Anthrop. Közl. *26;* 149—161. 1982.

PHYSICAL FITNESS AS RELATED TO BIOLOGICAL MATURITY

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Abstract: In the present overiew the relative importance of skeletal maturity in explaining body measurements and motor fitness components is reported.

The data result from the "Leuven Growth Study of Belgium Boys" as well as from pilot-studies of the "Leuven Growth Study of Flemish girls". The importance of skeletal maturity in explaining body measurement and motor fitness results was investigated by means of regression analyses and comparisons between maturity groups. In girls maturity groupings were also made according to the age at menarche.

In boys the relative importance of skeletal maturity reaches a maximum at 14—15 years and a fairly high percentage in body dimensions (± 50% for stature) is explained by skeletal age. For the motor fitness components the interaction of chronological age and skeletal age as such or in combination with height and/or weight have the highest predictive value although the explained variance is rather low ranging from 0% to 17%, except for static strength for which the explained variance ranged from 33% to 38%.

Skeletaly more mature and average maturing girls of 12 through 14 years have larger body dimensions than retarded girls. For the motor fitness components no clear differences were found except for static strength for which more mature girls obtained better results than the retarded girls. The observed differences between pre- and postmenarcheal 11 to 13 year old girls are in the same direction as the maturity-performance relationships for boys.

However, with increasing age these relationships are somewhat reversed resulting in a better performance for late maturing girls at ages 16—18 years.

Key words: Physical fitness, biological maturity, "Leuven Growth Study of Belgian Boys", "Leuven Growth Study of Flemish Girls", body measurements, motor fitness, skeletal age, menarche.

Introduction

Before going into detail of the relationship between different aspects of physical fitness and biological maturity it seems indicated to define more precisely what is meant by physical fitness and biological maturity.

Let us first consider the definition of *biological maturity*. Already in 1908 Crampton observed that the chronological age does not represent truthfully how far an individual has progressed along its road to biological adulthood. According to Tanner (1962) there are mainly four systems in use to assign a developmental age; these are:

- sexual characteristics
- morphological characteristics
- dental development
- skeletal development

In the present account we will not consider the different techniques presently used to estimate these biological maturity criteria. Overviews of the different techniques currently used are given by DEMIRJIAN (1978), MARSHALL (1978), and ROCHE (1978).

As was clearly shown by MARSHALL (1974) and further illuminated in an overview by MALINA (1978), no single maturation system provides a complete description of the growth and the maturation during adolescence but the somatic, sexual and skeletal indices of growth and maturation are sufficiently interrelated to indicate the developmental level of a group of children or populations.

Furthermore, DEMIRJIAN (1978), after reviewing the relationship between dental emergence or calcification and other maturity criteria, concluded that dental maturation is substantially independent from the other criteria. Although different systems are in use, and are to some extent independent of each other, several authors (see e.g. MARSHALL 1977, TANNER 1978) agree that the development of the skeleton provides one of the most useful indices of maturity.

Secondly the concept of *physical fitness* will be discussed. Definitions of physical fitness can be found in textbooks on measurement and evaluation in physical education (CLARKE 1976, CURETON 1947, LARSON and YOCOM 1951, SAFRIT 1973). According to SAFRIT (1973) two definitions seem to be most commonly used. From a medical point of view, physical fitness is defined as the capacity to adapt and recover from strenuous exercise, in other words cardio-respiratory fitness. A more general definition considers physical fitness as: "The ability to carry out daily tasks with vigor and alertness, without undue fatigue, and with ample energy to engage leisure time pursuits and to meet the above average physical stresses encountered in emergency situations (ANON, 1979)". This definition has now been endorsed by the American Academy of Physical Education, and is a somewhat modified version of the definition proposed by CLARKE (1976, p. 12).

In the LEUVEN GROWTH STUDIES on Belgian boys (OSTYN, SIMONS, BEUNEN, RENSON, and VAN GERVEN 1980) and on Flemish girls (BEUNEN, SIMONS, OSTYN, RENSON, VAN GERVEN, CLAESSENS, VANREUSEL, COLLA and SCHUEREMANS 1980) we interpreted physical fitness in this broad sense and

Table 1

The basic dimensions of motor fitness in boys and girls and the selected tests for the Leuven growth study on Belgian boys and on Flemish girls

Basic dimensions	Test Boys' study	Test Girls' study
Eye-hand coordination	Stick balance	—
Balance	—	Flamingo balance
Flexibility	Sit and reach	Sit and reach
Speed of limb movement	Plate tapping	Plate tapping
Running speed	Shuttle run	Shuttle run
Static strength	Arm pull	Arm pull
Explosive strength	Vertical jump	Vertical jump
Functional strength	Bent arm hang	Bent arm hang
Trunk strength	Leg lifts	Leg lifts
Endurance	1' step test	1' step test 500 m schuttle run Bicycle ergometer test

for this reason body measurements, body type and biological maturation were measured together with a battery of motor fitness components and sport participation. In most studies on motor fitness the total concept is broken down into subcomponents. In the above mentioned studies the basic dimensions of the motor fitness domain of growing boys and girls could be identified more accurately through factor-analyses of the results of each age group between 12 and 19 years (SIMONS, BEUNEN, OSTYN, RENSON, SWALUS, VAN GERVEN, WILLEMS 1969, SIMONS, OSTYN, BEUNEN, RENSON, VAN GERVEN 1978).

In Table 1 the extracted factors together with the tests measured in the study on Belgian boys and on Flemish girls are given.

With regard to the relationship between skeletal maturity and physical fitness we will concentrate on the relationship in boys starting from the boys' study although some preliminary results will be presented on the relationship in girls based on a few pilot studies.

Material and Methods

The boys' study is a mixed longitudinal study of the physical fitness of Belgian school boys (OSTYN, SIMONS, BEUNEN, RENSON, and VAN GERVEN 1980). This growth study consisted of a six-year longitudinal and cross-sectional study of a representative sample of Belgian school boys aged 12+ to 19+. The testing program started in 1969 and ended in 1974. A total of 21,052 examinations were made. Each year between 2500 and 4500 boys of one secondary school grade were tested beginning with the first grade. Therefore a stratified sample of schools was randomly selected taking into account the following factors:

- language group: French or Flemish speaking
- school affiliation: private (Catholic) or state schools
- type of schooling: vocational, technical schooling or humanities
- geographical distribution of the school population per province.

In each school a random sample consisting of entire classes was selected and all the boys in each class were examined. The same schools were studied throughout, which resulted in a combined longitudinal and cross-sectional study. This design, in which several birth cohorts are followed for several years with overlapping intervals, is recommended by SCHAIE (1965) and VAN'T HOF, WELS and KOWALSKI (1979) as the most efficient design for a developmental study.

In Table 2 the number of boys examined is reported classified according to the measuring period and the number of examinations. This table shows that 39% (5576) of the boys were measured twice or more with a mean of 2.2 observations. 587 boys were followed for six years, 1063 boys were followed for five years etc.

There was a considerable amount of drop-outs due to the design of the study although this drop-out was not selective over the whole study (OSTYN, SIMONS, BEUNEN, RENSON, and VAN GERVEN, 1980). All measurements were made each year during the same period from January till March with nearly exact yearly intervals. Seasonal effects on growth and development were thus limited to a minimum.

Table 2

Number of boys enrolled in the Leuven growth study of Belgian boys

Measuring period	Number of examinations						
	1	2	3	4	5	6	
1969	4282						
1970	1235	2921					
1971	1214	832	1863				
1972	1049	727	529	1177			
1973	699	674	379	366	783		
1974	312	422	482	239	280	587	
Total	8791	5576	3253	1782	1063	587	21052

Seventeen anthropometric measures and nine motor ability tests were administered, three standard photographs were taken to determine the somatotype and an X-ray of the left hand and wrist to estimate the skeletal development. Furthermore a standardized questionnaire was designed to evaluate sports participation and socio-cultural background of the subjects and their parents. All questionnaires were filled in by the parents and checked by interview with the boys. The entire testing programme was administered to each boy at each measuring period. The tests and measurements were taken by two teams of ten well-trained instructors, under the permanent supervision of the same research assistants who trained and accompanied that team throughout the entire study. Each school was visited twice at an interval of one week.

As already mentioned, a valid and reliable motor test battery was selected for boys of these age levels.

Skeletal maturity was assessed according to the methods of TANNER and WHITEHOUSE (TANNER and WHITEHOUSE 1959, TANNER, WHITEHOUSE and HEALY 1962, TANNER, WHITEHOUSE, MARSHALL, HEALY and GOLDSTEIN 1975). All assessments were made by the same observer *(G.B.)*. High intra-observer reliability (0.98) was obtained between two independent assessments (BEUNEN 1970) and no systematic difference between the means was observed. Furthermore a very good agreement was noted between the assessments made by this observer *(G.B.)* and the assessments made by experts in the method *(R. H. Whitehouse* and *N. Cameron)* (BEUNEN and CAMERON 1980).

The data in the two girls' studies are taken from two cross sectional samples of schools in Leuven.

The first sample consisted of 450 girls 12 through 16. Besides our own motor fitness test battery also the motor fitness test proposed by the International Committee on Standardisation of Physical Fitness Tests (LARSON and YOCOM 1951) were administered together with 27 anthropometric measurements. Skeletal age was also assessed according to the TW1 method by the same observer *(G.B.)*. For a more detailed description of this study see BEUNEN, OSTYN, RENSON, SIMONS and VAN GERVEN (1976). In the second sample 398 girls aged 11 through 18 were examined. Besides motor fitness tests age at menarche was recorded by means of the status quo method.

Results and Discussion

A. *PHYSICAL FITNESS – SKELETAL MATURITY RELATIONSHIPS IN BOYS* (based on publications by BEUNEN, OSTYN, RENSON, SIMONS, SWALUS, and VAN GERVEN 1974, BEUNEN, OSTYN, RENSON, SIMONS, and VAN GERVEN 1978, BEUNEN, OSTYN, SIMONS, VAN GERVEN, SWALUS, and DE BUEL 1978, BEUNEN, OSTYN, RENSON, SIMONS, and VAN GERVEN 1979, BEUNEN, OSTYN, SIMONS, RENSON, and VAN GERVEN 1981). In this overview we will consider the following questions:

– what are the age-specific relationships between skeletal maturity and physical fitness during adolescence and

– is there an evolution in the relationship?

– what part of the variability in physical fitness is accounted for by chronological age, skeletal age and for motor fitness also by size?

For all these relationships we will only consider the cross sectional analysis.

I. *Age specific relationships and evolution in these relationships*

In a first analysis correlations were calculated between skeletal age and physical fitness results at each age level. Moreover, comparisons were made between the mean results of boys of the same age but of varying degree of skeletal maturation.

Body measurements

All body measurements are fairly closely related to skeletal age (Table 3). The highest correlations are found for linear dimensions and the lowest for skinfolds. From 12 to 14 the correlations are fairly similar or increase; thereafter a significant decrease occurs first in weight, linear dimensions and bone breadth dimensions, thereafter for the other dimensions.

Motor fitness

For motor fitness results only static strength (arm pull) correlates fairly high with skeletal age at all age levels. At 13 and more clearly at 14 all motor tests are positively related to skeletal maturity. Only for eye-hand coordination (stick balance) and pulse rate at rest no significant correlations are found, and a slight negative correlation exists with pulse rate after exercise.

For static strength (arm pull) and explosive strength (vertical jump) the highest correlations are found at 14 to 15 years, thereafter the correlations decrease. For the other motor fitness components the correlations increase from 12 through 14 whereafter they remain unchanged.

II. *Percentage of variability in physical fitness accounted for by skeletal age, chronological age and size*

To answer this question two separate studies were undertaken. In the first study the relative contribution of skeletal age and chronological age was investigated in homogeneous age groups. Within each chronological age group first order partial correlations have been calculated between skeletal age and

Table 3

Correlation coefficients between skeletal age, structural measures and motor fitness components at different age levels

Test	12 years	13 years	14 years	15 years	16 years
Weight	0.573	0.615	0.650*	*0.627**	*0.524**
Height	0.603	0.676*	0.702*	*0.621**	*0.405**
Sitting height	0.521	0.664*	0.728*	*0.692**	*0.577**
Biacromial width	0.481	0.547	0.633*	0.631	*0.472**
Chest width	0.404	0.469	0.544*	0.561	*0.462**
Bicond. humerus	0.520	0.594*	*0.514**	*0.470**	*0.254**
Bicond. femur	0.477	0.464	0.433	*0.320**	*0.123**
Chest circumference insp.	0.486	0.559*	0.622*	0.624	0.517*
Chest circumference exp.	0.478	0.510	0.592*	0.605	*0.510**
Thigh circumference	0.464	0.434	0.497*	0.505	*0.458**
Calf circumference	0.507	0.503	0.505	0.487	*0.366**
Upper arm circumference	0.396	0.454	0.524*	0.539	*0.495**
Supra iliac skinfold	0.277	0.297	0.344	0.362	0.366
Subscap. skinfold	0.280	0.257	0.316*	0.332	0.373
Triceps skinfold	0.134	0.077	—*	—	0.042
Calf skinfold	0.195	0.118	0.116	—*	*—0.062**
Stick balance	—	—	—	—	—
Plate tapping	—	0.151	0.214*	0.178	0.167
Sit and reach	—	0.055	0.158*	0.190	0.145
Vertical jump	—	0.196*	0.319 *	0.379*	*0.321**
Arm pull	0.430	0.553*	0.652*	0.632	*0.512**
Leg lifts	—0.149	—0.118	0.039*	0.132*	0.188*
Bent arm hang	—0.189	—0.137	—*	0.145	0.132
Shuttle run A	—	—	0.128*	0.122	0.093
Pulse rate R.A	—	—	—	0.039	—
Pulse rate A.A	—0.103	—0.105	—0.077	—0.045	—0.082

Key: A: Sign reversed, indicating a poorer performance for an older skeletal age,
—: Correlation not significant different from zero,
*: Significant difference at 5% level between correlations of adjacent age levels after transformation into Fisher Z'-scores,
Coefficients *in italics* indicate a significant lower correlation in the older age group in comparison with the adjacent younger age group (after BEUNEN—OSTYN—SIMONS—VAN GERVEN—SWALUS—DE BEUL 1978).

the physical fitness results with chronological age partialed out and within each skeletal age group first order partial correlations have been calculated between chronological age and the physical fitness variables with skeletal age partialed out.

Since the results are fairly similar at all age levels only the partial correlations for boys of 13 (chronological or skeletal age) will be discussed.

Height, weight and static strength (arm pull) are highly related to skeletal age (Table 4). Relationships with other motor fitness components are low but differ significantly from zero, except for eye-hand coordination (stick balance) and speed (shuttle run). Trunk strength (leg lifts) and functional strength (bent arm hang) are negatively correlated with skeletal age at this age, although at 14 or 15 a positive relationship is found. Chronological age has a slight negative relationship to weight and no correlation with height.

Table 4

First order partial correlations between skeletal age (SA), chronological (CA), and physical fitness components. Data for thirteen-year-old boys

	$r_{SA\text{-}Var.CA}$	$r_{CA\text{-}Var.SA}$
Height	0.633	—
Weight	0.604	—0.086
Stick balance	—	0.126
Plate tapping	0.096	0.265
Sit and reach	—	0.063
Vertical jump	0.155	0.101
Arm pull	0.526	0.054
Leg lifts	—0.122	0.100
Flexed arm hang	—0.134	0.137
Shuttle run	—	—0.079
N	2162	1574

— partial correlation not significantly different from zero (after BEUNEN – OSTYN – RENSON – SIMONS – VAN GERVEN 1978).

Of the motor fitness items, the lowest partial correlation is found for static strength (arm pull). For the other tests the correlations are somewhat higher, especially for speed of limb movement (plate tapping).

In a second analysis stepwise multiple regression equations were derived with chronological age and skeletal age as the independent variables for body measures and with chronological age, skeletal age, height and weight, and interaction terms as the independent variables for the motor ability tests. The interactions between the variables were calculated by the product of these variables. The proportion of the variance accounted for by each of the independent variables was calculated by the product of the partial beta coefficient and the zero-order correlation.

Body mesurements

Within each age group only one or two percent of the total variance in body dimensions is explained by chronological age. For most measurements the explained variance is not significantly different from zero. Skeletal age accounts for a larger percentage of most body dimensions. A maximum is reached at 14 or 15 years, after which a rapid decline in the explained variance is observed. At the age of 18 only 0—11% of the variance is still accounted for (Table 5).

Motor fitness

In the age range 12 to 18 years eye-hand coordination (stick balance) is not related to any of the independent variables.

Only a very small percentage (0—3%) of the total variance in running speed (shuttle run) is explained by the variables considered herein. The same holds true for pulse rate at rest and after exercise. For speed of limb movement (plate tapping) and flexibility (sit and reach) the explained variance is low varying from 1 to 7%. The percentage of variance accounted for remains fairly constant for trunk strength (leg lifts) at 8—9%. For explosive strength (vertical jump) and functional strength (bent arm hang) a still higher proportion is explained 4—17%, but the highest predictive value is found for static strength (arm pull). The coefficient of determination increases from 36% at 12 years to 58% at 14 years and decreases to 30% at 18 years. From the analysis it appeared that the interaction between chronological age and skeletal age as such or in combination with height and/or weight explained the largest portion of the total variance for most of the motor fitness components (Table 6).

Table 5

Explained variance ($\beta \times r$) of structural measures accounted for by skeletal age (TW2)

Body dimensions	Explained Variance	
	12–15 years	16–19 years
Body weight	0.34—0.41	0.03—0.25
Stature	0.35—0.49	*ns*—0.14
Sitting height	0.30—0.52	0.02—0.29
Biacromial diameter	0.20—0.38	0.03—0.18
Bicondylar humerus	0.18—0.35	*ns*—0.04
Bicondylar femur	0.08—0.25	*ns*—0.01
Chest circumference inspiration	0.25—0.38	0.03—0.25
Chest circumference expiration	0.24—0.36	0.03—0.24
Thigh circumference	0.21—0.25	0.03—0.20
Calf circumference	0.23—0.28	0.04—0.13
Upper arm circumference contracted	0.17—0.28	0.04—0.23
Supra-iliac skinfold	0.09—0.14	0.02—0.13
Subscapular skinfold	0.07—0.12	0.03—0.15
Triceps skinfold	*ns*—0.03	*ns*—0.00
Calf skinfold	0.00—0.04	*ns*—0.00
Reaching height	0.32—0.46	*ns*—0.12

ns: partial regression coefficient not significantly different from zero ($\alpha = 0.01$). Adapted after BEUNEN—OSTYN—SIMONS—RENSON—VAN GERVEN (1981).

Table 6

Explained variance of motor fitness components

Test	R^2 range 12–18 years	Most important independent variables
Stick balance	*ns*—0.02	CA
Plate tapping	0.01—0.07	CA×SA×HT
Sit and reach	0.01—0.03	HT; CA×SA
Vertical jump	0.04—0.17	CA×SA×HT
Arm pull	0.30—0.58	CA×HT×WT; CA×SA×HT×WT; SA×WT; CA×SA×WT
Leg lifts	0.06—0.09	HT
Bent arm hang	0.09—0.16	WT
Shuttle run	*ns*—0.03	CA×SA
Pulse rate at rest	*ns*—0.01	WT
Pulse rate recovery	*ns*—0.04	WT; SA×WT

R^2: coefficient of determination; *ns:* R^2 not significantly ($\alpha = 0.01$) different from zero; CA: chronological age; SA: skeletal age; HT: height— WT: weight; CA×SA: interaction term chronological age and skeletal age. Adapted after BEUNEN—OSTYN—SIMONS—RENSON—VAN GERVEN (1981).

B. *PHYSICAL FITNESS – MATURITY RELATIONSHIPS IN GIRLS*

(based on publications by Beunen, Ostyn, Renson, Simons, and Van Gerven 1976, Beunen, De Beul, Ostyn, Renson, Simons and Van Gerven 1978).

Here we will consider the following questions:

— what are the relationships between skeletal maturity and physical fitness in adolescent girls and do they change with age?

— what are the relationships between sexual development (age at menarche) and physical fitness and do they change with age?

Table 7

Correlation coefficients between skeletal age, body measurements and motor tests[2]

	Age 12 N = 76 skel. age	Age 13 N=129 skel. age	Age 14 N=94 skel. age	Age 15 N=86 skel. age	Age 16 N=36 skel. age
Height	0.508	0.566	—	—	—
Reaching height	0.482	0.555	—	—	—
Sitting height	0.641	0.618	0.381	—	—
Leg length	—	0.391	—	—	—
Weight	0.367	0.537	0.480	—	—
Bicond. humerus	—	—	—	—	—
Bicond. femur	—	0.359	—	—	—
Bimal. ankle	—	0.378	—	—	—
Shoulder width	—	0.334	—	—	—
Hip width	0.435	0.455	0.517	—	—
Chest width	0.364	0.333	—	—	—
Chest depth insp.	0.393	0.316	0.338	—	—
Chest depth exp.	0.390	0.379	0.342	—	—
Chest depth	—	—	—	—	—
Chest girth insp.	0.488	0.501	0.446	0.289	—
Chest girth exp.	0.477	0.517	0.452	0.313	—
Chest ampliation	—	—	—	—	—
Abdominal girth	—	0.440	—	—	—
Hip girth	0.579	0.599	0.462	0.319	—
Thigh girth	0.397	—	0.367	0.355	0.506
Calf girth	0.475	0.526	0.416	0.351	—
Upper arm girth flexed	—	0.361	0.347	0.295	—
Upper arm girth ext.	—	0.315	0.415	0.306	—
Sub-iliac skinfold	—	0.272	0.275	—	—
Sub-scapular skinfold	—	0.304	0.282	—	—
Upper arm skinfold	—	—	—	—	—
Sum three skinfolds	—	0.262	0.315	—	—
Vertical jump	—	—	—	—	—
Sit and reach	—	—	—	—	—
Leg lifts	—	—	—	—	—
Shuttle run	—	—	—	—	—
Plate tapping	—	—	—	—	—
Arm pull	0.348	0.334	0.281	0.278	—
Bent arm hang	−0.419	—	—	—	—
Dodge run	—	—	—	—	—

— correlation not significant ($\alpha = 0.01$) different from zero.

Adapted after Beunen—Ostyn—Renson—Simons—Van Gerven (1976).

I. *Skeletal age — physical fitness relationships*

The skeletal age — physical fitness relationships will be treated first. From Table 7 it appears that the highest relationships are found between skeletal age and linear dimensions. Also for most breadth and girth measurements significant correlations are found. For hip width e.g. correlations between .44 and .52 are found for girls 12 through 14. The correlations for skinfolds are low and just significantly different from zero. Starting at 13 all correlations become smaller with increasing age and vanish at 15 to 16 years. For motor fitness only static strength (arm pull) is positively related to skeletal age from 12 to 15 years. At 12 a negative correlation is found for functional strength (bent arm hang). This can be explained by the negative influence of weight for this test (correlation between weight and bent arm hang equals $r = -.432$). For the other factors no significant correlations are found.

II. *Sexual maturity — physical fitness relationships*

In order to investigate the physical fitness-sexual maturity relationships, a sample of 398 girls was subdivided into maturity categories according to the age of first menstruation.

In Tables 8 and 9, the significant differences that were found between the maturity categories in each age group are indicated. For girls between 11 and, 13 years, postmenarcheal girls were taller and heavier and obtained better results for static strength (arm pull and hand grip) and equilibrium (balance test). Only slight differences occurred between the three maturity groups of 14 through 15 year-old girls. These differences were not significant except for one static strength test (handgrip) and one trunk strength test (leg raiser).

A totally different trend was found for girls 16—18 years. For trunk strength (sit up), explosive strength (standing broad jump), functional strength (bent arm hang), running speed (dodge run, shuttle run 40 m and 50 m) and speed

Table 8

Significant differences (t-test; $\alpha = 0.05$) between girls 12—15 years of different menarcheal age for height, weight and motor fitness components

Component	11—13 years pre-post menarche	14—15 years late-aver. menarche	14—15 years late-early menarche	14—15 years aver.-early menarche
Body measures	Height	—	—	—
	Weight	—	—	—
Static strength	Arm pull	—	—	—
	Handgrip	—	Handgrip	—
Equilibrium	Balance test	—	—	—
Trunk strength	—	—	—	Leg raiser
Explosive strength	—	—	—	—
Functional strength	—	—	—	—
Running speed	—	—	—	—
Speed of limb movement	—	—	—	—
Flexibility	—	—	—	—

All differences are in favor of the MORE mature girls
After Beunen—De Beul—Ostyn—Renson—Simons—Van Gerven (1978).

Table 9

Significant differences (t-test; $\alpha = 0.05$) between girls 16—18 years of different menarcheal age for height, weight and motor fitness components

Component	Late-aver.	Late-Early	Aver.-early
Body measurements	—	—	—
Static strength	—	—	—
Equilibrium	—	—	—
Trunk strength	sit up	—	—
Explosive strength	stand. broad jump	—	—
Functional strength	—	bent arm hang	—
Running speed	dodge run	—	—
	shuttle run 50 m	shuttle run 50 m	—
	shuttle run 40 m	—	—
	figure 8 duck	—	—
Speed of limb movement	1 foot tapping	1 foot tapping	—
Flexibility	—	—	—

All differences are in favor of the LESS mature girls.
After BEUNEN—DE BEUL—OSTYN—RENSON—SIMONS—VAN GERVEN (1978).

of limb movement (one foot tapping), several high significant differences were found between girls with a late menarche and girls with an early and/or average date of first menstruation. The late maturing girls always obtained better results than the average or early maturing girls.

In *summary* the results of the Leuven growth studies clearly demonstrate the contrasting maturity-performance relationships during adolescence that are apparent for boys and girls.

In an overview of the factors influencing strength and performance MALINA (1980) came to the same conclusion. The advent of adolescence brings about a marked increase in most motor performance factors (see e.g. BEUNEN, SIMONS, RENSON, VAN GERVEN and OSTYN 1980) and consequently considerable differences are found in boys of contrasting maturity status. Conversely a stagnation or even a decline in motor performance is found in adolescent girls (see e.g. ASMUSSEN 1974, ESPENSCHADE and ECKERT 1967). This contrasting maturity-performance relationship is also found in male and female athletes. In an attempt to explain these inversed relationships in girls MALINA, SPIRDUSO, TATE and BAYLOR (1978) offered a two part hypothesis:

First, the physique characteristics of late maturing females are probably more suitable for success in performance.

Second, among females the advancement in maturity may represent a performance advantage early in adolescence but with the attainment of menarche the early maturing girl is perhaps socialized away from physical performance and sports competition through a myriad of social-and-status-related motives.

Our results also indicate that the motor fitness components are rather independant of the anthropometric dimensions and biological maturity of adolescents. Since that, with the exception of static strength, skeletal age, chronological age, height, weight, neither taken separately, nor in combination with each other, explain high percentage of variance in motor fitness items.

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