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Evaluation of bone with quantitative ultrasound in healthy Turkish children

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SUMMARY: Tüzün Ş, Karacan İ, Akarırmak Ü, Kasapçopur Ö, Arısoy N. Evlauation of bone with quantitative ultrasound in healthy Turkish children. Turk J Pediatr 2003; 45: 240-244.

In this study bone status was assessed using a quantitative ultrasound (QUS) technique at the calcaneus in 141 healthy, prepubertal, Turkish schoolchildren (80 girls, 61 boys) aged 6-12 years. Broadband ultrasound attenuation (BUA. DB/MHz) was measured with a prototype pediatric contact bone analyzer (CUBA, McCue Ultrasonics Ltd). The relation of age, body weight and height to BUA was assessed. BUA increased linearly with age in boys and girls (R=0.448, p=0.0001 and R=0.382, p=0.002, respectively). BUA values in boys tended to be higher than in girls, reaching significance only at the age of seven years with a 95% confidence interval. In conclusion, the measurement of BUA in the calcaneus with QUS has important clinical implications in assessing bone mass in children. Further studies in not only healthy children but also in those with metabolic bone diseases would be helpful in order to evaluate its sensitivity and reproducibility.

***Key words:** quantitative ultrasound, Turkish children.*

Priority should be given to the prevention of the development of osteoporosis, rather than to its treatment. Therefore bone status should be well determined in childhood. So far, it is a common opinion that osteoporosis is a childhood disease. In other words, an early determination of bone status in childhood might prevent osteoporotic complications later in life by modifying environmental factors[1]. Peak bone mass (PBM), defined as the amount of bone tissue present at the end of skeletal maturation, is one of the most important determinants of developing osteoporsis and future fractures[2]. PMB is primarily determined genetically; however, its extent is influenced by environmental factors like nutritional habits and physical exercise[3-5]. Quantitative ultrasound (QUS) is a noninvasive and radiation-free technique for determining bone density and for quality assessment, by measuring the ultrasound waves attenuation by bone, termed broadband ultrasonic attenuation (BUA)[6,7]. Advantages of QUS portability, ease of use, lower cost, and absence of radiation make it useful for screening studies[8]. It has been emphasized in some studies that although QUS is the newest acceptable technique for assessing bone mass in adults, far less is known about the value of calcaneal ultrasound in children[9]. To date, there are only a few published studies in Turkish children providing normative ranges for BUA and there is no published data on bone status.

The purpose of our study was to evaluate bone status in a group of healthy Turkish children with the measurement of BUA in the calcaneus and to explore its correlation with demographic variables.

Material and Methods

One hundred and forty-one healthy school-children from two different primary schools in İstanbul were enrolled in the study. The study was approved by the local ethic committee and written consent was obtained from the parents and verbal consent from the children. Students and their parents were informed about the study by teachers. A detailed questionnaire form including personal data was completed by the parents. Height of the children was measured in centimeter and weight in kilogram. Height was measured to the nearest millimeter using a wall mounted height measuring tape. Children were weighed to the nearest 0.5 kilogram, dressed but without shoes.

We used a prototype Pediatric Contact Ultrasound Bone Analyzer (CUBA) (Cuba Clinical, McCue Ultrasonic Ltd., Winchester, England) as a QUS device. We assessed bone status with the measurement of broad band ultrasound attenuation (BUA: db/MHz) in the calcaneus.

After ultrasonic coupling jelly was applied, the transducers were placed on either side of the left heel. The BUA (in decibels per megahertz) was measured in triplicate at the calcaneus. The mean value of three measurements was calculated and accepted.

In vitro and in vivo coefficient of variation for the pediatric CUBA were 1.7 and 5%, respectively. All measurements were performed by the same operator.

Statistical Analysis

Arithmetic average was calculated by standard deviation, standard mistake and frequency statistics. For comparison of groups a confidence interval (CI) (with confidence limits of 95%) was used. To determine correlation between age, weight, height, body mass index (BMI) and BUA, curve estimation was performed with SPSS for Windows (version 10.0) program. The best fit was obtained with a linear regression.

Results

Demographic features of the entire cohort are presented in Table I.

With respect to gender, although BUA in boys tended to be higher at each age, there was a statistically significant difference only at seven years of age with a 95% CI.

Mean BUA values of the children are shown in Table II. The relationship between BUA and gender is presented in Fig. 1.

Broad band ultrasound attenuation values showed an increase with age. There was a

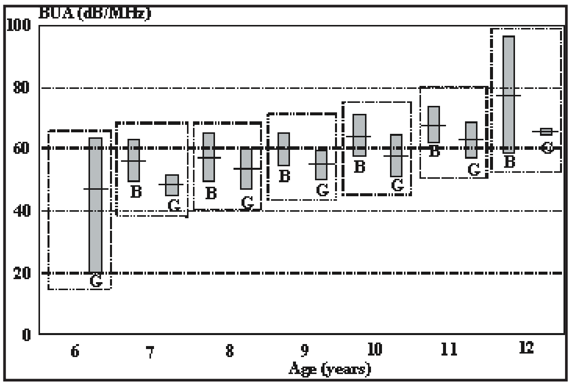

Fig. 1. The relationship between broadband ultrasound attenuation (BUA) and gender (B: Boys, G: Girls).

Table I. Distribution of Demographic Features by Ages in Boys and Girls (mean+SE)

Gender	Age (Year)	N (%)	Height (cm)	Weight (kg)	BMI
Boys	7.0-7.9	15 (24.6)	119.2 (1.09)	22.3 (0.60)	15.7 (0.29)
	8.0-8.9	11 (18.0)	126.2 (1.30)	24.8 (1.03)	15.5 (0.44)
	9.0-9.9	11 (18.0)	133.0 (1.15)	30.1 (0.88)	17.0 (0.28)
	10.0-10.9	11 (18.0)	133.9 (1.58)	31.4 (1.32)	17.4 (0.48)
	11.0-11.9	10 (16.4)	143.1 (1.67)	35.7 (1.57)	17.4 (0.59)
	12.0-12.9	3 (4.9)	145.0 (2.31)	36.0 (0.57)	17.1 (0.73)
	Total	61 (100)	130.7 (1.24)	28.6 (0.78)	16.5 (0.20)
Girls	6.0-6.9	4 (5.0)	116.5 (2.32)	21.0 (1.78)	15.5 (1.41)
	7.0-7.9	14 (17.5)	119.0 (1.25)	21.9 (0.62)	15.5

Table II. Mean BUA Values in Boys and Girls by Age

	Boys		Girls	
Age (year)	Mean	CI (95%)	Mean	CI (95%)
6.0-6.9	–	–	47.00	20.18-63.81
7.0-7.9	55.93	49.30-62.57	48.14	44.88-51.41
8.0-8.9	56.82	48.81-64.83	52.90	46.51-59.29
9.0-9.9	59.27	53.72-64.82	54.26	49.66-58.87
10.0-10.9	63.54	56.59-70.50	56.73	49.94-63.51
11.0-11.9	67.00	60.94-73.06	61.79	56.14-67.43
12.0-12.9	76.34	57.18-95.48	64.34	63.68-64.99

BUA: broadhand ultrasound attenuation, CI: confidence interval.

linear correlation between BUA and age in both girls and boys (R=0.448, p=0.0001, F=19.54, Sig F=0.0001, bo=27.082, Sig. Bo=0.0001, b1=3.239 Sig.b1=0.001; R=0.382, p=0.002, F=10.052, Sig F=0.002, bo=35.202, Sig. Bo=0.0001, b1=2.998 Sig.b1=0.002, respectively) (Fig. 2).

Some associations were also found between height, weight, BMI and BUA. After adjusting for age these associations disappeared in partial correlation test. According to partial correlation test there was no correlation between BUA and weight (Boys: R= -0.15, p=0.23, Girls: R=0.08, p=0.45). Likewise no correlation existed between BUA and height (Boys: R=0.04, p=0.71, Girls: R=0.04, p=0.69). The same results indicated that there was no correlation between BUA and BMI (Boys: R= -017, p=0.18, Girls: R=0.02, p=0.81). In other words, weight height and BMI as well as BUA increase with age in children. Therefore a correlation was detected between weight, height, BMI and BUA but it was of no clinical importance according to statistical correction.

Discussion

We evaluated bone mineral status in a group of Turkish children (aged 6-12 years) with the measurement of BUA in the calcanues using a quantitative ultrasound technique.

Broadband ultrasound attenuation (BUA) reflects density of bone on the one hand and its quality and architecture on the other[7,10,11]. A highly significant correlation between bone density and BUA was found by Laugier et al.[10]. Karlsson et al.[11] demonstrated that QuS measurements differed according to age and gender, suggesting that ultrasound may provide additional information on bone structure.

The clinical terminology of good bone quality does not always mean good bone mass. The first interesting finding of our study was a general higher trend of BUA measurement in boys than in girls. However it did not reach significance except at seven years of age. The influence of gender on bone mass in the prepubertal stage is still debated in the literature[12,13]. Although the difference between sexes is more marked at the cortical part of the skeleton, it should be noted that BUA values were obtained at the calcaneus which consists mostly of trabecular bone[3,14]. It has been reported that differences

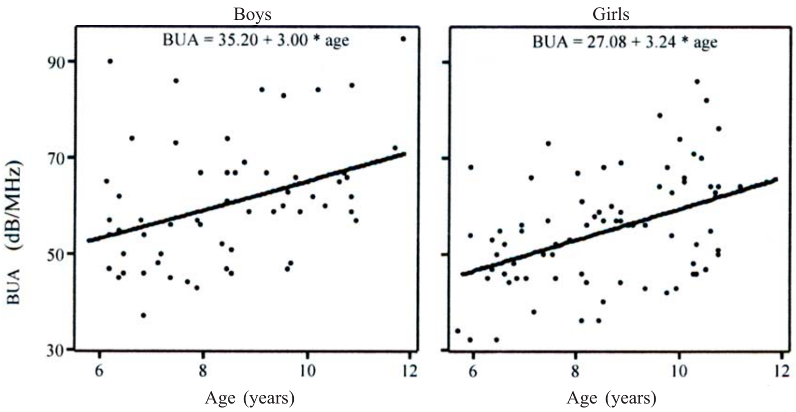

Fig. 2. The relationship between broadband ultrasound attenuation (BUA) and age in boys and girls.

in BUA by sex might be caused by the different onset of growth phases in boys and girls[15]. We believe the difference in BUA between genders cannot be explained with only one factor. This issue would be more clearly understood with longitudinal studies. Our data showed that BUA is associated with age rather than weight and height.

It has been reported that QuS is a useful measure to demonstrate physiological bone development in childhood and adolescence[15]. Our findings of a linear increase in BUA with age seven in such a relatively limited age group of children supported this statement. There have been other studies revealing an association between BUA and age. Mughal et al.[16] in their study evaluated 367 healthy white schoolchildren (193 girls, 174 boys) aged 6-15 years by BUA at the calcaneus. They found that mean BUA was significantly related to age, height and weight[16]. Sundberg et al.[17] in their study with ultrasound measurements on 260 healthy children aged 11-16 years found that all bone mineral variables in boys increased with age.

It should be borne in mind that bone in childhood is not stable as in adults. Bone mass is accumulated progressively from infancy through young adulthood and generally parallels linear growth. Thus a large percent of total skeletal mass is achieved during the adolescent growth spurt-an increase of approximately 8% per year. However the rate of increase in bone mineralization is much lower during the mid-childhood years than in adolescence and PBM is not reached until the middle part of the third decade of life[14,18].

The strong relationship between BUA and age might indicate that measuring BUA from childhood through early adulthood would make it possible to determine PBM, thus providing useful information for assessment of growth and development[19].

In Jones and Dwyer's[12] study on 330 children, anthropometrics, sunlight exposure and physical activity as well as bone density were evaluated. They found the magnitude of influence of both gender and environmental factors on PBM in adult life[12]. It is crucial to assess bone mass before achievement of PBM considering some environ-mental modifications such as dietary calcium supplementation, increased physical activity and sunlight exposure. Johnston et al.'s[20] study demonstrated that calcium supplementation over and above the recommended dietary allowance in prepubertal children led to an enhanced rate of increase in bone mineral density above a genetic threshold. There are also some studies showing the positive effect of physical activity on bone mass accumulation in children[21-24]. These indicate the importance of bone assessment especially in the prepubertal stage and should encourage screening studies in primary schools.

In conclusion, the measurement of BUA in the calcaneus with QUS has important clinical implications in assessing bone mass in children because of its speed, economy and lack of ionizing radiation. Further studies not only in healthy children but also in those with metabolic bone diseases would be helpful in order to evaluate its sensitivity and reproducibility.

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