ULTRASONIC ASSESSMENT OF CALCANEUS BONE DENSITY AND LEVEL OF MOTOR ABILITIES IN GIRLS DURING ADOLESCENCE

by

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The study makes an attempt at assessing the level of bone density and of motor abilities among 11-14 year old girls. Material was obtained from a group of 13 girls who were examined at yearly intervals from age 11 to 14. Measurements were taken of: calcaneus bone density with the ultrasonic method as well as height and body weight. According to „Eurofit" instructions and Żak's tests chosen motor abilities were assessed. These were: sense of balance, flexibility, explosive strength, muscular strength of the abdomen and hand as well as running endurance. Girls had the greatest motorial efficiency at the ages from 12-13 years. The greatest increase of SOS (32.2 m/s) and SI (10.7%) parameters was found in the 11 to 12 years' age group. During the same time girls manifested a considerable improvement in running endurance results and the lowering of explosive strength. Overstated bone density in relation to norms of calendar age was stated during each examination of the same girls (n=3), whereas lower bone density was found during specific periods in different examined girls (n=3 or 4). Changing tendencies in the level of particular motor abilities depending on bone density indicate the usefulness of QUS in assessing somatic development which conditions proper motor function.

Key words: motor abilities, puberty, quantitative ultrasound (QUS).

Introduction

Factors which participate in achieving maximum Peak Bone Mass (PBM) are as follows: genetic basis, high supply of calcium and motor activity. Examinations of bone mass density are carried out occasionally among healthy children, rarely in sick children and most often during the pre-, peri- and postmenpausal period in women who are threatened by osteoporosis (Barden et al. 1988, Ventura et al. 1996, van Daele et al. 1997, Halaba et al. 1997a, 1997b, Shono et al. 1997). However, longitudinal densitometric examinations in girls are not being carried out.

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Adolescence is the crucial period for obtaining high PBM. Girls show less interest in physical exercise during this period, whereas high physical activity is one of the elements in the prophylaxis of osteoporosis.

The study makes an attempt at assessing the level of bone density and the level of motor fitness in 11-14 year old girls.

Materials and methods

A group of 13 girls - primary school pupils was examined at yearly intervals from the age of 11 to the age of 14. Measurements were taken of: calcaneus bone density with the ultrasonic method by means of the Achilles apparatus as well as of height and body weight. The parameters recorded were as follows: speed of sound (SOS, m/s), broadband ultrasound attenuation (BUA, dB/MHz) and stiffness index (SI, %) calculated as a combination of SOS and BUA parameter data.

The assessment of motor fitness was carried out according to Żak's tests (1991) and „Eurofit" (1988). The following motor ability tests were applied.:

1. time measurement of maintaining balance on one leg - „flamingo balance" (balance),
2. in upright sitting position bending the trunk forward (flexibility),
3. long jump from standing position (explosive strength),
4. continuous run at a distance of 1000 m (running endurance),
5. dynamometric measurement of handgrip strength; due to dynamic asymmetry the average grip of the right and left hand were analysed,
6. sitting up from lying position (muscular strength of abdomen).

The results of tests from 1-4 were converted into points according to norms and Żak's charts (1991) comparing them with calendar age. This procedure allowed for the comparison of the size of changes in the level of specific motor abilities irrespective of the type of unit expressing the result.

A basic statistical analysis of material was carried out (x, SD, correlations, coefficients t-Student's or Cochran-Cox's Tests).

Results and discussion

Levels of average parameter values characterising calcaneus bone density as well as height and body weight, have been shown in Table 1.

Table 1. Value of ultrasonic test results of bones and somatic features

Parameter / Age	x ± SD			
	11	12	13	14
BUA	106,1 ± 6,7	107,5 ± 8,4	111,3 ± 9,3	116,4 ± 13,1
SOS	1541,0 ± 20,5	1573,0 ± 23,0	1581,0 ± 27,9	1577,0 ± 27,4
SI	82,1 ± 8,7	92,7 ± 8,3	96,7 ± 10,0	99,1 ± 13,1
Body weight	39,1 ± 7,9	43,5 ± 9,0	50,0 ± 7,8	53,4 ± 8,8
Body height	147,8 ± 5,5	152,2 ± 5,6	159,6 ± 5,1	162,6 ± 5,3

The biggest average yearly increase of SOS and SI parameter values took place between the 11th and 12th year of age. Increase in the speed of sound by 32.2 m/s stated in our own studies conforms with the dynamics of changes in densitometric parameters obtained with the use of other bone mass assessment techniques (Bonjour et al. 1991, Halaba et al. 1997a, 1997b, Lorenc et al. 1993). Both the DXA (Dual X-ray Absorptiometry) method as well as measurements of proximal phalanxes by quantitative ultrasound have confirmed the increased rate of bone mass accumulation round the age of 11.

Overstated bone density in relation to calendar age norms (Z-score>1) was present during each examination in the same group of girls (n=3), whereas lower bone density (Z-score<-1) during particular periods in different girls who were examined (n=3 or 4).

Table 2. Characteristic of motor fitness in girls (x ± SD) - results in absolute figures

Abilities / Age	x ± SD			
	11	12	13	14
Balance	5,1 ± 3,7	20,4 ± 22,6	12,5 ± 8,3	16,4 ± 14,0
Flexibility	59,1 ± 4,3	73,5 ± 3,9	79,6 ± 3,1	76,9 ± 4,6
Explosive strength	166,8 ± 15,8	162,8 ± 9,7	173,4 ± 19,4	178,3 ± 9,5
Grip strength of hand	15,3 ± 2,2	16,0 ± 3,3	19,1 ± 3,2	20,2 ± 3,1
Muscular strength of abdomen	20,9 ± 2,6	21,3 ± 4,1	23,4 ± 3,8	24,0 ± 2,6
Running endurance	338,0 ± 41,4	245,7 ± 40,6	287,8 ± 41,6	330,1 ± 40,1

The level of motor fitness in girls has been shown in Table 2. The biggest motor fitness was achieved by girls at the age of 12-13 years. Also during this period there was a statistically significant improvement of results in the majority of analysed motor abilities (Tab. 3). Muscular strength of the hand increased together with the girls' age, as did the muscular strength of the abdomen. These abilities depend on the body weight. According to literature explosive strength proceeds in conformity with the development of body height (Żak 1991). This conformability was found between the age of 12 and 13 when the abrupt puberty change in body height took place and results were improved on average by 10.5 cm. Among bone density parameters the SOS value increased the most during this period. Girls achieved the best time at the age of 12 in the 1000 m run. Deterioration of these test results during the abrupt puberty change and gradual regression are also known, and this also occurred during individual studies (Raczek 1992, Stokłosa and Raczek 1997).

Table 3. Assessment of importance in the differences in values of motor fitness result changes, bone density parameters and somatic features

Age / Abilities/ Trait	11-12		12 – 13		13 –14	
	d	t-test	d	t-test	d	t-test
Balance	15,3	2,41*CC	-7,9	1,18CC	3,8	0,85CC
Flexibility	14,4	8,80*	6,1	4,32*	-2,7	1,73
Explosive Strength	-4,0	0,77CC	10,5	1,75CC	4,9	0,82CC
Grip strength of hand	0,7	0,62	3,1	2,39*	1,1	0,93
Muscular strength of abdomen	0,4	0,28	2,1	1,33	0,6	0,47
Running endurance	-92,3	5,73*CC	42,1	2,61*	42,3	2,64*
BUA	1,4	0,49	3,7	1,08	5,1	1,15
SOS	32,2	3,77*	7,9	0,79	-3,2	0,29
SI	10,7	3,19*	4,0	1,10	2,4	0,52
Body weight	4,4	1,31	6,5	1,96	3,3	1,03
Body height	4,3	1,99	7,4	3,55*	2,9	1,47

*$p<0,05$
CC Cochran-Cox's test

The results of tests from 1 - 4 obtained by the girls having Stiffness Index values within norm as well as above and below norm, have been presented in Figure 1. Analysis based on the test results of several girls allows us only to

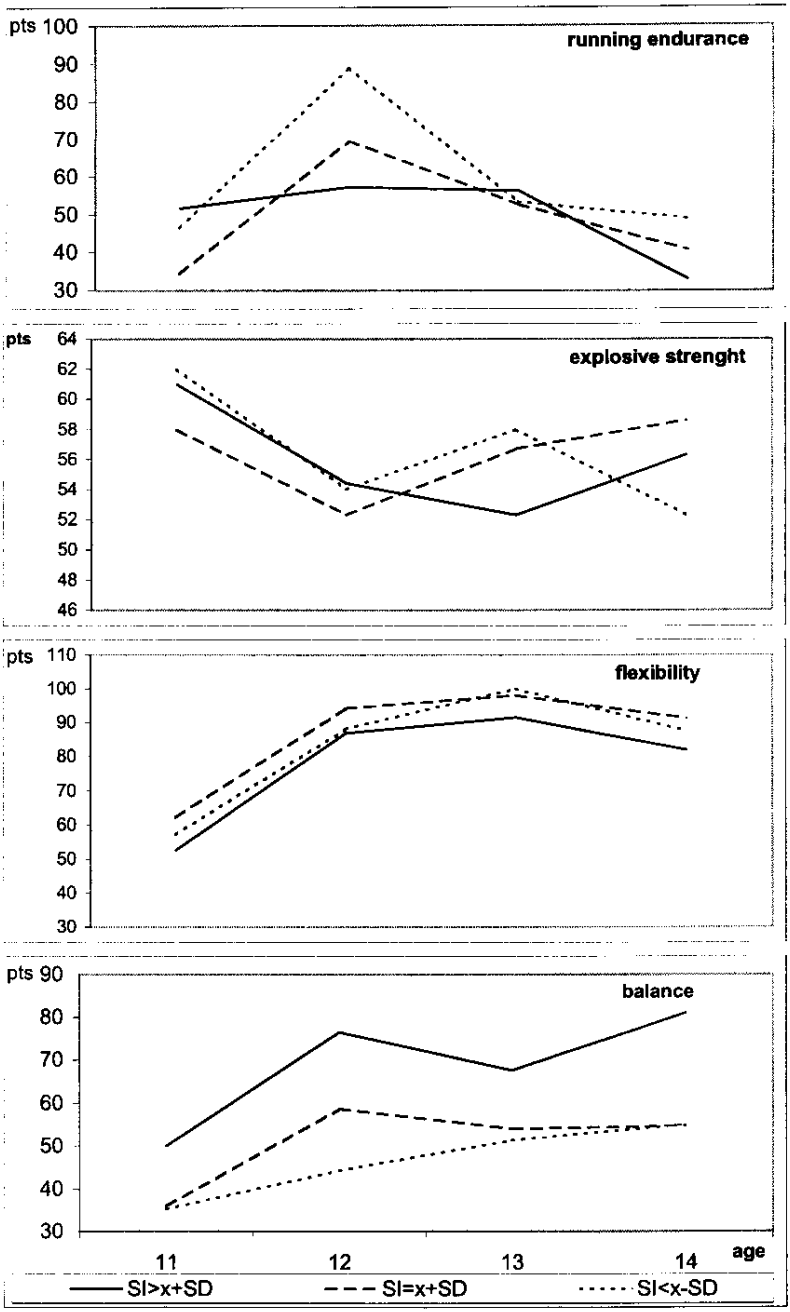

Figure 1. Results of motor fitness tests in age groups and Stiffness Index fractions

assume that particular fractions of morphologic age (bone density) indicate respectively progress or regression of results, conformable with kinetics of changes in birth certificate age (Żak 1991, Stokłosa and Raczek 1997).

Table 4. Correlation index between bone density parameters and motor fitness tests in age groups

Trait	Balance	Flexibility	Explosive strength	Grip strength of hand	Muscular strength of abdomen	Running endurance
11-years						
BUA	0,51	-0,18	0,23	0,65*	-0,19	-0,21
SOS	0,46	-0,23	0,36	0,17	-0,16	-0,26
SI	0,56	-0,25	0,35	0,42	-0,18	-0,29
12-years						
BUA	0,31	0,12	0,23	0,37	-0,48	0,21
SOS	0,37	-0,14	-0,04	0,02	0,00	0,39
SI	0,45	0,00	0,04	0,17	-0,12	0,45
13-years						
BUA	0,54	-0,42	-0,35	0,70*	0,71	-0,17
SOS	-0,04	-0,10	-0,01	0,03	-0,32	0,14
SI	0,30	-0,35	-0,23	0,46	-0,13	-0,01
14-years						
BUA	0,38	-0,20	0,14	0,65	-0,42	0,51
SOS	0,09	0,10	0,14	-0,20	-0,21	0,43
SI	0,29	0,07	0,18	0,30	-0,40	0,59*

*$p<0,05$

The low number of girls subjected to examination makes interpretation of relationships between bone density parameters and particular motor abilities

difficult. The calculated correlation indexes (Tab. 4) suggest the existence of such dependencies or confirm the already known dependencies. For example BUA and SOS parameters in 14-year old girls show a positive correlation, and SI even statistically significant correlation ($t=0.59$, $p<0.05$) with running endurance. Girls with higher bone mass density take longer to run the distance of 1000 m. This is normal for girls with normal and accelerated somatic development, who are going through the puberty period (Hirtz 1985, Raczek 1992).

From among the analysed parameters BUA most often shows higher than 0.2 correlation indexes. This might suggest that *substantia spongiosa* of the bones, of which BUA is the measure, more than *substantia compacta* characterised by SOS, depends on mechanical loads caused by physical activity. This has been made evident during examinations of cosmonauts in whom no SOS parameter changes had been found after 1 and 6 months of flight, whereas BUA showed a great decrease (Collet et al. 1997). Also the studies of Rho et al. (1997) pertaining to biomechanical properties of different parts of the tibia showed differentiation of its structure, whereas the biggest correlation existed between BUA and the anterior/posterior direction (AP $r=0.75$). The point that strength and resistance of bones not only depends on their mass, but also on their structure has been confirmed during individual studies by the more frequent BUA parameter correlation with results of motor ability tests (Cadossi et al. 1996).

The observed changes in bone density parameters and the conducted assessment of motor fitness in girls on that basis, have to be confirmed by tests conducted on a more numerous group of persons.

Conclusions

1. The biggest accumulation of bone tissue takes place in girls between 11th and 12th year of age, and this is made evident by the increase of SOS and SI parameter values.
2. Changing tendencies in the level of particular motor abilities depending on the bone density show the usefulness of QUS in assessing somatic development which conditions motor fitness.

3. The calcaneus bone density measurement with the ultrasonic method should be included in the examinations of health conditions of children during the preliminary selection for sport training.

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