

Advanced Bone Maturation and its Relation to Percent Overweight in Obese Japanese Children

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The prevalence of obesity in children has increased strikingly over the past two decades, presumably due to life style changes in Japan. We evaluated bone ages in obese children using the Tanner-Whitehouse 2 (TW2) bone age standard for Japanese children and analyzed the relation of bone maturation to percent overweight. A group of 207 obese children (130 boys and 77 girls, ranging in age from 3 to 16 years) was studied. Percent overweight ranged from 22.0-157.7% in boys and 23.7-105.4% in girls. Bone ages of both sexes were demonstrated to be advanced relative to chronological age and to correspond to height ages in young children (boys < 12.3 years old, girls < 10.5 years old). An advanced rate of radius, ulna and short (RUS), but not carpal (CARP), bone age was significantly correlated with percent overweight in both sexes ($r=0.345$ in boys, $r=0.594$ in girls) in the young group but only in girls ($r=0.364$) in the older group. The promotion of RUS bone maturation in obese Japanese children was demonstrated using the recently established TW2-Japanese method, and correlated significantly with percent overweight. The volume of body fat or factors secreted by adipose tissues are suggested to be associated with promoting RUS bone maturation in obese children.

Key words: obesity, bone age, percent overweight

Introduction

The prevalence of obesity in Japanese children has risen to approximately 10%, more than doubled, in the past 30 years. This extraordinary change in the prevalence of obesity may be due to drastic changes of life style in Japan, especially to adoption of the high fat, low fiber diet of the industrialized West, and inadequate exercise secondary to the development of modern conveniences which allow a lower total energy expenditure. Advanced bone age has been recognized in obese children¹⁾²⁾ using the well-established rating method of Greulich and Pyle (GP)³⁾, as well as by Tanner (Tanner-Whitehouse 2, TW2)⁴⁾. It is well known that obese children experience augmented bone maturation that accounts for a tall prepubertal stature in Caucasians.

However, this obesity-related phenomenon has not been confirmed in Japanese children, because a

standard for assessment of bone maturation has not been available. The bone age in Japanese children has been evaluated using standards for Caucasians, TW2 and GP. The TW2 and GP methods were established in the 1950s in the UK, and in the 1930s in the USA, respectively. Japanese girls were demonstrated to show earlier maturation than girls in the UK in the 1960s, Belgium in the 1970s, Spain in the 1980s, and the USA in the 1980s⁵⁾. Clearly, it is not possible to assess the bone age of Japanese children precisely using the original TW2 and GP methods due to racial differences as well as the aforementioned secular trends.

In the present study, we evaluated the bone ages of obese children, using the recently established TW2 bone age standard for Japanese children (TW2-Japanese)^{6)~8)}, to elucidate the issue of bone maturation in these children. The TW2-Japanese was derived from the original TW2 by investigating

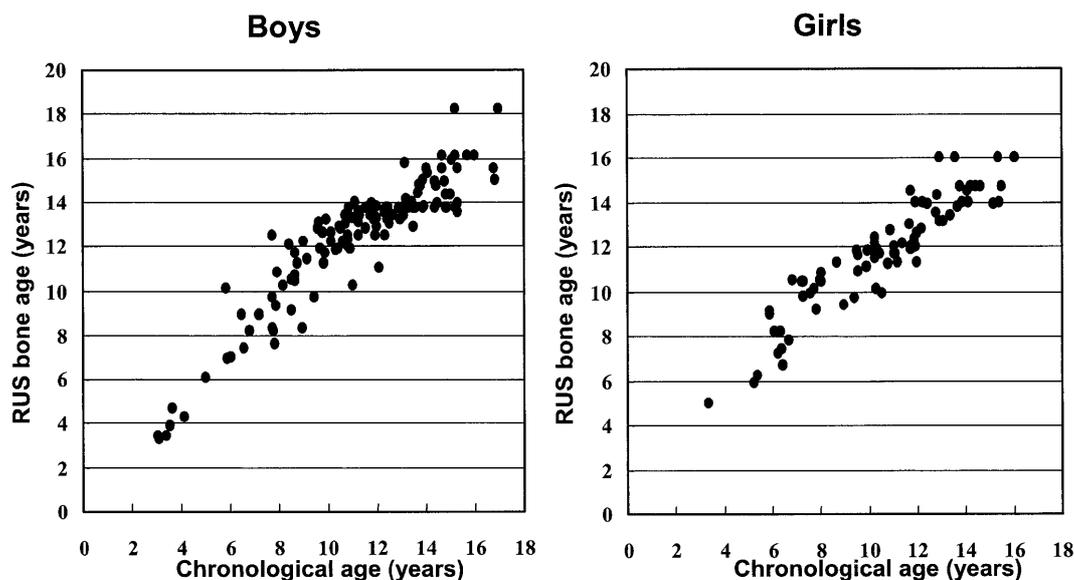


Fig. 1 Relation between chronological age and RUS bone age in obese boys (left) and girls (right)

RUS bone ages were advanced compared with the chronological ages in 84.6% of the obese boys and 90.9% of the obese girls.

hand X-ray films taken from 1,457 Japanese children (753 boys and 704 girls) in 1986.

In addition, we focussed on the relation between advanced bone maturation and body fat. We analyzed the associations of an advanced rate of bone maturation with percent overweight (relative body weight).

Subjects and Methods

A total of 207 Japanese children with simple obesity (130 boys and 77 girls) who visited our clinic from 1992 to 1999, were studied. We excluded obesity attributable to medicine (e.g. prednisolone) or primary disease (e.g. Cushing's syndrome, diabetes mellitus). The subjects' chronological ages ranged from 3 to 16 years.

Percent overweight, which ranged from 22.0-157.7% in boys and 23.7-105.4% in girls, was determined using the Japanese standard body weights for height by age and sex (standard weight)⁹ as follows, (actual body weight - standard weight)/standard weight $\times 100$ (%). The subjects were divided into young and older groups, based on an age of 12.3 years in boys and 10.5 years in girls. These are the median ages of sesamoid bone appearance near the first metacarpal in Japanese¹⁰.

Bone age was assessed according to the TW2-

Japanese method, which has been standardized for Japanese^{6,7}. The radius, ulna and short (RUS) bone ages, the carpal (CARP) bone age and their sum (20-Bone) were assessed. Bone age rate was calculated as follows, (bone age - chronological age)/chronological age $\times 100$ (%).

This study was carried out in accordance with the principles of the Declaration of Helsinki. Informed consent was obtained from each subject or his/her parents.

The data were analyzed using Statview 4.5 (Abacus Concepts Inc., Berkeley, CA). Values of $p < 0.05$ were considered significant.

Results

RUS bone age was demonstrated to be advanced compared with chronological age in 84.6% of 130 obese boys and 90.9% of 77 obese girls. Fig. 1 shows the relation between RUS bone age and chronological age. Advanced ($>20\%$) RUS bone age was found in 28.5% of obese boys and 31.2% of obese girls.

Body height SD scores at each chronological age of obese boys and girls are shown in Fig. 2. In the young group, body height SD scores were apparently higher (mean SDS, boys: 1.25, girls: 1.48), than those in the older group (mean SDS, boys: 0.03, girls: 0.38). Body height SDS correlated significantly with

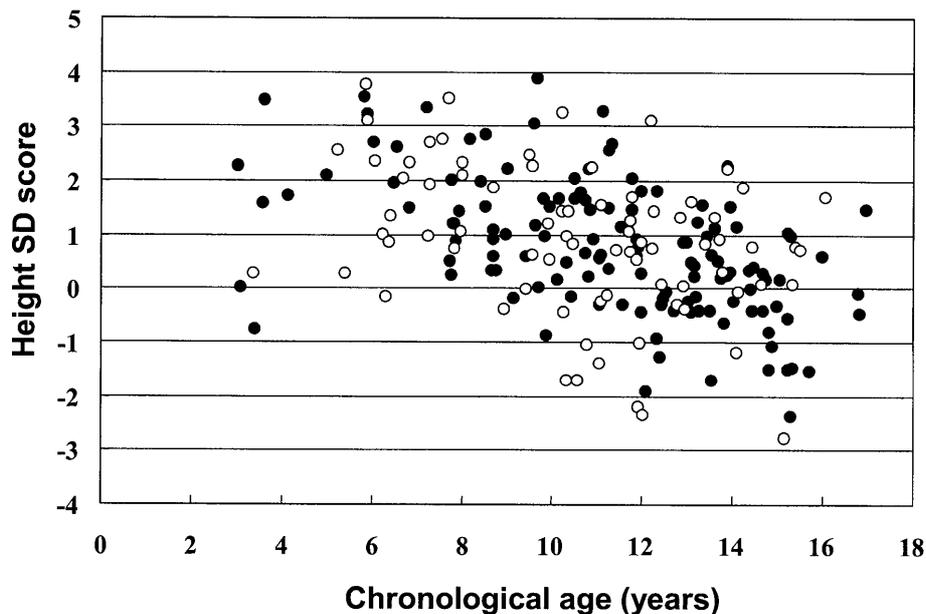


Fig. 2 Body height SD score at each chronological age in obese boys (●) and girls (○). In the young group (boys < 12.3 years old, girls < 10.5 years old), height SD scores were relatively high (mean SD score, boys: 1.25, girls: 1.48). However, in the older group height SD scores were not high (mean SD score, boys: 0.03, girls: 0.38).

chronological age in boys ($r = -0.521$, $p < 0.0001$), and girls ($r = -0.359$, $p = 0.001$). In the young group, body height SDS correlated significantly with chronological age in boys ($r = -0.259$, $p < 0.05$), but not in girls. In the older group, body height SDS did not correlate with chronological age in either sex. Final heights of obese children are suggested to not be particularly elevated despite the greater height SDS in the young group.

RUS bone age (y) correlated significantly with height age (x), nearly equaling height age in the young group for both sexes (boys: $y = 1.0x + 0.19$, $r = 0.918$, $p < 0.01$; girls: $y = 0.87x + 1.58$, $r = 0.913$, $p < 0.01$), but not in the older group (boys: $y = 0.38x + 9.11$, $r = 0.499$, $p < 0.01$; girls: $y = 0.27x + 9.67$, $r = 0.526$, $p < 0.01$).

The relation between an advanced bone age and relative body weight was analyzed. In the young group, an advanced rate of RUS and 20-Bone bone age correlated significantly ($p < 0.01$) with percent overweight in both sexes (Table, Fig. 3). In contrast, CARP bone age did not correlate, with relative body weight in either (Table). In the older group, an advanced rate of RUS and 20-Bone bone age correlated significantly ($p < 0.05$) with percent overweight only in girls (Table). It is noteworthy that

the correlations of RUS and 20-Bone with percent overweight, in the young group, were stronger in girls than in boys (Table).

Discussion

The recently established Japanese-standardized TW2 method was used for the evaluation of bone maturation in obese Japanese children in the present study. We have shown RUS bone age to be more advanced than chronological age and nearly the same as height age in the young group. Furthermore, we have shown that an advanced rate of RUS and 20-Bone bone age correlated significantly with percent overweight in the young group, while CARP bone age did not. These differences in maturation rates among RUS, 20-Bone and CARP are of interest. Our results were consistent with those of Polito et al, who reported CARP bone age to be less sensitive than RUS bone age to factors promoting early skeletal maturation in obese Italian children¹¹.

Our results suggest that higher adiposity indices promote more advanced bone maturation in the young children. There may be a physiological connection between the promotion of skeletal bone maturation and fat volume and/or hormonal fac-

Table Relation between relative body weight and advanced rate of TW2-Japanese bone age

TW2 bone age	Young Group				Older Group			
	Boys (n = 75)		Girls (n = 36)		Boys (n = 55)		Girls (n = 40)	
	r	p value	r	p value	r	p value	r	p value
RUS	0.345	p < 0.01	0.594	p < 0.01	0.031	NS	0.364	p < 0.05
CARP	0.077	NS	0.232	NS	0.094	NS	0.337	NS
20-Bone	0.335	p < 0.01	0.551	p < 0.01	0.144	NS	0.352	p < 0.05

The subjects were divided into two groups according to age: 12.3 years in boys and 10.5 years in girls. These are the median ages of sesamoid bone near the first metacarpal. NS: not significant.

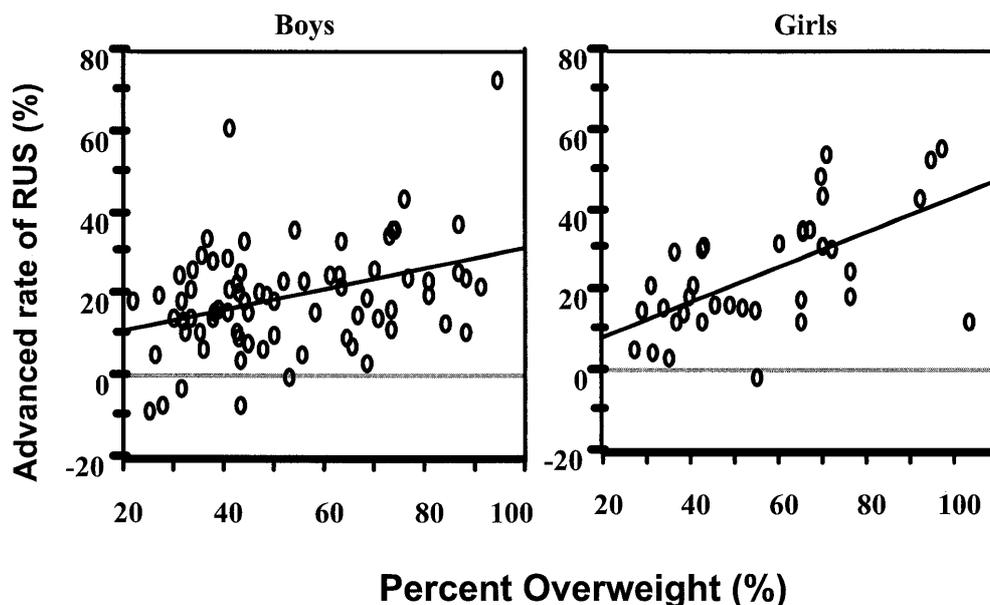


Fig. 3 Correlation between an advanced rate of RUS bone age and the percent overweight in the young group

There was a significant positive correlation in both boys ($r=0.345$, $p < 0.01$) and girls ($r=0.594$, $p < 0.01$).

tors, such as leptin, produced by adipose tissues. Studies in normal weight and obese humans have confirmed that serum leptin concentrations accurately reflect body mass index and percent body fat^{12)~14)}. In our preliminary data, serum leptin levels correlated significantly with percent overweight ($r=0.465$, $p < 0.005$) of 42 obese children in this study. These advanced rates of RUS bone age correlated significantly with serum leptin concentrations ($r=0.326$, $p < 0.05$), in contrast that advanced rates of CARP bone age did not correlate with serum leptin levels ($r=0.045$, $p=0.781$) (data not shown). But further study is needed to discuss on the relation of advanced bone maturation and leptin produced by adipose tissue.

Several hormones including GH, thyroid hor-

monone, estrogen and androgens, play roles in the growth and maturation of bones. GH secretion is reportedly reduced in obese children, despite their accelerated growth¹⁵⁾. The action of estrogen has been suggested to be critical for bone maturation in both sexes¹⁶⁾.

Our observations that bone maturation correlates with percent overweight may raise the following possibilities. ① The leptin level may correlate only with fat volume, which would account for aromatase activity producing estradiol in adipose tissues¹⁷⁾ in prepubertal children. ② Leptin stimulates gonadotropin-gonadal axis through the hypothalamus¹⁸⁾¹⁹⁾ thereby raising estrogen levels in prepubertal children. ③ Leptin itself or other factors secreted from adipose tissues may affect the

growth factors that subsequently promote bone maturation. For instance hyperinsulinemia in insulin resistance, induced mainly by TNF- α secreted from adipose tissues²⁰⁾, leads to the elevation of IGF-I which in turn promotes bone growth and maturation¹⁵⁾. Further studies are needed to evaluate the roles of compounds in bone growth and maturation.

In conclusion, the early promotion of body height growth along with skeletal bone maturation was demonstrated in obese Japanese children using the recently established TW2-Japanese method. RUS bone maturation in obese children was found to be related to percent overweight, suggesting the volume of body fat or factors secreted by adipose tissues are suggested to be associated with promoting RUS bone maturation in obese children.

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日本人肥満小児における骨成熟の促進—肥満度との関連についての検討

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三浦	直子	・金	恵淑	・池崎	綾子	・岩間	彩香
スガワラ	ヒサエ	マツオカ	ヒサフミ	スギハラ	シゲタカ		
菅原	久江	・松岡	尚史	・杉原	茂孝		

当科外来を受診した 207 人の肥満小児（男子 130 人，女子 77 人，3～16 歳，肥満度 22.0～157.7%）の骨年齢を日本人標準化 Tanner-Whitehouse 2 (TW2) 法を用いて評価した。20-Bone 法，RUS 法による骨成熟促進度は低年齢群では男女ともに肥満度と正の相関関係にあったが，高年齢群では女子でのみ正の相関関係がみられた。また Carpal 法では低年齢群でも相関関係はみられなかった。暦年齢と身長 SD スコアによる検討では低年齢群では標準体型の児にくらべて高身長であったが，高年齢群ではその傾向はなかった。肥満小児における骨年齢の促進現象の機序は不明であるが，肥満度との相関が強いことから，体脂肪量の影響，すなわち脂肪細胞の分泌するホルモンなどの関与が示唆され今後の検討が期待される。