

Body and head dimensions of adults in Sardinia (Italy) support different intensities of relative secular trends

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Due to the paucity of historical series for anthropometric variables other than height in males and females, there are very few analyses of secular trends of body and head dimensions. Moreover, there is also little anthropometric data regarding females. Therefore, in this latter case and due to the absence of any historical series, research on secular changes in head and body dimensions of adult women must make use of data from cross sectional samples consisting of different age groups (Sanna & Danubio, 2009) and also consider the contribution to secular height changes by analyzing the lengths of different body regions and secular changes in craniofacial dimensions.

A topic of debate in the field of secular changes regards whether head shape is undergoing a process of debrachycephalization or dolichocephalization (Buretic-Tomljanovic *et al.*, 2007; Abu Dalou *et al.*, 2008). The plasticity of the cranium and trunk-head height are considered less labile than height and especially lower limb lengths due to the impact of stress on growth (Pomeroy *et al.*, 2012).

The present paper aims to determine if there have been changes in anthropometric variables of body and head dimensions among different cohorts of Sardinian adult females and males (20.00-39.99 years) in order to evaluate the existence of an ongoing secular trend.

The island of Sardinia is well-known for its long isolation. Its peculiar environmental and cultural background has resulted in particular

genetic characteristics and microdifferentiation of its communities from the populations of continental Europe and the circum-Mediterranean area (Vona & Calò, 2006). Moreover, biological continuity between past and modern populations has been recorded (D'Amore *et al.*, 2010). This peculiar genetic and biodemographic history makes Sardinia an ideal place to study the impact of the environment on biological characters.

The cross sectional sample consists of 412 Sardinian women measured in the period 2005-2009 and 451 Sardinian men measured in 2003-2008. They were born in the metropolitan area of Cagliari, southern Sardinia, of parents that are native to the same Sardinian area and are unrelated, apparently healthy and with no physical defects or malformations. Around 20% of the Sardinian population lives in Cagliari, the capital of Sardinia (a region of Italy), and in its surrounding metropolitan area.

The female and male samples were divided into four 5-year age groups, the first with individuals 20.00 to 24.99 years of age, the last with individuals 35.00 to 39.99 years of age.

Informed consent was obtained from each participant in the survey following guidelines established by Italian laws L 31-12-1996 n. 675 and DL 30-6-2003 n. 196 assuring privacy and informed consent in the collection and treatment of personal data.

To assess possible demographic and socio-economic differences among the four female

and male subsamples, the socioeconomic status (SES), sibship size of family of origin, paternal and maternal age at the individual's birth and order of birth were determined by means of a questionnaire answered by each man and woman. A proxy of socioeconomic status was determined according to the classification in five-point-scale (Sanna & Danubio, 2009; Sanna *et al.*, 2014). One-way ANOVA was used to evaluate significant differences in the anthropometric, socioeconomic and demographic variables among the four age groups. One-way ANCOVA (controlling for SES) was used to evaluate the significance of differences among the distributions of anthropometric variables that showed significant differences in the ANOVA.

Table 1 reports, for both sexes, the mean values of the socioeconomic variables: socioeconomic status (SES), sibship size of the family of origin, paternal and maternal age at the individual's birth and order of birth. For both males and females, one-way ANOVA revealed significant differences between the four age groups ($p \leq 0.05$) only regarding the proxy variable socioeconomic status (SES).

Table 2 includes the descriptive statistics of the anthropometric variables and ANOVA results for the four age groups of women and men respectively.

It can be argued that the age span considered in this study is limited. In the present study, we analyzed women and men aged 20.0–39.9 years so that the observed differences should not be masked by effects of aging (Arking *et al.*, 1998).

For positive secular trends in height, there is evidence that the increase is due more to the increase in lower limb length than to increased sitting height (Sanna & Soro, 2000; Sanna & Palmas, 2003; Sanna & Danubio, 2009).

The differences in height and estimated lower limb length among the four age groups of Sardinian women and men are statistically significant (ANOVA). In both sexes, the height values are highest in the 20.00–24.99 age group and decrease in the subsequent classes (Tab. 2). From the oldest age group to the youngest, there is an increase of 1.43% in females (from 158.77

cm to 161.04 cm) and 1.35% in males (from 169.41 to 171.70). The same trend, albeit more pronounced, can be seen for estimated lower limb length, with an increase from the oldest to youngest group of 2.83% in females (from 75.57 cm to 77.71 cm) and 3.56% in males (from 83.44 cm to 86.41 cm). The values of sitting height remain largely stable, with a decrease of only 0.10% in females (from 83.13 cm to 83.21 cm) and 0.80% in males (from 85.98 cm to 85.29 cm). In contrast, the highest values of relative sitting height index can be found in the 35.00–39.99 age group, with an decrease from the oldest to youngest group of 1.28% in females (from 52.43 to 51.76) and 2.05% in males (from 50.75 to 49.71).

According to the results of ANCOVA (with covariate SES), the significant differences in socioeconomic conditions among the four age groups do not mask the effects of the secular trend of the analyzed body dimensions.

In analyses of secular changes in head shape, the most frequently investigated craniofacial parameters are head length and head breadth, through the use of the cephalic index. A frequently observed secular pattern is a change in the cephalic index from low (dolichocephaly) to high (brachycephaly), i.e. brachycephalization (Little *et al.*, 2006). However, cephalic index change is not always toward brachycephaly, since debrachycephalization or dolichocephalization is also observed. The reversal of brachycephalization has generally been attributed to a decline in head breadth with little change in head length (Little *et al.*, 2006). Yet secular changes in head measurements related to debrachycephalization have also been attributed to an increase in the length of the head, similar to what was observed in the present samples of Sardinian adults and in previous samples of Sardinian children (Sanna & Soro, 2000; Sanna & Palmas, 2003), as well in Hungarian university students (Gyenis, 1994), conscripts (Gyenis *et al.*, 2003), adults, children, and infants (Magyar *et al.*, 2006), in Jena-Germany (Zellner *et al.*, 1998) and in Russian children (Godina, 2011). Secular changes in the shape of the head have been recorded since the end of World War I.

Tab. 1 - Means and standard deviations of paternal and maternal ages, sibship size and birth order of the four age groups of adult females and males from the metropolitan Cagliari area.

		20.00 – 24.99	25.00 – 29.99	30.00 – 34.99	35.00 – 39.99
FEMALES					
SOCIOECONOMIC VARIABLES	N	102	92	100	118
SOCIOECONOMIC STATUS*	M	2.56	2.83	2.89	3.22
	SD	0.88	0.89	1.02	0.83
SIBSHIP SIZE	M	2.90	2.96	3.27	3.29
	SD	1.19	1.24	1.38	1.45
MATERNAL AGE	M	28.27	28.61	28.98	28.35
	SD	5.53	5.76	5.70	5.96
PATERNAL AGE	M	31.83	32.21	32.75	32.44
	SD	5.50	6.35	5.78	6.90
ORDER OF BIRTH	M	2.20	2.24	2.30	2.43
	SD	1.18	1.24	1.27	1.38
MALES					
SOCIOECONOMIC VARIABLES	N	129	113	108	102
SOCIOECONOMIC STATUS*	M	2.74	3.06	3.06	3.07
	SD	0.95	0.92	0.96	1.01
SIBSHIP SIZE	M	3.10	3.27	2.78	2.80
	SD	1.57	1.76	2.16	2.51
MATERNAL AGE	M	28.48	27.71	29.20	28.29
	SD	5.81	5.23	5.88	5.89
PATERNAL AGE	M	31.93	31.98	32.27	32.06
	SD	5.79	6.41	6.54	6.59
ORDER OF BIRTH	M	2.38	2.35	2.11	2.30
	SD	1.47	1.49	1.39	2.26

* females $p < 0.001$; males $p < 0.05$ by one-way ANOVA

A process of debrachycephalization or dolichocephalization has been generally observed in several populations of industrialized Western countries (Gyenis *et al.*, 2003, Buretic-Tomljanovic *et al.*, 2007; Godina, 2011).

The differences in head dimensions among the four age groups of Sardinian women and men are not significant (ANOVA), even though

in both sexes the length of the head is greatest in the 20.00-24.99 age group and decreases slightly in the older age groups (Tab. 2).

All this would seem to indicate a tendency towards a long-lasting process of debrachycephalization or dolichocephalization in both sexes. This is suggested by the fact that the 20.00-24.99-year-old women and men present a higher mean head

Tab. 2 - Descriptive statistics (mean and SD) of the anthropometric variables in the four age groups of adult females and males from the metropolitan Cagliari area.

		20.00 – 24.99	25.00 – 29.99	30.00 – 34.99	35.00 – 39.99
FEMALES					
ANTHROPOMETRIC VARIABLES	N	102	92	100	118
	HEIGHT (CM) *	M 161.04	159.54	159.42	158.77
	SD	4.83	6.13	6.11	5.48
SITTING HEIGHT (CM)	M	83.13	83.17	83.21	83.21
	SD	2.83	3.02	3.24	2.89
RELATIVE SITTING HEIGHT INDEX **	M	51.76	52.15	52.21	52.43
	SD	1.61	1.12	1.47	1.37
ESTIMATED LOWER LIMB LENGTH (CM) **	M	77.71	76.37	76.21	75.57
	SD	4.12	3.96	4.30	3.94
HEAD BREADTH (CM)	M	14.51	14.52	14.61	14.62
	SD	0.48	0.58	0.47	0.47
HEAD LENGTH (CM)	M	18.32	18.26	18.24	18.22
	SD	0.62	0.49	0.48	0.55
CEPHALIC INDEX	M	79.26	79.58	80.19	80.31
	SD	3.14	3.49	3.26	3.19
MALES					
ANTHROPOMETRIC VARIABLES	n	129	113	108	102
	HEIGHT (CM) *	M 171.69	170.98	170.24	169.41
	SD	4.98	6.96	5.91	6.53
SITTING HEIGHT (CM)	M	85.29	85.38	85.67	85.97
	SD	3.37	4.13	4.45	4.85
RELATIVE SITTING HEIGHT INDEX **	M	49.68	49.95	50.33	50.75
	SD	1.59	1.67	1.94	2.12
ESTIMATED LOWER LIMB LENGTH (CM) **	M	86.41	85.60	84.56	83.44
	SD	4.01	4.85	4.39	4.94
HEAD BREADTH (CM)	M	14.82	148.47	148.53	14.87
	SD	5.09	6.62	5.90	5.36
HEAD LENGTH (CM)	M	18.69	186.57	186.04	18.53
	SD	6.14	7.34	7.15	8.22
CEPHALIC INDEX	M	79.54	79.63	79.91	80.33
	SD	2.99	3.30	3.37	3.17

* $p < 0.05$; ** $p < 0.01$ by one-way ANOVA

length whereas the head breadth values show an opposite tendency, and thus there is a lower cephalic index. This tendency towards a longer head over time rather than appreciable changes in head breadth is confirmed by data recorded in children aged 3-5 years (Sanna & Palmas, 2003) and 7-10 years (Sanna & Soro, 2000) from Cagliari, the capital of Sardinia.

The reliable earliest data on the head shape of living Sardinians concern the cephalic index of military conscripts from 1879-1883. These 20 year-old Sardinian men (born in the period 1859-1863) had a mean cephalic index of 77.5 (mesocephaly). Division of the conscripts into subsamples from the then province of Cagliari, i.e. central-southern Sardinia, and the then province of Sassari, northern Sardinia and the central mountainous part of the island, revealed cephalic index values of 77.2 (mesocephaly) and 78.1 (mesocephaly) respectively (Livi, 1905). In 1978, adult males aged 18-24 from northern Sardinia had a mean cephalic index of 80.01 (mesocephaly) (Floris, 1978). Therefore, a process of brachycephalization appears to have occurred in young men from northern Sardinia, with an increase in the cephalic index of 1.91 in almost a century. However, the cephalic index values of 79.54 in our 20.00-24.99-year-old males and 80.33 in the 35.00-39.99-year-old ones suggest that recently there has been a slow process of debrachycephalization or dolichocephalization. In summary, cephalic index values of adult Sardinian men would seem to indicate a long-term trend toward brachycephalization, whereas the current data for urban Sardinian women and men suggest that the opposite trend, i.e. toward debrachycephalization or dolichocephalization, is in progress.

Therefore, while the differences in height, estimated lower limb length and relative sitting height index among the four age groups of Cagliari women and men are statistically significant (ANOVA and ANCOVA controlling for SES), the differences in head dimensions are not. This would seem to confirm that environmental factors have a greater influence on height and especially lower limb length than on head dimensions.

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Editor, Giovanni Destro Bisol



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