Annals of Human Biology, January–February 2007; 34(1): 107–122

informa healthcare

ORIGINAL ARTICLE

Socio-economic status, growth, physical activity and fitness: The Madeira Growth Study

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(*Received 17 April 2006; revised 29 June 2006; accepted 17 October 2006*)

Abstract

Background: Within a country social conditions change over time and these conditions vary from country to country. The associations between these conditions, somatic growth, physical activity and fitness reflect these changes.

Aim: The study documented variation in somatic growth, physical activity and fitness associated with socio-economic status (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. Anthropometric measurements included lengths, body mass, skeletal breadths, girths and skinfolds. Physical activity and SES were collected via questionnaire and interview. Physical fitness was assessed using the Eurofit test battery. Variation in somatic growth, physical activity and physical fitness by SES (high, average and low) was tested with analysis of variance.

Results: Significant differences between SES groups were observed for height, body mass and skinfolds. Boys and girls from high SES groups were taller, heavier and fatter (subscapular and triceps skinfolds) than their peers from average and low SES groups. At some age intervals, the high SES group had larger skeletal breadths (girls) and girths (boys and girls) than low SES. Small SES differences were observed for physical activity (sport and leisure-time indices). SES was significantly associated with physical fitness. At some age levels, boys from the low SES group performed better for muscular and aerobic endurance whereas girls from the high SES group performed better for power.

Conclusion: Considerable variation in somatic growth and physical fitness in association with SES has been demonstrated, but little association was found for physical activity.

Keywords: *Socio-economic status, growth, fitness, physical activity*

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ISSN 0301–4460 print/ISSN 1464–5033 online
DOI: 10.1080/03014460601080983

Introduction

In adults, physical activity and fitness are related to a large number of health outcomes (Billewicz et al. 1983; Raitakari et al. 1994; Bar-Or et al. 1998; Bailey et al. 1999; Malina et al. 2004), whereas in growing children physical activity and fitness are related to risk factors associated with adult health and disease (Strong et al. 2005). In addition, the growth status of children and adolescents is a tool to assess variation in economic conditions and nutritional status of populations. As Tanner formulated it, growth is a mirror of the conditions in society (Tanner 1986). Even in children and adolescents, regular physical activity is associated with risks for cardiovascular diseases and type 2 diabetes mellitus, obesity, visceral and abdominal obesity, and osteoporosis (Raitakari et al. 1994; Bar-Or et al. 1998; Bailey et al. 1999; Malina et al. 2004; Strong et al. 2005). In adults, cardiovascular fitness is associated with reductions in all-cause and cardiovascular disease (CVD) mortality rates (Blair et al. 1989). Components of fitness and physical activity track, at least to a moderate degree, from adolescence to adulthood (Malina 1996).

In European countries, associations between socio-economic status (SES) and height are inconsistent, and in some countries the difference between social groups has disappeared in children (Rona 2000). Studies about SES associations with body mass, breadths, girths and skinfolds are less extensive but some evidence suggests that girls from low SES are fatter than their high SES peers (Taks et al. 1991). Very little is known about associations between SES, physical activity and physical fitness in European children and adolescents, and results from different studies are also inconsistent (Renson et al. 1980; Taks et al. 1991; Raudsepp and Viira 2000).

There is accumulating evidence that precursors of adult diseases take place during pregnancy, childhood and adolescence (Barker 1998; Li et al. 2004). Furthermore, evidence suggests associations between SES, somatic dimensions, fitness and physical activity. Thus, a study about variation in somatic growth, physical activity and physical fitness in association with SES may be useful for setting priorities and designing programmes that are appropriate for SES subgroups in the population (Sallis et al. 1996; Sallis 2000). At the same time, it underlines the responsibility of the community and the state to act in order to reduce differences in somatic growth or health in a population due to socio-economic inequalities (Rona 2000).

In studying secular changes in height for conscripts born between 1966 and 1982, Padez (2003) demonstrated a clear positive trend. This trend was explained by the improvement in the general living conditions especially nutrition and general health after 1960. In contrast to many other European countries that had important social and economic changes after World War II, the general improvement in the living conditions of the Portuguese population took place late during the 1960s. In early 1960s from the demographic point of view, Portugal had the highest proportion of young people, the lowest proportion of old people, the lowest life expectancy at birth, the highest rate of natality and the highest rate of infant mortality compared to most other European countries (Padez 2003).

When, on average, the most developed districts in Portugal (Lisboa and Braga) are compared to the lesser developed districts (Madeira, Castelo Branco, Leiria, Coimbra) adolescents from the more developed districts are taller than those from the lesser developed districts (Padez 2003). Furthermore, significant secular changes in stature are still observed in the Portuguese population (Padez 2003). Both observations indicate that SES differences are, at present, a significant differentiating factor in growth and, most likely, in performance characteristic of youngsters.

Consequently, the purpose of this study is to verify SES-associated variation in somatic growth, physical activity and physical fitness in Portuguese children and adolescents living in Madeira and Porto Santo Island. The hypothesis tested is that growth characteristics, physical activity and physical fitness differ according to SES.

Methods

Subjects and study design

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 selected in the 11 districts of the Autonomous Region of Madeira. These schools were representative for 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. For each of the five cohorts, about 50 boys and 50 girls were observed annually. There were only eight drop-outs during the whole study and some missing data resulting in a sample of 1493 subjects (Tables I and II).

The study was approved by the Medical Ethics Committee of the University of Madeira and the Regional Education Authority. All participants were informed about the nature and purposes of the study and a written informed consent was obtained from each child and his/her legal guardian.

Data were collected by a trained team of 14 teachers of physical education and two physicians. Before the study started each member of the team was trained in specific tasks by experienced anthropometrists and fitness researchers, who conducted several large-scale growth studies in the past. Furthermore, test–retest reliability was verified before the start of the project and in-field reliability tests were also conducted (see *Measurements* section). In order to maximize the number of observations and the power of the analyses, a cross-sectional analysis was carried out for the present study.

Measurements

The anthropometric measurements were made according to the standardized procedures described by Claessens et al. (1990). Height and sitting height were measured with a portable stadiometer (Siber-Hegner, GPM, Zurich, Switzerland) and recorded to the nearest millimetre. Body mass was measured on a balance-beam scale accurate to 0.1 kg (Seca Optima 760, Hamburg, Germany). Skeletal breadths (biacromial, bicristal, biepicondylar femur and biepicondylar humerus) were assessed with a spreading caliper with an accuracy of 1 mm (Siber-Hegner, GPM). Girths measurements (arm flexed and relaxed, calf, forearm, hip, thigh, and waist) were taken with a flexible steel tape (Holtain, Crymych, UK) accurate to 1 mm. Skinfold thickness (biceps, calf, subscapular, suprailiac and triceps) was measured using a skinfold caliper and recorded to the nearest 0.2 mm (Siber-Hegner, GPM). Biological maturity, i.e. skeletal maturity, was not included in the

Table I. Number of subjects enrolled in the five birth cohorts of the Madeira Growth Study: 1996, 1997 and 1998.

Cohort:		1		2		3		4		5		
Birth year:		1988		1986		1984		1982		1980		
Year	DO	M	F	M	F	M	F	M	F	M	F	Total
1996	–	50	50	49	51	55	44	53	57	49	49	507
1997	7	50	50	49	51	55	43	51	56	48	47	500
1998	1	50	50	49	50	55	43	51	56	48	47	499
Total	8	150	150	147	152	165	130	155	169	145	143	1506

DO, Drop outs; M, male; F, female.

Table II. Sample size for boys and girls classified into three SES groups.

	SES group			
Chronological age (years)	High (1)	Average (2)	Low (3)	Total
Boys				
7–9	76	68	35	179
10–11	51	67	30	148
12–13	74	58	27	159
14–15	70	61	21	152
16–18	44	49	24	117
Total	315	303	137	755
Girls				
7–9	70	70	35	175
10–11	45	59	37	141
12–14	66	112	40	218
15–18	50	116	38	204
Total	231	357	150	738
Grand total	546	660	287	1493

present analyses since it was demonstrated that SES differences in skeletal maturity were only present in 10-year-old youngsters (Freitas et al. 2004).

All one-sided measurements were taken on the left side of the body. Subjects were measured in the schools while wearing a swimming suit (two-piece for women), without shoes and jewellery removed. Measurements were performed twice and a third measurement was carried out in case of excessive difference. The scores of the two or two closest measurements were averaged to reduce measurement error.

Before the Madeira Growth Study started a pilot study was carried out in one school class (grade 7). All the subjects were measured twice with an interval of 1 week. Intraclass correlation coefficients (R) for the 19 anthropometric dimensions varied between 0.854 and 0.998, which indicated that the measurements were taken with acceptable reliability. Intra-observer reliability was also examined during the course of the study. About 10 subjects (five boys and five girls) were re-measured during the same day by the same team member, totalling 100 subjects per time of measurement (1996, 1997 and 1998).

The reliability was found to be consistent with the results of the pilot study and varied between 0.87 and 0.99.

A questionnaire developed by Baecke et al. (1982) was used to assess physical activity. Although, the original Baecke questionnaire encompasses three dimensions, namely: physical activity at work, sport, and leisure time excluding sport, the work index was not used in this study. All response categories range from 1 to 5, except questions 1 and 9. Physical activities indices were calculated for sport (questions 9–12) and leisure time (questions 13–16). A sport score (one or two main sports) was also calculated from a combination of the intensity of the sport which was played, the amount of time per week playing that sport, and the proportion of the year in which the sport was played regularly.

The team members filled out the questionnaires by means of a face-to-face interview with the subjects before the anthropometric measurements were taken. Children under 10 years of age had the assistance of the teacher of physical education or a parent. Evidence is accumulating that the Baecke questionnaire and modifications of this questionnaire provide reliable and valid information. Test–retest reliability of the sport and leisure-time indices, measured with an interval of 1 week during the pilot study, were 0.80 and 0.73, respectively, and parallels the results found by Baecke et al. (1982) in the original sample of Dutch adult men and women (0.81 and 0.74, respectively). Recently, Philippaerts et al. (2005) verified the reliability and validity of a physical activity questionnaire developed for adolescents (12–18 years of age). The sport and leisure-time dimension of the Baecke questionnaire were included in this questionnaire. Intraclass correlation coefficients for sport and leisure time activities exceeded $R = 0.70$ in adolescents of both sexes. Moreover, sport participation during leisure time and total transported and sport participation index showed significant correlation ($r > 0.50$) with the Computer Science and Applications uniaxial accelerometer counts.

Physical fitness was assessed using the Eurofit test battery (Adam et al. 1988), which includes nine health and performance related fitness items, namely: flamingo balance (balance), plate tapping (speed of limb movement), sit and reach (flexibility), standing broad jump (explosive strength), handgrip (static strength), sit ups (trunk strength), flexed arm hang (functional strength), and the 10×5 m shuttle run (running speed). The endurance shuttle run was replaced by the 12-min run–walk (aerobic endurance) from the AAHPERD (1988). During the pilot study the reliability of the motor tests was also verified. The intraclass correlation coefficients (R) were high and varied from 0.78 (standing broad jump) to 0.96 (handgrip).

SES information was collected with a standardized questionnaire developed by the Portuguese Institute of Statistics (Instituto Nacional de Estatística 1995). The questionnaires were interviewer-administered to the subjects before the anthropometric and motor tests measurements. For younger children the questionnaires were completed by the parents and afterwards checked by the school teacher and members of the research team. 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 1 and 2 were grouped into the highest SES, ranking 3 into the average SES, and rankings 4 and 5 into 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. This age grouping was used to incorporate the difference in timing of the pubertal period in boys and girls. Children between 7.00 and 7.99 were considered to belong to the 7-years-old age (note that the differences in total sample size between Tables I and II is due to missing values).

Statistical analyses

All analyses were performed using the Statistical Analysis System Program (SAS Institute 1990). Descriptive statistics are expressed as means and standard deviations (mean ± SD). Test–retest reliability for anthropometric characteristics, sport and leisure-time indices, and motor tests was estimated on the basis of the intraclass (R) and Pearson (r) correlation coefficients. ANOVA was used to test for differences in somatic growth, physical activity and physical fitness by SES within each sex by age group. *Post hoc* analysis was carried out using Tukey comparisons. ANCOVA was performed to test for differences in physical fitness tests between SES groups using height and body mass as covariates. Statistical significance was chosen at $p < 0.05$.

Results

SES variation in somatic dimensions

Figure 1(a) illustrates the SES-associated variation in height of Portuguese 7–18-year-old males and females. Figure 1(b) provides this information for body mass. In general, subjects from high SES are taller than their peers from average and low SES. The differences are significant for one age level in boys (10–11 years) and for three age levels in girls starting from 10 to 11 years (Figure 1a). A similar trend is found for body mass. With few exceptions, boys and girls from high SES groups have higher body mass than those of average or low SES. Among boys, statistically significant differences are observed at all age levels except at 7–9 and 14–15 years, whereas for girls differences are found from 10 to 11 to 15–18 years (Figure 1b).

Results of analysis of variance for sitting height, breadths, girths and skinfolds (biceps, calf and suprailiac) by SES groups are presented in Table III. For sitting height, a significant differentiation between SES groups is present in girls. The high SES group has greater lengths than average and low SES groups at 10–11 and 15–18 years. For skeletal breadths, only three significant differences appear in boys. The high SES group have broader shoulders (12–13 years) and hips (10–11 years) than those of low SES. At 16–18 years of age, however, boys from low SES have wider hips than average SES group. Girls in the high SES group tend to have broader shoulders and hips than those of average and/or low SES. The differences are significant at 10–11 and 15–18 years. As for boys, but in biepicondylar humerus breadth, low SES girls have larger breadths than average SES peers at 15–18 years.

SES differences for girths are generally in favour of the high SES group. Boys and girls from high SES groups show larger measurements on the trunk and extremities than average and/or low SES groups. An exception is observed in boys at 7–9 years where low SES group has somewhat larger arm flexed and waist girths than the average SES group. For girls, no significant differences are found at this age level.

Skinfolds also differ significantly between SES groups. For subscapular skinfold, boys from the high SES group have greater thickness than low SES group at 14–15 and 16–18 years. The differences for girls are significant at 10–11 and 12–14 years. In some

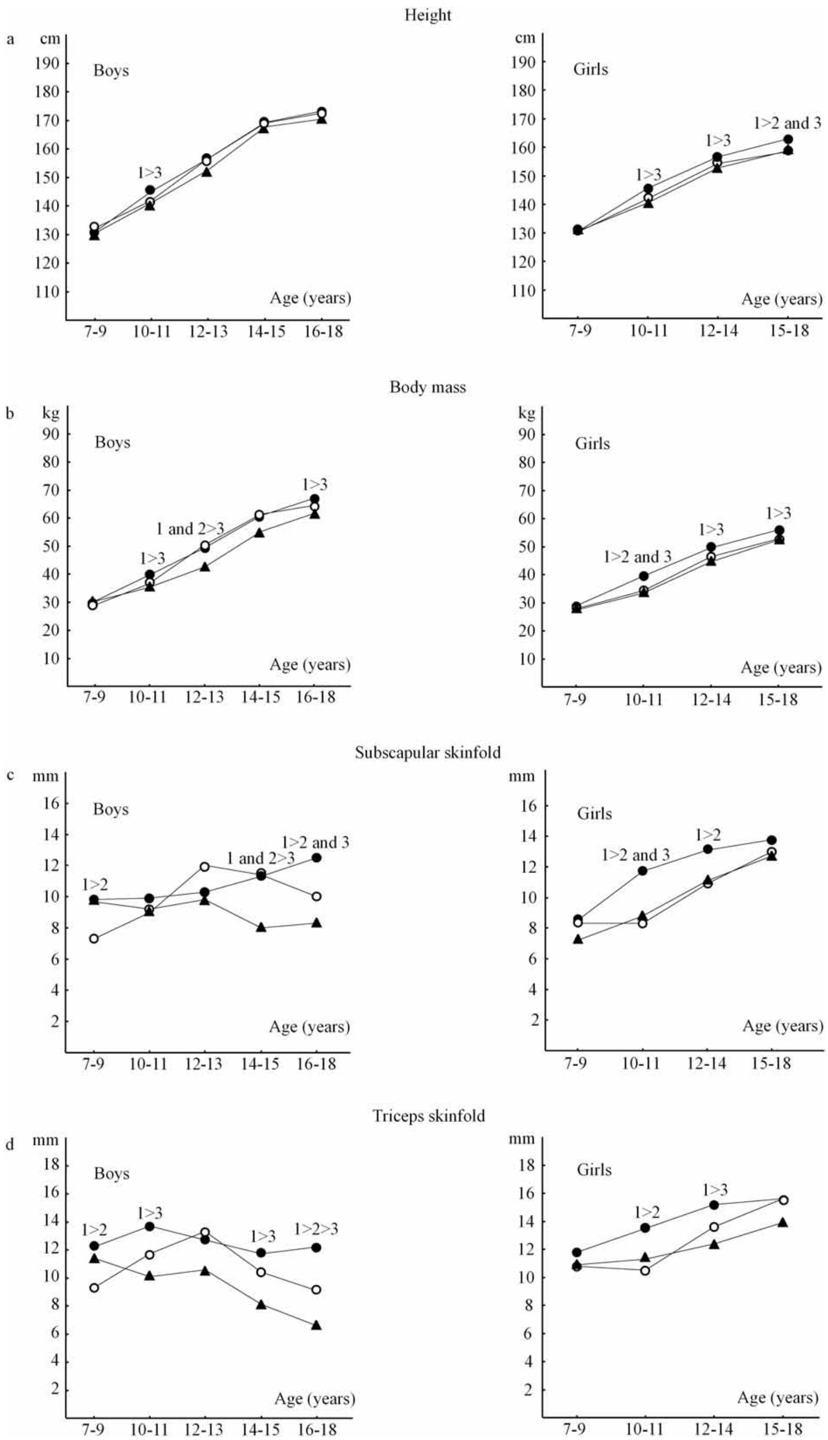

Figure 1. Mean height (a), body mass (b), subscapular (c), and triceps (d) skinfolds of 7–18-year-old Madeira boys and girls classified into three SES groups: high (●), average (○), and low (▲).

Table III. Analysis of variance for anthropometric measurements of 7–18-year-old Madeira boys and girls classified into three SES groups: high (1), average (2) and low (3).

	Age interval (years)				
Anthropometric measurements	7–9	10–11	12–13	14–15	16–18
Boys					
Sitting height	NS	NS	NS	NS	NS
Breadths					
Biacromial	NS	NS	1 > 3	NS	NS
Bicristal	NS	1 > 3	NS	NS	2 < 3
Femur	NS	NS	NS	NS	NS
Humerus	NS	NS	NS	NS	NS
Girths					
Arm (flexed)	2 < 3	1 > 3	1 and 2 > 3	NS	NS
Arm (relaxed)	NS	1 > 3	1 and 2 > 3	NS	NS
Calf	NS	1 > 3	1 and 2 > 3	1 and 2 > 3	NS
Forearm	NS	NS	1 and 2 > 3	NS	NS
Gluteal (hips)	NS	NS	NS	1 and 2 > 3	1 > 2 and 3
Thigh	NS	1 > 3	1 and 2 > 3	1 and 2 > 3	1 and 2 > 3
Waist	2 < 3	1 > 3	NS	NS	NS
Skinfolds					
Biceps	1 > 2	1 > 3	2 > 3	1 > 3	1 > 2 and 3
Calf	NS	1 > 3	2 > 3	1 > 3	1 and 2 > 3
Suprailiac	1 > 2	NS	NS	1 and 2 > 3	1 > 2 > 3
Girls	7–9	10–11	12–14	15–18	
Sitting height	NS	1 > 2 and 3	NS	1 > 2 and 3	
Breadths					
Biacromial	NS	1 > 2 and 3	NS	1 > 2	
Bicristal	NS	1 > 2 and 3	NS	1 > 2	
Femur	NS	NS	NS	NS	
Humerus	NS	1 > 3	NS	2 < 3	
Girths					
Arm (flexed)	NS	1 > 2 and 3	1 > 3	NS	
Arm (relaxed)	NS	1 > 2 and 3	1 > 3	1 > 3	
Calf	NS	1 > 2 and 3	1 > 3	NS	
Forearm	NS	1 > 2 and 3	1 > 3	1 > 2	
Gluteal (hips)	NS	1 > 2 and 3	1 > 3	NS	
Thigh	NS	1 > 2 and 3	1 > 3	NS	
Waist	NS	1 > 2 and 3	1 > 3	NS	
Skinfolds					
Biceps	NS	1 > 2	NS	NS	
Calf	NS	NS	NS	NS	
Suprailiac	NS	1 > 2 and 3	NS	NS	

NS, non-significant.

age intervals, significant differences are also found between high and average SES groups (Figure 1c). SES differences in triceps skinfold display a similar pattern for boys and girls. The high SES show generally more adiposity than their low SES peers. In boys, differences are statistically significant at all age intervals except at 12–13 years, whereas in girls a large subcutaneous fat differentiation is also observed at 10–11 and 12–14 years (Figure 1d). For biceps, calf and suprailiac skinfolds, SES differences are more consistent for boys. The high SES group show more adiposity than average and/or low SES groups. For girls, significant differences among SES groups are only present at 10–11 years, favouring the high SES group.

SES variation in physical activity

The SES differentiation in sport score is given in Figure 2(a). Boys from high SES score significantly higher than boys from low SES at 7–9, 12–13 and 14–15 years. At 12–13 years, those from high SES also score significantly higher than average SES. The pattern is identical in girls from 10–11 to 15–18 years but significant differences in favour of the high SES are only observed at 12–14 years. SES differences are small for boys and girls 10–11 years, for boys of 16–18 years and girls 15–18 years. High SES also presents a decline in the sport score after 14–15 years in boys and 12–14 years in girls.

SES is also associated with sport index but the only difference is seen in boys at 12–13 years where boys in the high SES group score higher than the low SES group (Table IV). In girls, SES differences are small and do not reach statistical significance. Similarly, the SES differentiation for the leisure-time index is only significant for boys 12–13 years, and girls 15–18 years. At these age levels, boys from average SES are more active than the high SES, and girls from high SES are more active than those from low SES.

SES variation in physical fitness

SES differences for sit and reach, sit ups and shuttle run are shown in Figure 2(b–d). Boys from the low SES group perform significantly better on sit and reach than boys from average and high SES groups. Differences are significant from 10 to 11 years onwards. In contrast, girls do not significantly differ from 7–9 to 12–14 years. Girls from low SES outperform their peers at 15–18 years (Figure 2b). For sit ups, the differentiation between SES groups in boys favours the high SES, but statistical differences are observed only at 12–13 and 16–18 years. Some SES variation occurs in girls. Average SES is more proficient than high SES at 7–9 years, and high SES performs better than low SES at 15–18 years. The differences are statistically significant at these age levels (Figure 2c). High SES boys perform significantly better on shuttle runs from 10–11 to 12–13 years. A similar trend is observed in girls from 10–11 to 12–14 years (Figure 2d).

There is no clear pattern of differentiation among the three SES groups for the remaining motor tests (Table V). The results indicate that low SES boys perform better than high SES in flamingo balance, bent arm hang and 12-min run–walk. The differences are significant at 10–11 years for flamingo balance and at 10–11, 12–13 and 16–18 years for bent arm hang. Statistically differences are also observed at 7–9 and 16–18 years for 12-min run–walk. The directions of these relationships are identical when comparing low with average and/or high SES for plate tapping at 7–9 years and standing long jump at 16–18 years. For handgrip average SES tends to be higher than for the low SES and the difference is statistically significant at 12–13 years. For girls, there are no significant differences between SES groups in plate tapping, handgrip, bent arm hang and 12-min run–walk. However, girls from high SES demonstrate significantly better performance in standing long jump at 12–14 and 15–18 years.

Discussion

The results indicate that SES is significantly associated with somatic growth of Portuguese children and adolescents. Generally, boys and girls from high SES groups are taller and

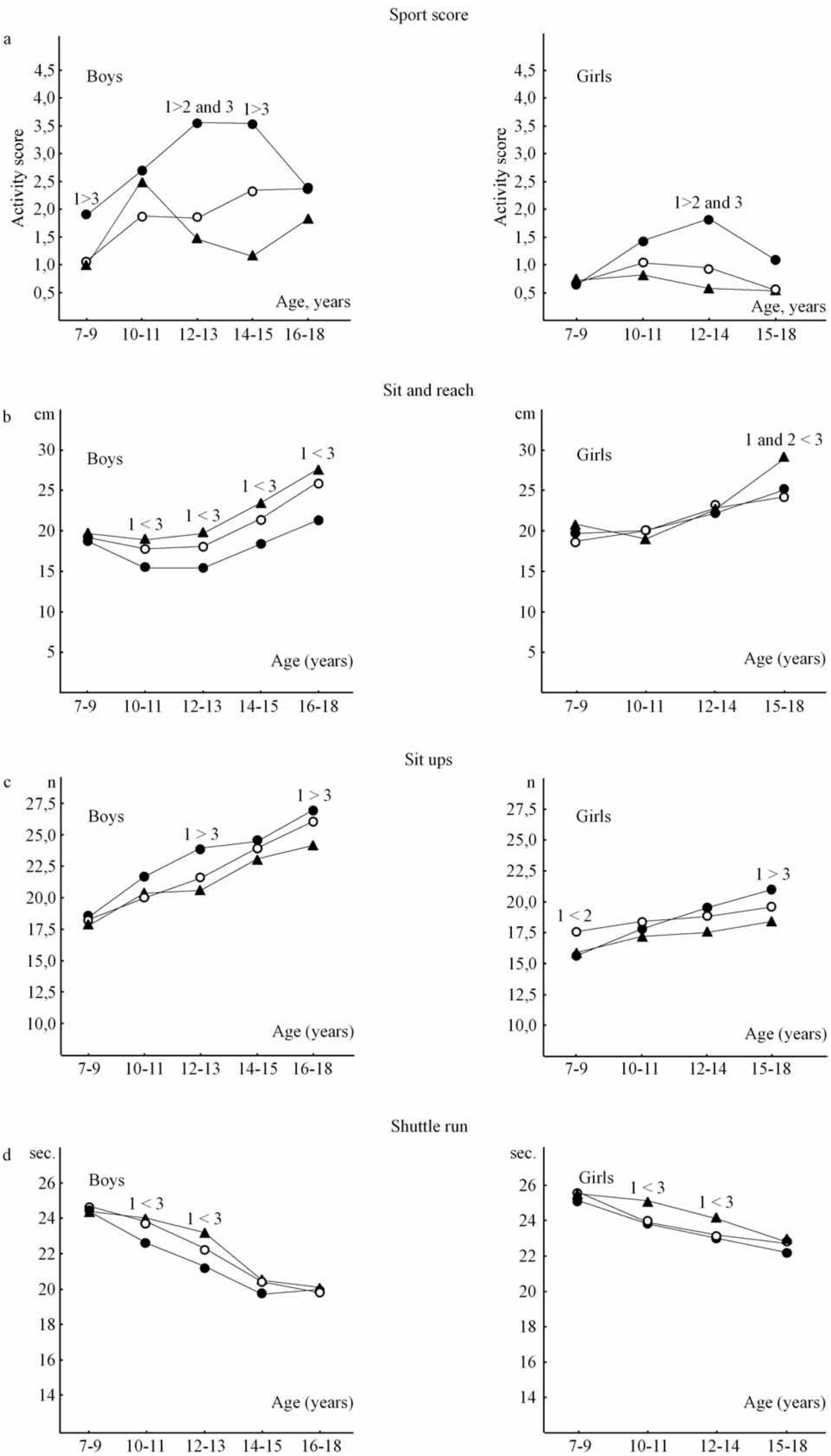

Figure 2. Mean sport score (a), sit and reach (b), sit ups (c), and shuttle run (d) of 7–18-year-old Madeira boys and girls classified into three SES groups: high (●), average (○), and low (▲).

Table IV. Analysis of variance for physical activity (sport and leisure-time indices) of 7–18-year-old Madeira boys and girls classified into three SES groups: high (1), average (2) and low (3).

	Age interval (years)				
Physical activity	7–9	10–11	12–13	14–15	16–18
Boys					
Sport index	NS	NS	1 > 3	NS	NS
Leisure-time index	NS	NS	1 < 2	NS	NS
Girls	7–9	10–11	12–14	15–18	
Sport index	NS	NS	NS	NS	
Leisure-time index	NS	NS	NS	1 > 3	

NS, non-significant.

Table V. Analysis of variance for motor tests of 7–18-year-old Madeira boys and girls classified into three SES groups: high (1), average (2) and low (3).

	Age interval (years)				
Motor tests	7–9	10–11	12–13	14–15	16–18
Boys					
Flamingo balance	NS	1 > 3	NS	NS	NS
Plate tapping	2 > 3	NS	1 < 3	NS	NS
Standing long jump	NS	NS	NS	NS	1 < 3
Handgrip	NS	NS	2 > 3*	NS	NS
Bent arm hang	NS	2 < 3	2 < 3*	NS	1 < 3
12-min run–walk	1 < 2 and 3	NS	NS	NS	1 < 3
Girls	7–9	10–11	12–14	15–18	
Flamingo balance	1 > 2 and 3	NS	NS	NS	
Plate tapping	NS	NS	NS	NS	
Standing long jump	NS	NS	1 > 2	1 > 3	
Handgrip	NS	NS	NS	NS	
Bent arm hang	NS	NS	NS	NS	
12-min run–walk	NS	NS	NS	NS	

NS, non-significant.
*Significant SES effects disappear when height and body mass are partialled out.

heavier than their average and low SES peers. SES differences in sport and leisure-time indices are small and results for physical fitness do not favour one socio-economic group.

Comparing these results with previously published studies is not straightforward because of the differences in the SES in the populations under study, the definition of SES, sample characteristics, and the strategy of the statistical analysis used. Nevertheless, the observed differences in height among social groups were consistent with an earlier report of 18-year-old Portuguese boys. Adolescents from Lisboa and Braga, the most developed districts in Portugal, were taller than those from Madeira, Castelo Branco, Leiria and Coimbra (Padez 2003). From these observations it can be inferred that social inequalities still exist in Portugal. Similar findings showing that boys and girls from high SES were taller than those from the low SES were found in several Europeans studies (Billewicz et al. 1983; De La Puente et al. 1997; Li et al. 2004) but a SES differentiation in height is no longer present in Sweden (Lindgren 1976) and Norway (Brundtland et al. 1980). It is important to note that, given changes in socio-economic conditions over time, the SES associations within a country probably change over time, and vary also between countries. This reflects the growth as a mirror of conditions in society (Tanner 1986).

SES differences in height can be obscured by differences in growth tempo, hence by the biological maturation process. However, in a recent publication using data from the Madeira Growth Study it was shown that SES differences in skeletal maturity were only significant among 10–11-year-old boys and girls (Freitas et al. 2004). In the remaining age intervals no statistical differences were found among social groups, suggesting that biological maturity does not account for the differences observed in the current study.

Children and adolescents from high SES were also heavier and had more adiposity than those from average and/or low SES. These trends do not parallel the literature in developed countries. Brundtland et al. (1980) found that Norwegian children from low SES weighed more than children from high SES. In Belgian boys, no significant differences appeared in body mass between boys classified according to the educational level of the father and mother (Renson et al. 1980). Corresponding data for Belgian girls grouped by degree of urbanization showed that urban girls weight somewhat less than rural girls up to 17 years of age (Taks et al. 1991). Garn et al. (1981) also reported in North Americans boys and girls a greater gain in subscapular and triceps skinfold thickness in children of lower family income level in comparison to those of higher family incomes. In reviewing the available evidence, Malina et al. (2004) concluded that, during adolescence and especially in later adolescence, girls, and to a lesser extent boys, from the low SES tend to be, on average, fatter than those in high SES. It seems plausible that high SES has a preference for slenderness, and a different attitude toward and perception of fatness which probably does not occur in our sample.

The greater levels of subcutaneous fat observed in boys and girls from high SES may also indicate a more than adequate energy intake and probably low physical activity levels. Although we have no information about nutritional intake for the subjects of this sample, differences in physical activity levels among social groups are nearly non-existent across age intervals, meaning that physical activity levels do not explain the above results.

Studies about SES variation in other body dimensions, sitting height, skeletal breadths and girths, are more limited. In Belgian boys, Renson et al. (1980) showed no significant differentiation in these measurements according to the educational level of the father and mother. When the subjects were classified by socio-professional status of the father and degree of urbanization of dwelling area, on the other hand, the lower class and rural boys presented greater girths than the upper class and urban counterparts. Data for Flemish girls (Taks et al. 1991) also showed, with few exceptions, that differences in skeletal breadths were not significant among socio-geographic groups. For upper arm, thigh and calf girths, semi-urban and rural girls showed larger measures, but differences were not significant. These results were in opposition of our findings.

Bogin et al. (2002) suggested that human body proportions are more sensitive to environmental factors. To test this hypothesis the sitting height ratio (sitting height to stature $\times$ 100) was calculated for each SES groups (high, average and low). No statistically significant differences were found in boys and girls across all age intervals. These observations support the view that SES effects are stronger in size than shape in Madeira children and adolescents. Similar data were reported by Norgan (1998) when comparing Mexican and Mexican-American children in America in response to malnutrition.

SES was not associated with sport and leisure-time indices. There were some possible reasons for this lack of association. First, children and adolescents from Madeira may have an equal access and exposure to physical activities. As subjects have compulsory physical education at school one would expect that these classes provide similar exercise opportunities to the students and counteract any impact of SES (Aaron et al. 1993). Second, Malina (1973) suggested that the more permissive rearing atmosphere that characterizes low SES might be conducive to greater freedom of activity and opportunity for practice and, in turn, compensate the higher extra-school participation in regular sports noted by average and high SES. This could also be a factor in children reared in Madeira, although no studies documenting the rearing styles in Madeira families are available.

There appears to be some inconsistency in the literature with regard to specific associations between SES and physical activity. Belgian boys from the upper social level showed a higher amount of sport involvement and greater diversity in sport participation over their lower-class counterparts (Renson et al. 1980). Also, Belgian girls from urban areas spent more hours per week on sports than their semi-urban and rural peers (Taks et al. 1991). A higher physical activity level was also observed in Estonian adolescents with parents of higher professional status (Raudsepp and Viira 2000). Conversely, a lack of SES differences in physical activity has been observed by Aaron et al. (1993) in North American adolescents.

It is worth noting that SES differences in physical activity were more pronounced for the sport score derived from the Baecke questionnaire, i.e. the participation in regular sports activities (see Methods). A possible explanation may be that subjects from high SES had a well defined pattern of exercise and the ability to pay the costs of lessons of some sports like gymnastic, golf, swimming and tennis (Sallis et al. 1996). Moreover, children and adolescents from high SES could have greater access to a wider variety of exercise facilities near subjects' homes or transportation to a sports activity place (Sallis et al. 1990). It is interesting to note a decline in the sport score after 14–15 years in boys of high SES and already at 12–14 years in girls of all social groups. This decline probably reflects cultural factors, such as changing social interests and expectations, pressure from peers and lack of motivation as they go through puberty (Malina et al. 2004).

Variability of physical fitness is considerable in this study. Boys from low SES do better than boys from average or high SES in sit and reach and endurance run tests. There are also indications that boys from high SES perform better than low SES in sit ups and shuttle run tests, and that girls from high SES present better scores in shuttle run. Similar contrasts have been reported in the literature. Ponthieux and Barker (1965) found that girls from low SES were faster (50-yard dash), better coordinated (softball throw), and had more endurance (600-yard run–walk) than the girls from high SES. Boys from low SES were faster (50-yard dash) and better coordinated (softball throw) than boys from the high SES. Boys from the high SES surpassed the low SES, however, in measures of strength (sit ups) and agility and speed (40-yard shuttle run). In Belgian boys, the sons of university-trained fathers were more proficient in the explosive strength (vertical jump) but no differences between paternal educational level groups were found in trunk strength (leg lifts), functional strength (bent arm hang) and pulse frequencies after a step test. Upper class and city boys also presented better scores in explosive strength (vertical jump) and the running speed (50-m shuttle run) (Renson et al. 1980). Urban girls performed somewhat better than rural peers in explosive strength (vertical jump), trunk strength (leg lifts), flexibility (sit and reach) and running speed (50-m shuttle run) (Taks et al. 1991).

Considerable amount of variation in physical fitness could be explained by differences in size and body mass (Beunen et al. 1983; Malina et al. 1995). Since significant average differences are found for height and body mass between SES groups, ANCOVA was carried out separately by sex and age level to control for additional variation in motor tests. In each analysis height and body mass were both taken as covariates. Significant SES effects remained in the majority of the motor tests and age levels. Only for boys, significant differences disappeared for handgrip ($F = 1.10$, $P = 0.335$) and bent arm hang ($F = 2.21$, $p = 0.113$) at 12–13 years. This means that SES differences in motor tests are not related to size and body mass in Madeira boys and girls.

The strengths of the study are: (1) the large sample size of boys and girls covering Madeira and Porto Santo Island, (2) the number of characteristics included in the study, (3) the documentation of the in-field reliability of each of these characteristics, (4) the use of five social variables to define SES, and (5) a single data set including SES correlates of growth, physical activity and physical fitness in Portuguese children and adolescents.

Some limitations should be noted regarding this study: (1) physical activity was assessed using a self-reported questionnaire. It is possible that subjects do not recall their activities accurately. To address this shortcoming the questionnaire was completed by the children and adolescents with the assistance of a trained interviewer, and children 8–9 years of age had the aid of the teacher or a parent. (2) A cross-sectional analysis of the data was carried out and changes over time were not considered. (3) The social stratification method used in this study is not often used in other studies, which makes it difficult to compare these results with those previously reported.

In summary, this study clearly demonstrated a SES differentiation in growth and to a lesser extent also in some fitness characteristics of Madeira children and adolescents. Physical activity was not related to SES. These findings are difficult to generalize across countries, since SES has different meanings and implications (associations) in different cultures and societies. These findings highlight the need for (1) public health strategies that promote equal environmental opportunities to remove some SES differences in growth, (2) additional research to verify SES differences in physical fitness, and (3) a replication of this study using more objective physical activity measures.

Acknowledgements

The Madeira Growth Study was co-sponsored by the POP-RAM II, within the scope of the European Social Funds, via CITMA and the Professional Qualification Centre.

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