and tendons [23]. The above-mentioned phenomena are obviously related with the transformations that occur during the formation of movement range. They occur more slowly than the developmental lines, which indicates potential somatic possibilities during the performance of flexibility tests.

It can be said, therefore, that the traditional measurement of movement range in a greater degree measures the natural development of the longitudinal characteristics and their proportions than the actual flexibility. Better results in thus conducted test are more likely in the case of higher values of the longitudinal indices of body proportions. The subjects with relatively longer upper extremities and the trunk, in comparison with the length of the lower extremities, achieved better results during this test more often than their peers, in whom reverse relations were found (naturally within the developmental standards). The analysis of the results clearly proved a weakness of the universally applied in practice methods to measure flexibility taken during the sit-and-reach-forward test. This results from the ignoring of the somatic conditioning, body proportions. They are imbedded in the relations of the length of upper extremities to the lower ones, and especially in relations between the length of the trunk and the length of lower extremities.

The inclusion of these factors in the studies on flexibility of children and adolescents, who experience a period progressive development, becomes particularly important in the light of the recent opinions and considerations on human motor fitness structure [review of the issues in question - 9,10,17]. There is an urgent need not only to continue research work in this direction but also mainly to determine the relationship between motor effects and elementary as well as primitive in comparison with the somatic, psychomotor and physiological traits. It is also indispensable to draw more attention to the research on the conditioning of these elementary functional features, which determine the level of human motor effectiveness. It should be remembered that the somatic and motor development occur in a progressive period in the same direction, whereas the structural development always precedes the development of functions. At the same time, it mustn't be forgotten that the discovered somatic predispositions during the flexibility test take a diverse course during the ontogenesis. The rate of their development in individual subjects and of both sexes is also different. There is also a considerable variability within every age category (development and genetic conditioning). Grave social and pedagogical consequences also result from the outlined problem and they were discussed more widely in another publication [27].

The supervision of motor effects in the work of every teacher is obviously very important. This facilitates a conscious control over physical education process. It consists in a rational selection of means and methods as well as the adaptation of workload to the age and gender, body build and motor fitness of the pupil. The most essential thing is that the evaluation should concern the real and authentic motor effects.

The elimination of the flexibility measurement from the body proportions factor makes such an objective evaluation possible. Our research proved that the procedure of relativisation of results is considerably deficient in terms of the range of movements of the boys from the urban population. In its absolute results, this phenomenon was elusive and presented a false picture of the studied reality. The method we suggest allows to avoid these errors and to draw practical conclusions. In our opinion, the regression observed has no justification in biological transformations, or it is rather caused by a low motor activity of our adolescents as well as negligence and unsuitable work in terms of the school and extra-school physical education.

In the recapitulation of the considerations mentioned above, we suggest the following measurement or flexibility for the needs of the population under research, taking into consideration the ease with which the trial is performed and its accuracy as well as equipment requirements:

$$FI = \frac{results\ of\ flexibility\ measured\ in\ the\ sit-and-reach\ forward\ test\ (in\ cm)}{length\ of\ upper\ extremities + trunk\ length - length\ of\ lower\ extremities + 50\ cm} * 100$$

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