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# RELATIONSHIPS OF BONE AGE, PHYSICAL DEVELOPMENT AND ATHLETIC PERFORMANCE AT THE AGE OF 11 TO 12 YEARS

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**Abstract.** Performance in five athletic tests and seven body dimensions were measured, Conrad's two indices of growth type and wrist bone age were assessed in 26 girls and 16 boys engaged in track and field events. The chronological age of the subjects ranged from 10.9 to 12.9; their bone age showed a mean acceleration of 6 to 8 months (about 7%). The purpose of the study was to see if physique and performance were related to biological age. The girls were less robust and more leptomorphic than the non-athletic reference group, but had a similar stature and minimally lighter weight. The boys were taller, heavier and more robust than their nonathletic age-mates. Bone age was significantly related in both sexes to all body dimensions and the plastic index, to three performance items in the boys and to four in the girls. In order to help estimation of biological age in a simple way, prediction formulae were developed for the two sexes from stature, hand circumference and calendar age. These may help the coach to avoid mistaking accelerated youths for talented ones, and to assign training exercise more adequately.

*Key words:* biological age and performance, estimation of bone age, track and field athletes.

## Introduction

Coaches are always on the hunt for individuals talented in athletic activities. In selecting trainees from among the children who volunteer for long-term training the risk of mistakes is particularly great. This led the coaches to prefer physically well-developed pupils, because these are likely to perform better at an earlier age. It is a common error of the coaches, however, that they tend to consider children with an advanced maturation being more talented than the ones following the normal course of development.

The present study was initiated to see if in motor tests commonly employed in the selection procedure performance was related to biological age, and how physique related to the same.

## Material and Methods

Twelve min run-walk, 60 m dash, long and high jump, fistball throw and seven body dimensions were measured in 42 track and field athletes between 10.9 and 12.9 years, 26 girls and 16 boys. Test performance was registered according to athletic principles. In recording body dimensions IBP suggestions

(WEINER and LOURIE 1969) were observed. Bone age was estimated by comparing wrist X-rays to a standard atlas (GREULICH and PYLE 1959). Body dimensions were used also to calculate CONRAD's metric and plastic indices (CONRAD 1963) which previously were evidenced to follow a characteristic pattern during development (SZMODIS et al. 1976). Where available, a comparison with healthy non-athletic reference groups was also made (MÉSZÁROS and MOHÁCSI 1978). Formulae developed for bone age estimation were derived by multivariate regression equations.

## Results and Discussion

Developmental status of the subjects is shown in Fig. 1. The boys were taller than, and the girls agreed with the reference stature. The boys were heavier while the girls were minimally lighter and less robust (plastic index) than their age-mates. The boy's metric index agreed with the reference data. Girl athletes

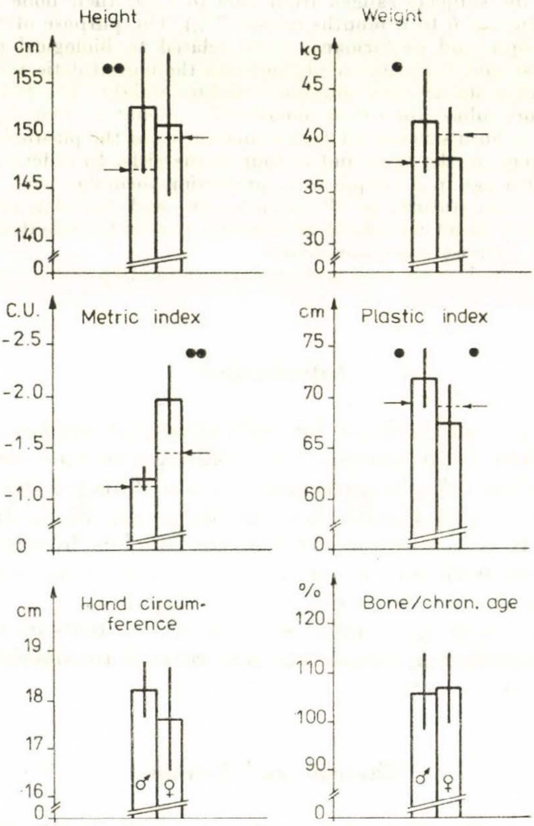


*Fig. 1:* Physique of adolescent track and field athletes. The arrows denote non-athletic reference means. Presence and number of bold circles indicate significant differences on the 5% (single circle) or 1% (double circle) level. — Bone/chron age: ratio of bone age to chronological age; C.U.: Conrad units of leptomorphy—pyknomorphy scale

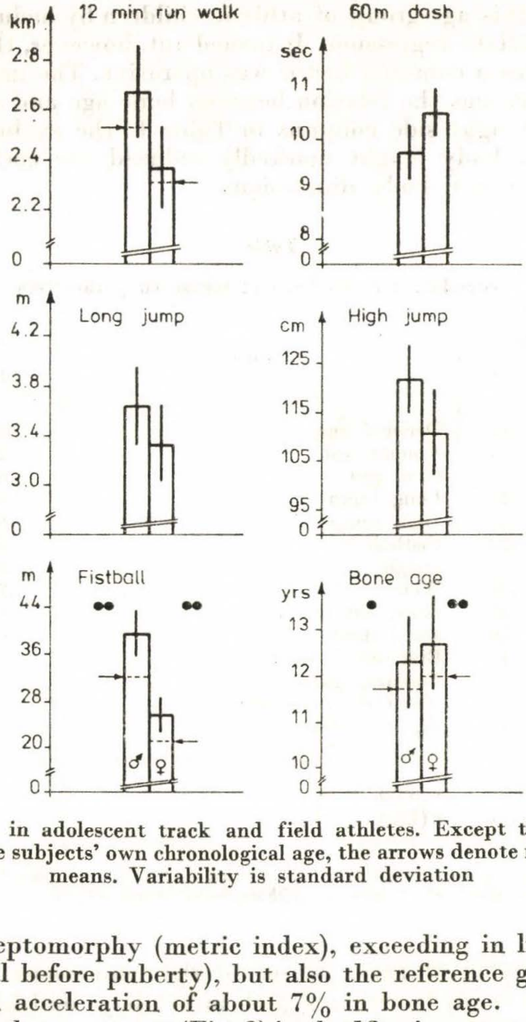


*Fig. 2:* **Performance in adolescent track and field athletes. Except the bars of bone age where they refer to the subjects' own chronological age, the arrows denote non-athletic reference means. Variability is standard deviation**

**showed marked leptomorphy (metric index), exceeding in linearity not only the boys (as usual before puberty), but also the reference group. Both sexes displayed a mean acceleration of about 7% in bone age.**

**Performance of the test group (Fig. 2) in the 12-min run-walk though higher, failed to exceed reference values significantly because of the very wide range of variability in the non-athletic group. All performance items showed a superiority of the boys despite that in girls this is usually a period of rapid growth both structurally and functionally. As apparent in fistball throw where reference values were available, both test groups displayed much greater explosive strength than non-athletic children. A part of this higher performance is apparently also due to their accelerated maturation which was by about 8 months ahead of calendar age.**

**To find out if it was this acceleration indeed that contributed to better performance and, in some dimensions of physique, to larger values, we related all measurements and the plastic index to bone age. As seen in Table 1, all the physical dimensions and also several of the performance items had a significant connection with skeletal age. This challenged us to look for a means of estimat-**

ing bone age for this age-group of athletic children by including these parameters in a multivariate regression. It turned out, however, that behind a great number of relations a common factor was operative. The main contributor to this common effect was the relation between bone age and stature. As shown by the respective right side columns in Table 1, the exclusion of the effect mediated through body height markedly reduced the coefficients for both motor performance and body dimensions.

*Table 1*

**Full and partial correlation coefficients of measured parameters with bone age***

| Boys (N = 16) | | Dimensions | Girls (N = 26) | |
|---|---|---|---|---|
| full | partial | | full | partial |
| .45 | .42 | Decimal age | .46 | .23 |
| .59 | .33 | Cooper test | .27 | .04 |
| —.45 | —.09 | 60 m run | —.60 | —.41 |
| .54 | .08 | Long jump | .68 | .45 |
| .62 | .23 | High jump | .82 | .54 |
| .47 | —.02 | Fistball | .54 | .20 |
| .83 | — | Height | .80 | — |
| .77 | .39 | Weight | .78 | .34 |
| .77 | .34 | Chest width | .66 | .27 |
| .75 | .16 | Chest depth | .67 | .18 |
| .77 | .18 | Biacromial width | .75 | .39 |
| .82 | .55 | Forearm girth | .72 | .44 |
| .78 | .41 | Hand circumference | .86 | .61 |
| .85 | .47 | Plastic index | .83 | .54 |
| .50 | .51 | $r$ (5%) | .39 | .40 |
| .62 | .64 | $r$ (1%) | .49 | .50 |

* Partial correlation excluded the variability in stature. Bottom rows indicate tabular values of the linear correlation coefficient on the 5 and 1 per cent levels of significance with degrees of freedom n-2 (full) and n-3 (partial).

When variability of stature, as one of the main signs of developmental status, is held constant, lower arm girth in the boys and hand circumference in the girls remained qualified for predicting bone age by non-radiological means. Since lower arm girth as a predictor for the boys was only slightly better and the gain in accuracy by using it in place of hand circumference was negligible, we employed the latter for both sexes (Table 2). Accordingly, to provide the possibly simplest and easiest way for assessing biological age, stature, hand circumference and chronological age expressed in decimal years were eventually included in the multivariate prediction equations. All the three predictor variables are easily measurable, and may be used to advantage by coaches, too.

The drastic drop in the correlations between bone age and motor performance due to the exclusion of variability in stature supports the assumption that functional improvement resulting from regular training in motor skills may have a larger share among the factors contributing to athletic proficiency than merely structural advantage. Accelerated maturation will anyway come to an

*Table 2*

Estimation of bone age in track and field athletes of 10 to 13 years of age: Sex-dependent formulae to predict bone age

BOYS

$Y = 0.084ST + 0.608HC + 0.498DA - 17.496 \pm 0.508$; $R = 0.980$

GIRLS

$Y = 0.034ST + 0.562HC + 0.362DA - 6.720 \pm 0.481$; $R = 0.888$

where
Y = bone age in yrs;
ST = body height in cm;
HC = hand circumference in cm;
DA = chronological age in decimal yrs.;
variability is scatter around regression line, and
R = multiple linear correlation coefficient.

end in the long run. Until better means of prediction are developed, such simple ways of assessing developmental age may serve coach and consulting kinanthropometrist alike in avoiding mistakes when children are selected for competitive athletics.

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