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Skeletal maturity and socio-economic status in Portuguese children and youths: the Madeira Growth Study

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Summary. *Background*: Skeletal maturity is used to evaluate biological maturity status. Information about the association between socio-economic status (SES) and skeletal maturity is limited in Portugal.
Aims: The aim of this study is to document the skeletal maturity of youths in Madeira and to evaluate variation in maturity associated with SES.
Subjects and methods: The study involved 507 subjects (256 boys and 251 girls) from the Madeira Growth Study, a mixed-longitudinal study of five cohorts (8, 10, 12, 14 and 16 years of age) followed at yearly intervals over 3 years (1996–1998). A total of 1493 observations were made. Skeletal age was estimated from radiographs of the hand and wrist using the Tanner–Whitehouse 2 method (TW2). Social class rankings were based on Graffar's (1956) method. Five social rankings were subsequently grouped into three SES categories: high, average and low.
Results: Median for the radius, ulna and short finger bones (RUS scores) in the total sample of boys and girls increased curvilinearly across age whereas median for the 7 (without pisiform) carpal bones (Carpal scores) increased almost linearly. The 20-bone maturity scores demonstrated distinctive trends by gender: the medians for boys increased almost linearly while the medians for girls increased curvilinearly. SES differences were minimal. Only among children aged 10–11 years were high SES boys and girls advanced in skeletal maturity. Madeira adolescents were advanced in skeletal maturity compared with Belgian reference values.
Conclusion: The data suggests population variation in TW2 estimates of skeletal maturation. Skeletal maturity was not related to SES in youths from Madeira.

1. Introduction

The Tanner–Whitehouse 1 and 2 methods (TW1 and TW2) for assessing skeletal maturity (Tanner *et al*. 1962, 1975, 1983) have been widely used in several European countries with a twofold purpose: (1) to construct reference values, and (2) to quantify possible differences in biological maturation among populations. Swedish children, for example, were advanced from 1 to 7 years of age in comparison with the British reference (Taranger *et al*. 1976). Dutch boys (Van Venrooij-Ysselmuiden and Van Ipenburg 1978) showed a delay in radius, ulna and short finger bones (RUS)

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and TW2 20-bone (RUS plus carpal bones) scores from 8 to 13–14 years, and thereafter a little advancement until 17, whereas girls showed a delay to the age of 10–11 years, followed by advancement until 15, and then a delay at 16–17 years compared to the British reference. In another study of Dutch children, mean bone ages were similar to or slightly ahead of the British reference from 4 to 8.5 years and delayed from 9 to 14 years (Prahl-Andersen and Roede 1979).

Danish data (Wenzel and Melsen 1982) also indicated a delay in boys until the age of 13, followed by an advantage up to 15, and equal scores to the British reference at 16 years of age; Danish girls were slightly delayed in TW2 20-bone scores until 11 and were then advanced to 15 years, while mean RUS bone ages were nearly similar to the reference until 10 and shifted to slight advancement to 15 years. Austrian boys (Wenzel *et al.* 1984) were also delayed compared with the British reference in the TW2 20-bone scores from 7.5 to 15.5 years. Girls were somewhat behind the British reference until 8.5 years and subsequently were advanced to 14.5 years. Boys from the Brussels longitudinal study were delayed compared with the British reference (Susanne *et al.* 1986). However, Belgian boys from the Leuven Growth Study (Beunen *et al.* 1990) were advanced in RUS scores and delayed for Carpal scores (7 carpal bones without pisiform) compared with the British reference. In contrast, girls showed an advantage for TW2 20-bone and RUS scores. It is generally assumed that genetic and environmental factors contribute to the differences between specific groups.

The association between socio-economic status (SES) and skeletal maturity has been investigated in several European countries to a lesser extent. Inconsistent associations have been noted between SES and skeletal maturity in several populations. A positive secular trend in skeletal maturity has also been identified (Beunen *et al.* 1990, Eveleth and Tanner 1990). In the context of population, SES and secular variation, Tanner *et al.* (1983) have suggested that each country should develop reference values and revise them periodically. Skeletal maturity information for Portugal are limited. Hence, this study has two objectives: (1) to provide reference data on skeletal maturity in youths from Madeira, and (2) to investigate variation in skeletal maturity associated with SES.

2. Subjects and methods

2.1. Sample

Children and adolescents comprising the sample are from the Madeira Growth Study. The study was approved by the Medical Ethics Committee of the University of Madeira, and written permission from the parents was also given for their children to participate in the study. The Madeira Growth Study is a mixed-longitudinal design with five birth cohorts (8, 10, 12, 14 and 16 years of age) observed at yearly intervals in 1996, 1997 and 1998 and four overlapping ages (10, 12, 14 and 16 years). Subjects were selected with a stratified sampling procedure with the number of districts, the educational level and school facilities as stratification factors. Overall, 36 schools were sampled in the 11 districts of the Autonomous Region of Madeira. In total, 507 subjects (256 boys and 251 girls) participated in the project. In the first year 8-, 10-, 12-, 14- and 16-year-old subjects were evaluated. The following year included the same individuals at the ages of 9, 11, 13, 15 and 17 years. In the final year the same subjects were observed at 10, 12, 14, 16 and 18 years. Thus, within the 3-year period data were collected across 8–18 years.

Table 1. Sample size and mean chronological age of boys and girls stratified into three SES groups.

Chronological age (years)	SES group						
	n	High (1)	*n*	Average (2)	*n*	Low (3)	Total
Boys							
7–9	76	8.71	68	8.87	35	8.85	179
10–11	51	11.15	67	11.07	30	11.17	148
12–13	74	13.04	58	13.07	27	13.09	159
14–15	70	15.01	61	15.07	21	15.03	152
16–18	44	17.03	49	16.96	24	17.03	117
Total	315		303		137		**755**
Girls							
7–9	70	8.75	70	8.80	35	8.89	175
10–11	45	11.14	59	11.07	37	11.00	141
12–14	66	13.33	112	13.59	40	13.49	218
15–18	50	16.45	116	16.36	38	16.25	204
Total	231		357		150		**738**
Grand total	546		660		287		**1493**

A cross-sectional analysis was carried out for the present study. Observations for 1470 youths were used to construct skeletal maturity percentile curves from 8 to 17 years (subjects at the ages of 7 and 18 were excluded because of reduced numbers). However, in the analysis of SES-associated variation in skeletal maturity the total sample of 1493 individuals was used. Mean chronological age by age group, sex and SES is reported in table 1.

2.2. *Assessment of skeletal maturity and observer agreement*

Skeletal age was estimated using the Tanner–Whitehouse method (TW2) (Tanner *et al.* 1983). Radiographs were taken of the left hand and wrist of each child in the 3 years with a portable X-ray device designed after Greulich and Pyle (1959).

Members of the Madeira research team (António Rodrigues, Celso Silva and Duarte Freitas) were instructed by Gaston Beunen in the TW2 method and subsequently did an intra- and inter-observer reliability study. After the instruction period, 50 X-rays of the Leuven Growth Study of Belgian Boys (Ostyn *et al.* 1980) were assessed twice by the members of the Madeira team within a 15-day interval. Ratings were compared with those of the experienced assessor. Inter-observer agreement between the Madeira team and the experienced assessor was 81.3%, but there was a variation among individual bones ranging from 66% (middle phalange of the fifth finger) to 92% (scaphoid). The overall intra-observer agreement for the Madeira team was 91.8% with a range of 84% (first metacarpal) to 100% (proximal phalange of the thumb). In case of disagreement between ratings, the difference was virtually always one stage. A two-staged difference was observed only in four cases for the first, third and fifth metacarpals.

SES was based on *Census 91* (Instituto Nacional de Estatística 1995). Five characteristics (parental occupation, education, income, housing, and residential area features) were used and each was rated on a five-unit scale. The social stratification framework of Graffar (1956) was used, but the five social rankings were combined in three categories: high, average and low. Rankings one and two were grouped into the highest SES, ranking three into the average SES, and rankings four and five in to the lowest SES.

Allowing for variation in the number of subjects by SES, the sample was combined by age into several groups: boys 7–9, 10–11, 12–13, 14–15 and 16–18; girls 7–9, 10–11, 12–14 and 15–18 (table 1). ANOVA was used to test for differences in skeletal maturity by SES within each sex by age group. *Post hoc* analysis was carried out using Tukey comparisons.

2.3. Smoothing percentile curves (RUS, Carpal and TW2 20-bone)

The smoothing procedure for the 10th, 50th and 90th percentile curves was carried out in two successive steps. First, the original values for P10, P50 and P90 were smoothed by eye with a graphical fitting procedure. Second, freehand software tools (8.6.0 version, Macromedia 1988–1998) were used to fit the final curves.

3. Results

3.1. Skeletal maturity

Figures 1 and 2 illustrate the smoothed percentiles for RUS (a), Carpal (b) and TW2-20 bone (c) scores in the total sample of boys and girls, respectively. RUS median scores increase curvilinearly from 8 to 16 years in boys (figure 1a). Carpal median scores reach the adult maturity at the age of 15.0 years (figure 1b). Median Carpal scores increase rather sharply from 8 to 10 years, and then show a lesser, but almost linear increase. The increase in median TW2 20-bone scores (figure 1c) is similar to that of the Carpals, but there is a curvilinear increase from 8 to 11 years of age and then a linear increase to the maximum score at 16.1 years.

In girls, RUS median scores reach the highest value at 15.2 years of age (figure 2a). The scores increase curvilinearly, gradually between 8 and 11 years and then more steeply. Median Carpal scores increase linearly between 9 and 12.9 years of age. At

(a)

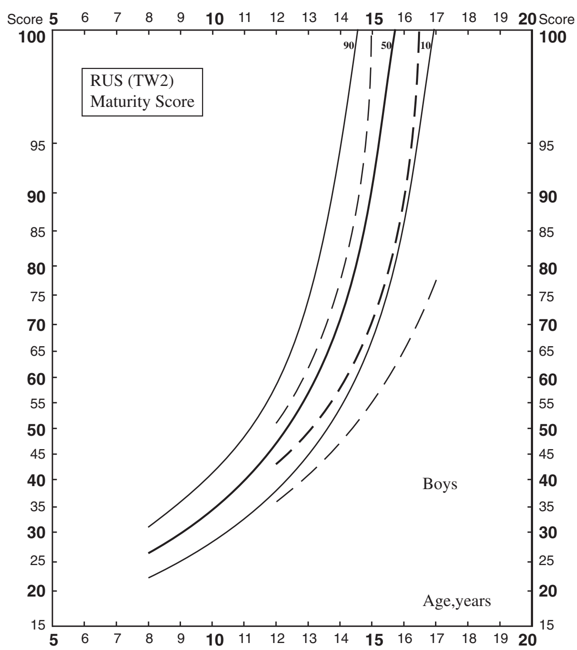
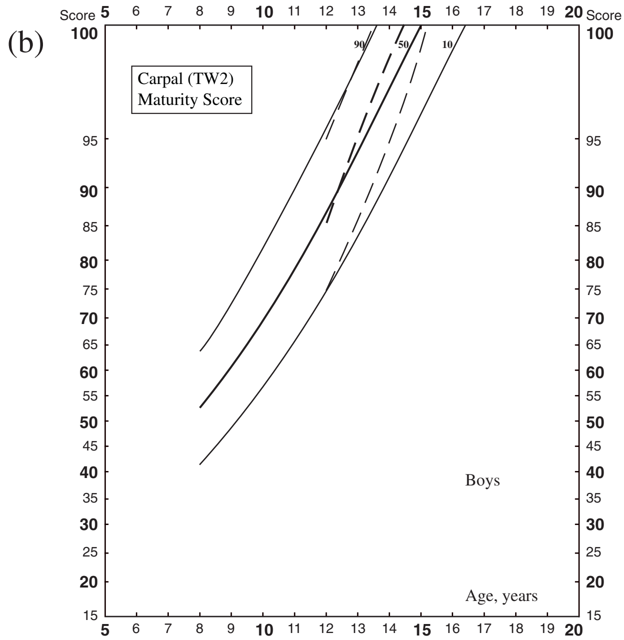


Figure 1. Comparison of 10th, 50th and 90th percentiles in boys from Madeira (——) and the Belgian reference (----) (Beunen *et al.* 1990): RUS (a), Carpal (b) and TW2 20-bone (c) scores.



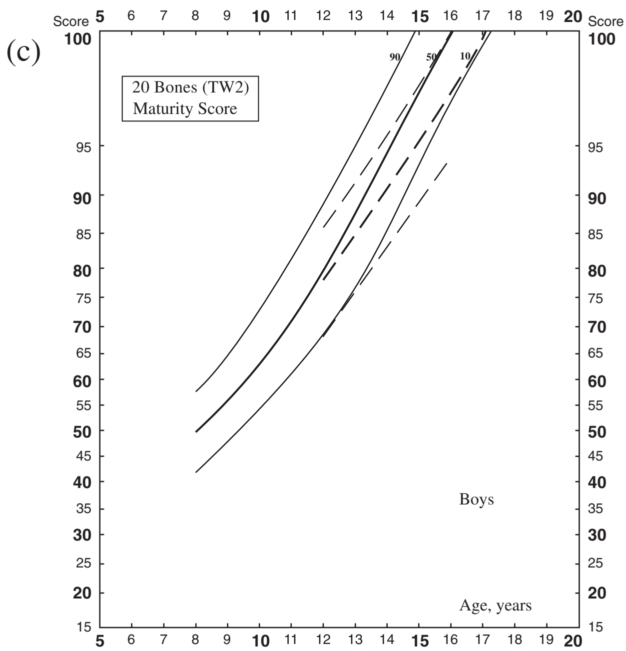


Figure 1. Continued.

this age the maximum score is attained by 50% of girls (figure 2b). TW2 20-bone scores rise curvilinearly with a steep increase between 8 and 12 years and a more gradual increase thereafter (figure 2c).

Median skeletal maturity scores for Belgian boys and girls are also included in the figures. Median RUS scores of boys from Madeira are higher at all ages than those of Belgian boys (Beunen *et al.* 1990). Between 13 and 15 years of age P50 values of Madeira boys are close to P90 values of Belgian boys. Likewise, P10 values are closer to Belgian P50 values. In contrast, Carpal scores of Madeira boys show a delay compared with Belgian boys at most ages. TW2 20-bone scores demonstrate the

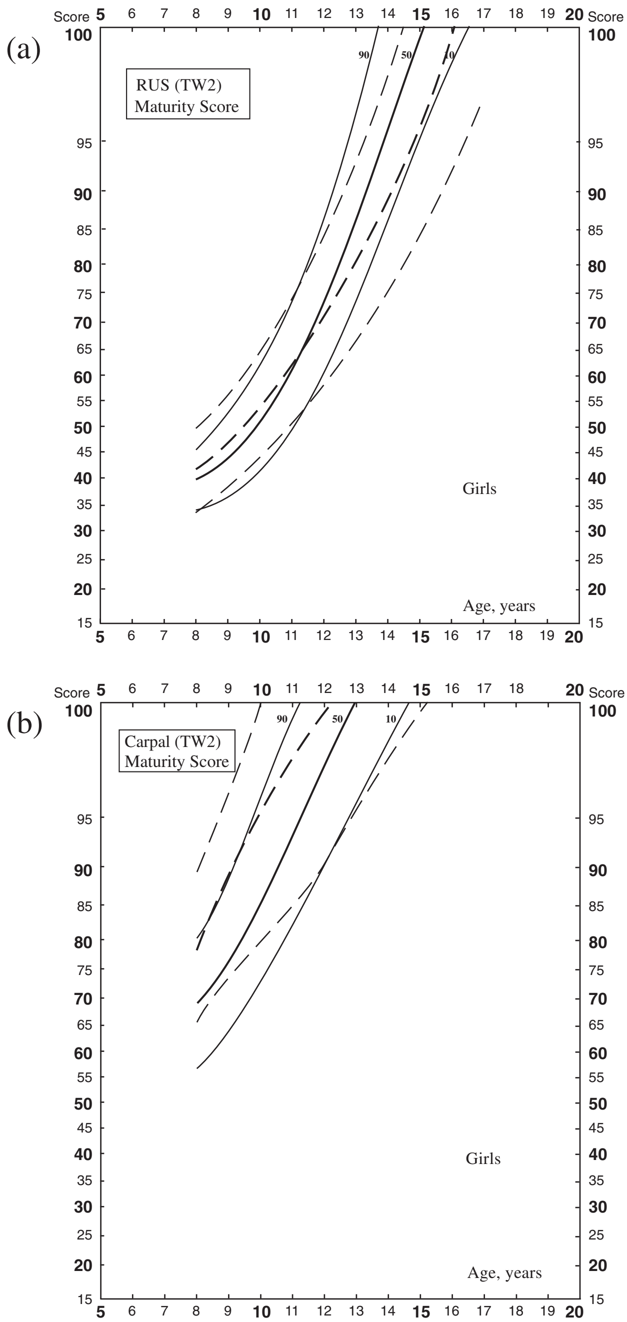


Figure 2. Comparison of 10th, 50th and 90th percentiles in girls from Madeira (——) and the Belgian reference (- - - -) (Beunen *et al.* 1990): RUS (a), Carpal (b) and TW2 20-bone (c) scores.

(c)

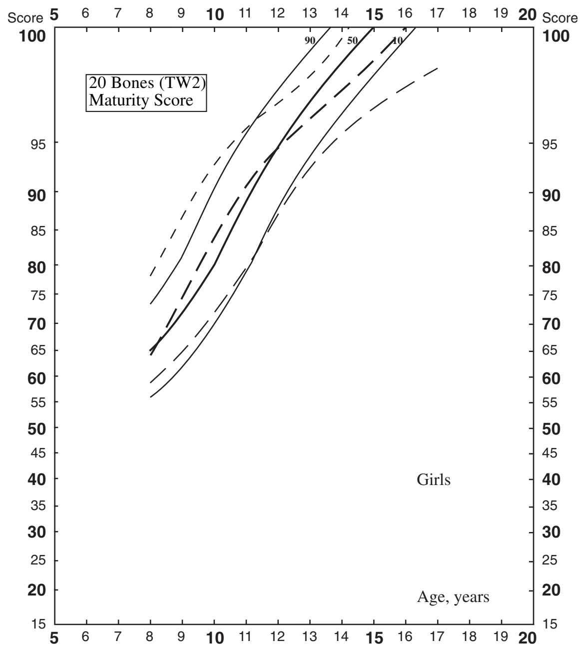


Figure 2. Continued.

same differentiation as the RUS scores. At the age of 12, P10, P50 and P90 values of Madeira boys are almost identical to those of Belgian boys, subsequently, Madeira P10 values show a displacement towards the Belgian P50 values, and the Madeira P50 values move toward the Belgian P90 value.

Madeira girls show a delay in median RUS scores compared with Belgian girls to 11.2 years of age (Beunen *et al.* 1990). From this age onward, the median RUS values move to the Belgian P90, and achieve maturity 1 year earlier. After 11 years the P10 values for Madeira girls shift towards the medians, and in turn, P90 values reach maturity about 0.8 years earlier than Belgian P90 values. In contrast, median Carpal scores for Madeira girls show a delay at all ages compared with Belgian girls. Between 8 and 9.4 years Madeira median values are fairly close to Belgian P10 values. Subsequently, the medians gradually shift to Belgian P50 values, and attain maturity at about 0.8 year later. Median TW2 20-bone scores of Madeira girls are similar at 8 years, but are then delayed to 12 years. Median scores then show a slight advance over Belgian girls.

3.2. SES variation in skeletal maturity

Chronological ages do not differ by SES in each of the age-by-sex categories (table 1; $0.08 < F < 2.03$; $0.13 < p < 0.92$). Mean skeletal maturity scores and skeletal ages for Madeira youths stratified by SES are summarized in table 2. SES differences in skeletal maturity are significant only among 10–11-year-old boys and girls.

4. Discussion

The present analysis indicates relatively large differences in skeletal maturity between Madeira and Belgian boys and girls. Since intra- and inter-observer agreement is fairly high, the differences probably do not reflect methodological vari-

Table 2. Skeletal maturity scores and skeletal ages for RUS, Carpal and TW2 20-bone scores by sex, age and SES.

	Socio-economic group							
	High (1)		Average (2)		Low (3)			
Variables	Score*	Skeletal age	Score	Skeletal age	Score	Skeletal age	*p*	Contrast †
Boys								
7–9 years								
RUS	276.5	9.1	272.8	9.0	265.1	8.8	0.496	NS
Carpal	608.0	8.8	580.6	8.5	600.0	8.7	0.365	NS
TW2 20-bone	540.7	9.0	524.9	8.8	525.3	8.8	0.492	NS
10–11 years								
RUS	388.5	12.6	347.6	11.5	348.5	11.6	0.034	1 > 2
Carpal	807.1	11.0	733.0	10.1	768.1	10.5	0.007	1 > 2
TW2 20-bone	713.6	11.5	647.2	10.6	669.0	10.9	0.009	1 > 2
12–13 years								
RUS	561.2	14.8	550.6	14.7	491.7	14.2	0.118	NS
Carpal	927.4	12.7	904.9	12.3	910.3	12.4	0.277	NS
TW2 20-bone	860.6	13.7	839.8	13.4	821.0	13.1	0.185	NS
14–15 years								
RUS	827.9	16.5	865.1	16.7	784.9	16.2	0.133	NS
Carpal	990.3	14.2	988.2	14.1	984.2	13.9	0.633	NS
TW2 20-bone	966.9	15.9	969.0	16.0	955.5	15.6	0.469	NS
16–18 years								
RUS	978.0	17.6	989.8	17.7	995.8	17.9	0.207	NS
Carpal	1000.0	Adult	1000.0	Adult	1000.0	Adult	–	–
TW2 20-bone	996.8	17.5	998.5	17.7	999.4	17.1	0.194	NS
Girls								
7–9 years								
RUS	428.5	10.0	423.1	9.9	431.7	10.0	0.881	NS
Carpal	744.2	8.9	744.4	8.9	757.9	9.0	0.826	NS
TW2 20-bone	673.5	9.2	670.5	9.2	681.1	9.3	0.892	NS
10–11 years								
RUS	639.2	12.7	603.5	12.3	564.7	11.9	0.040	1 > 3
Carpal	920.7	10.6	894.1	10.2	869.1	10.0	0.052	NS
TW2 20-bone	871.0	11.4	839.2	10.9	808.8	10.6	0.036	1 > 3
12–14 years								
RUS	868.4	14.8	892.7	14.9	840.1	14.5	0.086	NS
Carpal	983.4	11.8	981.7	11.7	972.3	11.5	0.360	NS
TW2 20-bone	967.7	13.4	969.0	13.5	954.1	13.0	0.258	NS
15–18 years								
RUS	996.4	15.9	992.7	15.8	992.6	15.8	0.689	NS
Carpal	1000.0	Adult	999.0	12.9	999.4	12.9	0.334	NS
TW2 20-bone	999.5	Adult	998.0	15.7	998.4	15.7	0.427	NS

* Score = maturity score.
† Tukey test—*post hoc* procedure; NS = non-significant; 1 > 2 = differences between the highest and the average groups; 1 > 3 = difference between opposing groups (high and low).

ation. Baughan *et al*. (1979) reported a slight delay in TW2 20-bone scores in French–Canadian compared with British children (Tanner *et al*. 1983). However, the French–Canadian subjects showed a major advance in RUS scores and a delay in Carpal scores. Beunen *et al*. (1990) also demonstrated differences between Belgian and British youths. Belgian girls presented an advance in RUS scores at all ages from

6 to 15 years and in Carpal scores up to 11 years. Belgian boys showed an advance in RUS scores, but a delay in Carpal scores.

More recently, Ashizawa *et al.* (1996) have shown that the progress in RUS scores in Japanese children was faster during puberty compared with Indians (Prakash and Cameron 1981), British (Tanner *et al.* 1983), Belgian (Beunen *et al.* 1990) and Chinese children (Ye *et al.* 1992). Moreover, comparison among Argentinian, British, Spanish and Italian children led Lejarraga *et al.* (1997) to conclude that Argentinian children were more advanced than the British (Tanner *et al.* 1983) and to a lesser extent than the Spanish (Hernández *et al.* 1991). The skeletal maturity pattern of Argentinian children was generally closer to that of the Italians (Nicoletti *et al.* 1991).

Some of the observed trends in comparison of skeletal maturity between Madeira and Belgium children were also apparent in a Madeira–UK comparison. Madeira children achieved the adult stage of RUS scores approximately 2.4 years earlier in boys and 0.8 year in girls. In contrast, mature Carpal scores were attained at the same age in boys (15.0 year), but at a younger age in girls (12.9 year). TW2 20-bone scores showed the same trend as RUS scores; Madeira boys and girls reached maturity, respectively, about 1.9 years and 1 year sooner than the British. There was a closer correspondence in maturity status of youths from Madeira, Italy and Japan.

Beunen *et al.* (1990) suggested that secular changes in the populations studied over the last 40 years might underlie some of the variation contributing to the advance of Belgian compared with British adolescents. However, the authors also indicated that there is no firm evidence for a very recent secular acceleration in skeletal maturation. The issue of secular change in skeletal maturity in European and other populations needs further study.

The occurrence of a spurt in the RUS scores comparable to that of height and weight was reported in British children by Tanner *et al.* (1983). Yearly increments in the RUS scores for Madeira boys and girls are compared with other samples in figure 3. Estimates were obtained from mean scores at successive ages. The yearly increment curves are rather similar except that those for Madeira, Italian and Japanese children are displaced to the left corresponding

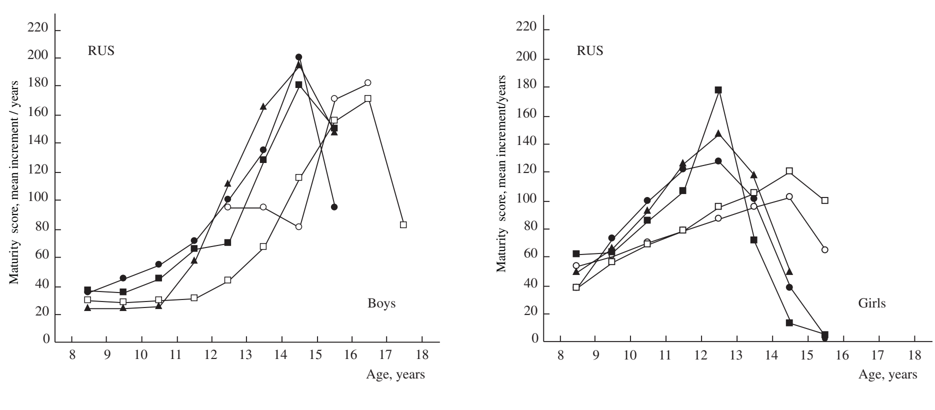


Figure 3. Mean yearly increments for RUS scores in children and youths: ○, Belgium (Beunen *et al.* 1990); □, UK (Tanner *et al.* 1983); ■, Italy (Nicoletti *et al.* 1991); ▲, Japan (Ashizawa *et al.* 1996); and ●, Madeira (current study).

approximately to a 2-year shift compared with Belgian and British children. The maximum velocity for Madeira boys is somewhat higher than those in the other samples. It is reached at 14.5 years of age whereas in Belgian and British boys the maximum is reached at 16.5 years. The Madeira, Italian and Japanese girls show a more marked acceleration from 8 years and reach a maximum at 12.5 years. The Belgian and British girls appear to reach a maximum velocity at 14.5 years of age.

Consistent with the findings by Baughan *et al.* (1979) and Beunen *et al.* (1990), youths from Madeira showed a delay in Carpal scores and advancement in RUS scores. The contrary direction of apparent population differences in Carpal and RUS scores has led Baughan *et al.* (1979) to propose that skeletal maturity should not be viewed as a single concept. Beunen (1975) identified three factors in skeletal maturity of the 20 bones in the hand and wrist: (1) skeletal maturity of the proximal secondary ossification centres; (2) skeletal maturity of the distal secondary ossification centres; and (3) skeletal maturity of the carpals. Each factor explained about the same percentage of the total variance in maturity scores of the 20 bones of the hand and wrist. Further, the three maturity factors were strongly correlated ($r = 0.85$–0.95). Drawing on these results Beunen (1975) and Beunen *et al.* (1990) suggested a common factor influencing the maturity status of the bones of the hand and wrist. The covariation among bones of the hand and wrist does not exclude the possibility that maturity levels in different regions (i.e. Carpals or RUS) can differ systematically.

Variation in skeletal maturity by SES was low in the Madeira sample. It is unclear why SES differences are present only in 10–11-year-old boys and girls. In the Leuven Growth Study of Belgian boys 12–19 years, degree of urbanization and parental employment were not associated with skeletal maturity, but from 15 years onwards urban boys were more advanced than rural boys (Renson *et al.* 1980). Andersen (1968) observed no association with the maternal employment status in a sample of 1009 Danish youths (477 boys and 532 girls 7–17 years). There was a tendency for the percentage of delayed children to increase with decreasing income, but the difference was not significant. Finally, a significant larger number of boys delayed in skeletal maturity was observed among those living in crowded flats. The same trend was apparent in girls, but it was not significant.

In summary, the current study provides reference data on the skeletal maturity status of youths from Madeira and demonstrates that the RUS and TW2 20-bone scores of Madeira children and adolescents are advanced compared to Belgian youths. Carpal maturity scores of Madeira youths show, on the other hand, a delay compared to the Belgian reference. The patterning of skeletal maturity in the Madeira youths appears to be similar to that of Italian, Japanese and Argentinian children and youths especially with regard to the more rapid progression during adolescence. SES-associated variation in skeletal maturity in Madeira youths is limited to the pre-adolescent years, but an explanation for this observation is not immediately apparent.

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References

Andersen, E., 1968, Skeletal maturation of Danish school children in relation to height, sexual development, and social conditions. *Acta Paediatrica Scandinavica Supplement*, **185,**, 102–115.

Ashizawa, K., Asami, T., Anzo, M., Matsuo, N., Matsuoka, H., Murata, M., Ohtsuki, F., Satoh, M., Tanaka, T., Tatara, H., and Tsukagoshi, K., 1996, Standard RUS skeletal maturation of Tokyo children. *Annals of Human Biology*, **23,** 457–469.

Baughan, B., Demirjian, A., and Levesque, G., 1979, Skeletal maturity standards for French–Canadian children of school-age with a discussion of the reliability and validity of such measures. *Human Biology*, **51,** 353–370.

Beunen, G., 1975, Skeletal maturation structure and a simplified Tanner, Whitehouse, and Healy method for boys aged 12 through 15. *Hermes*, **9,** 393–408.

Beunen, G., Lefevre, J., Ostyn, M., Renson, R., Simons, J., and Van Gerven, D., 1990, Skeletal maturity in Belgian youths assessed by the Tanner–Whitehouse method (TW2). *Annals of Human Biology*, **17,** 355–376.

Eveleth, P., and Tanner, J., Worldwide Variation in Human Growth. Second Edn (Cambridge: Cambridge University Press).

Graffar, M., 1956, Une méthode de classification sociale d'échantillons de population. *Courier*, VI: 8: 455–459.

Greulich, W., and Pyle, S., 1959, *Radiographic Atlas of Skeletal Development of the Hand and Wrist* (Stanford: Stanford University Press).

Hernández, M., Sánchez, E., Sobradillo, B., and Rincón, J., 1991, *Skeletal Maturation and Height Prediction: Atlas and Scoring Methods* (Madrid: Ediciones Diaz de Santos, SA).

Instituto Nacional de Estatística, 1995, *Antecedentes, Metodologia e Conceitos: Censos 91* (Lisboa: Instituto Nacional de Estatística).

Lejarraga, H., Guimarey, L., and Orazi, V., 1997, Skeletal maturity of the hand and wrist of healthy Argentinean children aged 4–12 years, assessed by the TWII method. *Annals of Human Biology*, **24,** 257–261.

Nicoletti, I., Cheli, D., Bufalini, G., Pandimiglio, A., Innocenti, P., and Vichi, G., 1991, *Crescita e Maturazione Scheletrica —Età Ossea e Predizione della Statura Adulta—a Cura di Ivan Nicoletti* (Florence: Edizioni Centro Studi Auxologici).

Ostyn, M., Simons, J., Beunen, G., Renson, R., and Van Gerven, D., 1980, *Somatic and Motor Development of Belgian Secondary Schoolboys: Norms and Standards* (Leuven: Leuven University Press).

Prahl-Andersen, B., and Roede, M., 1979, The measurement of skeletal and dental maturity. In *A Mixed-longitudinal Interdisciplinary Study of Growth and Development*, edited by B. Prahl-Andersen, C. Kowalski and P. Heydendael (New York: Academic Press), pp. 491–520.

Prakash, S., and Cameron, N., 1981, Skeletal maturity of well-off children in Chandigarh, North India. *Annals of Human Biology*, **8,** 175–180.

Renson, R., Beunen, G., De Witte, L., Ostyn, M., Simons, J., and Van Gerven, D., 1980, The social spectrum of physical fitness of 12 to 19 year-old boys. *Kinanthropometry II*. International Series on Sport Sciences, edited by M. Ostyn, G. Beunen and J. Simons (Baltimore: University Park Press), vol. 9, pp. 105–118.

Susanne, C., Hauspie, R., Gyenis, G., and Wachholder, A., 1986, Skeletal maturation in a longitudinal study of Belgian boys. *Anthropoligiai Közlemenyek*, **30,** 77–91.

Tanner, J., Whitehouse, R., and Healy, M., 1962, A new system for estimating skeletal maturity for the hand and wrist, with standards derived from a study of 2.600 healthy British children (Paris: Centre International de l'Enfance).

Tanner, J., Whitehouse, R., Cameron, N., Marshall, W., Healy, M., and Goldstein, H., 1983, *Assessment of Skeletal Maturity and Prediction of Adult Height (TW2 Method)* (Oxford: Academic Press).

Tanner, J., Whitehouse, R., Marshall, W., Healy, M., and Goldstein, H., 1975, Assessment of skeletal maturity and prediction of adult height (London: Academic Press).

Taranger, J., Bruning, B., Claesson, I., Karlberg, P., Landström, T., and Lindström, B., 1976, Skeletal development from birth to 7 years. *Acta Paediatrica Scandinavica Supplement*, **258,** 98–108.

Van Venrooij-Ysselmuiden, M., and Van Ipenburg, A., 1978, Mixed longitudinal data on skeletal age from a group of Dutch children living in Utrecht and surroundings. *Annals of Human Biology*, **5,** 359–380.

Wenzel, A., and Melsen, B., 1982, Skeletal maturity in 6–16-year-old Danish children assessed by the Tanner–Whitehouse-2 method. *Annals of Human Biology*, **9,** 277–281.

Wenzel, A., Droschl, H., and Melsen, B., 1984, Skeletal maturity in Austrian children assessed by the GP and the TW2 methods. *Annals of Human Biology*, **11,** 173–177.

Ye, Y., Wang, C., and Cao, L., 1992, Skeletal maturity of the hand and wrist in Chinese children in Changsha assessed by TW2 method. *Annals of Human Biology*, **19,** 427–430.

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Zusammenfassung. *Hintergrund*: Skelettreife wird verwendet, um den biologischen Reifegrad zu bestimmen. Für Portugal besteht wenig Information über die Beziehung zwischen dem sozio-ökonomischen Status und der Skelettreife.
Ziele: Das Ziel dieser Studie ist die Dokumentation von Skelettreife von Kindern und Jugendlichen aus Madeira und die Beurteilung, inwieweit die Variation der Skelettreife mit dem sozio-ökonomischen Status (SES) assoziiert ist.
Probanden und Methoden: Die Studie umfaßte 507 Probanden (256 Knaben und 251 Mädchen) aus der 'Madeira Growth Study', einer gemischt-longitudinalen Studie aus fünf Gruppen (im Altern von 8, 10, 12, 14 und 16 Jahren), die über drei Jahre (1996-1998) in jährlichen Abständen untersucht wurden. Insgesamt wurden 1493 Untersuchungen gemacht. Das Skelettalter wurde anhand von Röntgenbildern der Hand- und Handwurzelknochen nach Tanner-Whitehouse II bestimmt (TWII). Die sozialen Klassen wurden nach Graffars Methode (1956) eingeteilt. Fünf soziale Klassen wurden hernach in drei SES Kategorien eingeteilt: hoch, mittel, niedrig.
Ergebnisse: Der Median der RUS-Scores der gesamten Gruppe von Knaben und Mädchen stieg kurvilinear über das Alter an, während der Median des Carpal-Scores annähernd linear anstieg. Die 20-Knochen-Reife-Scores zeigten charakteristische Geschlechtsunterschiede: die Mediane für Knaben stiegen annähernd linear an, während die Mediane für Mädchen kurvilinear anstiegen. Die Unterschiede im sozio-ökonomischen Status waren minimal. Nur bei den 10- bis 11-jährigen Kindern waren Knaben und Mädchen mit hohem SES bezüglich ihrer Skelettreifung beschleunigt. Im Vergleich zu belgischen Referenzwerten waren Kinder und Jugendliche aus Madeira hinsichtlich ihrer Skelettreifung beschleunigt.
Zusammenfassung: Die Daten legen nahe , dass Bevölkerungsvariation hinsichtlich von TWII-Werten für Skelettreife besteht. Bei Kindern und Jugendlichen aus Madeira war die Skelettreife nicht mit dem SES korreliert.

Résumé. *Arrière plan*: La maturité squelettique est utilisée pour évaluer le statut de maturité biologique. Les informations disponibles sur l'association entre le statut socio-économique et la maturité squelettique, sont limitées au Portugal.
Buts: Cette étude a pour but d'apporter des informations sur la maturité squelettique des jeunes de Madère et d'évaluer ses variations en fonction du statut socio-économique (SSE).
Sujets et méthodes: L'étude implique 507 sujets (256 garçons et 251 filles) provenants de " l'Etude de Croissance de Madère", une étude semi longitudinale de cinq cohortes (8,10,12,14 et 16 ans) suivies annuellement pendant trois ans (1996 à 1998). Un total de 1493 observations ont été effectuées. L'âge squelettique a été estimé à partir de radiographies de la main et du poignet, en employant la méthode de Tanner-Whitehouse II (TWII). Le classement en rang social a été effectué d'après la méthode de Graffar (1956). Cinq niveaux sociaux ont de la sorte été groupés en trois catégories de SSE : haute, moyenne et basse.
Résultats: Les scores RUS médians dans l'échantillon global des garçons et des filles s'accroîssent curvilinéairement avec l'âge, alors que les scores médians du carpe s'accroissent presque linéairement. Les scores de maturité des 20 os indiquent des tendances différentes suivant le sexe: les médianes des garçons s'accroissent presque linéairement alors que les médianes des filles s'accroissent curvilinéairement, Les différences entre catégories de SSE sont minimes. Seuls les enfants de 10-11 ans sont ceux chez lesquels les garçons et les filles de haut SSE ont une maturité squelettique avancée. Les adolescents de Madère ont une maturité squelettique précoce par rapport aux valeurs belges de référence.
Conclusion: Les données suggèrent l'existence d'une variation intrapopulationnelle des estimations TWII de la maturité squelettique. La maturité squelettique n'est pas associée au SSE chez les jeunes de Madère.

Resumen. *Antecedentes*: La madurez esquelética se utiliza para evaluar el estado de madurez biológica. En Portugal, la información sobre la asociación entre el nivel socioeconómico y la madurez esquelética es limitada.
Objetivos: El objetivo de este estudio es ofrecer datos sobre la madurez esquelética de los jóvenes de Madeira y evaluar su variación según el nivel socioeconómico (SES).
Sujetos y métodos: El estudio incluyó a 507 sujetos (256 chicos y 251 chicas) del "Estudio de crecimiento de Madeira", un estudio semi-longitudinal de 5 cohortes (8, 10, 12, 14 y 16 años de edad) seguidas a intervalos anuales durante 3 años (1996 – 1998). Se realizaron un total de 1493 observaciones. La edad esquelética se estimó a partir de radiografías de la mano y la muñeca con el método de Tanner-Whitehouse II (TWII). Las categorías de clase social se basaron en el método de Graffar (1956). Posteriormente, las 5 clases sociales obtenidas fueron reagrupadas en tres categorías de nivel socioeconómico (SES): alto, medio y bajo.
Resultados: Las puntuaciones RUS medianas de la muestra total de chicos y chicas aumentaban de forma curvilínea con la edad, mientras que las puntuaciones Carpal medianas aumentaban casi de forma lineal. Las 20 puntuaciones de madurez ósea mostraron tendencias diferentes con el sexo: las medianas de los

chicos incrementaban casi de forma lineal, mientras que las medianas de las chicas aumentaban de manera curvilínea. Las diferencias según el SES fueron mínimas. Sólo entre los niños de 10-11 años de edad, los chicos y chicas con SES alto tenían una madurez esquelética avanzada. Los adolescentes de Madeira estaban adelantados en su madurez esquelética respecto a los valores belgas de referencia.
Conclusión: Los datos sugieren una variación poblacional en las estimaciones de madurez esquelética con el método TWII. La madurez esquelética no estaba relacionada con el SES en los jóvenes de Madeira.