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Variation of head and facial morphological characteristics with increased age of Han in Southern China

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We investigated 13940 (6735 male, 7250 female) adult head and facial physical attributes from 19 different Han ethnic groups in 10 southern-China provinces, and calculated 12 head and facial indexes. Indexes were used to analyze the variation of head and facial morphological characteristics with increased age. Results showed that as age increases: (1) Head breadth, minimum frontal breadth, face breadth, interocular breadth, external biocular breadth, lip height, lip thickness, head circumference, auricular height, length-breadth head index, length-height head index, and lip-index values decline significantly in a linear fashion. (2) Nose breadth, mouth breadth, morphological facial height, upper-lip height, physiognomic ear length, physiognomic ear breadth, visor skin-fold, and vertical head-facial index values significantly increase in a linear fashion.

head and facial morphology, age, Han in Southern China, China

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Indexes of human head and facial morphology, and derived indexes, are the main sources of head and facial characteristics that influence human appearance, and are the main basis for recognizing individuals. As age increases, appearances change gradually and regularly. Reports regarding the Variation Rule of human head and facial morphological indexes are limited. A paleo-anthropological study that examined long-term changes in human head and facial characteristics found that from the Neolithic Ages to modern times, cranial and facial skeletons tend to shrink, the nasal opening tends to narrow, the orbits tend to become high and narrow, the cranium tends to become round, and the mandibula tends to become smaller [1]. From the perspective of individual variation, another study has reported that as age increases, the rate of mongoloid fold decreases, lips become thinner, and eye color lightens [2]. Additionally, upper-lip height and mouth breadth have been shown to be positively related to age [3,4]. However, whether other indices of head and facial characteristics have relationships with age is currently unknown. Recently, a number of reports [5,6] have provided data regarding the relationships between head and facial characteristics and age within ethnic groups in a certain province.

Several studies have reported on the regional distribution of physical characteristics of Chinese people. When they studied the distribution of genetic marker (GM) factor in the blood of all ethnic groups in China, Zhao et al. [7] suggested that Chinese ethnic groups can be divided into two main groups (North and South) at 30 degrees north latitude. Zhang [8] proposed that modern Chinese can be divided into two groups at the Yangtze River. Liu et al. [9] also supported a similar north-south division, however they stressed that the north and south types have large overlapping ranges with transitional changes from north to south. Wen et al. [10] found that almost all people of Han nationality have similar Y-chromosome haplogroup distributions, while the mitochondrial haplogroup distributions of northern and southern Han are very different. This indicates that

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intermixing in the Southern Han groups has a strong gender bias. Li et al. [11,12] analyzed the genetic characteristics of the Fujianese ethnic group and the Hakka Han, and concluded the Fujian Chinese are Han immigrants from the North. Unlike other Southern-Han nationality biases towards the Zhuang and Dong language ethnic groups, the Hakka Han are biased in favor of the She (a member of the Miao Language ethnic group). Xu et al. [13] used analyses of whole-genome data of over 1700 individuals in 26 provinces and cities in China, and found that the structure of the Han nationality is very complex, and can be roughly divided into northern, southern, and central subgroups. Several thousand years of different degrees of isolation, integration, and migration has inevitably led to genetic differences between different regions constituting the Han nationality. The Southern Han comprise the main portion of the Han nationality, and have some differences in head and facial characteristics from the Northern Han.

Compared with body characteristics, head and facial characteristics are more affected by genetic than environmental factors. Anthropological races are classified according to the characteristics of the head and facial characteristics [14]. Since 2009 we have undertaken the Study of Han Physical Anthropology project, carrying out measurements of Han physique in China. Currently the Southern-Han physical measurements have been completed and the whole Southern Han nationality can be studied with the complete data set. The Northern-Han data is not yet completed, and investigations of individual provinces are ongoing. This article will first summarize the information and statistics of the Southern Han data, analyzing how increased age relates to changes in head and facial characteristics of Southern-Han, which can then be used as a control to carry out a similar study of Northern Han in the future. Ultimately, this can provide a fundamental basis for exploring a potential universal law that describes changing age and head and facial characteristics in all Chinese people and even the Mongoloid race in general. These findings have value outside academia, particularly in the beauty industry, medical science (such as in cosmetic medicine), and production enterprises (such as eyeglass and hat manufacturing).

1 Subjects and methods

1.1 Survey locations and sample sizes

Between 2009 and 2012, the Study Group investigated 13940 adult Han (eastern China: 6266, southern China: 3329, central China: 2898, and southwest China: 1447) and obtained head and facial data. From eastern China this included 694 cases (353 male) from Chuzhou, Anhui; 732 (370 male) from Huai'an, Jiangsu; 699 (349 male) from the Hangjiahu plain, Zhejiang; 687 (330 male) from Shaoxing, Zhejiang; 699 (349 male) from Jingdezhen, Jiangxi; 705 (354 male) from Fengcheng, Jiangxi; 683 (337 male) from Ganzhou, Jiangxi; 678 (321 male) from Zhangzhou, Fujian; and 692 (339 male) from Fuzhou, Fujian. From southern China this included 1293 cases (544 male) from Huazhou, Guangdong; 671 (313 male) from Meizhou, Guangdong; 722 (366 male) from Wenchang, Hainan; and 643 (334 male) from Qionghai and Wanning, Hainan. From central China this included 735 cases (347 male) from Jingmen, Hubei; 695 (335 male) from Jingzhou, Hubei; 738 (347 male) from Ningxiang, Hunan; and 730 (353 male) from Loudi, Hunan. From southwest China, this included 748 cases (368 male) from Qionglai, Sichuan and 699 (342 male) from Jianyang, Sichuan.

1.2 Age distribution of the sample

Head and facial characteristics may change as age increases, so sample sizes are relatively equal across age groups of 20-, 30-, 40-, 50-, and over 60-year-olds. Data was divided into three groups comprising 20–40 year-olds, 40–60 year-olds, and over-60 year olds, and separated by sex. Overall, data from 6735 men and 7205 women were obtained. Male sample sizes were 2667 (young), 2702 (older), and 1366 (senior), and those of females were 2846 (young), 2960 (older), and 1399 (senior). These data can be further broken down by area, with eastern China yielding male sample sizes of 1224 (young), 1225 (older), and 638 (senior), southern China yielding 599 (young), 621 (older), and 337 (senior), central China with 554 (young), 554 (older), and 273 (senior), and southwest China with 290 (young), 302 (older), and 118 (senior). Likewise, eastern China yielded female sample sizes of 1235 (young), 1323 (older), and 621 (senior), southern China yielded 724 (young), 708 (older), and 340 (senior), central China provided 591 (young), 621 (older), and 305 (senior), and southwest China provided 296 (young), 308 (older), and 133 (senior). The ratio of urban to rural populations was 4 to 3.

1.3 Research indicators

Lengths, heights, and widths were measured with straight and curved foot gauges (Qingyunpu Measurement Instrument, Nanchang, China). Auricular height was calculated indirectly as stature minus the tragus point. The remaining index values were measured directly. Twelve head-facial indicators were calculated based on measurements. Head circumference measurements were made using plastic tape; cheek skin-folds were measured with an imitation Rong Yan sebum thickness meter (China Institute of Sport Science, Beijing, China). In total, 22 indicators were obtained from each participant: head length (HL), head breadth (HB), minimum frontal breadth (MFB), face breadth (FB), bigonial breadth (BIGB), interocular breadth (IB), external biocular breadth (EBB), nose breadth (NB), mouth breadth (MB), physiognomic facial height (PFH), morphological facial height (MFH), nose height (NH), nose length (NL), nasal depth (ND), upper-lip height (ULH), lip height (LH), thickness of lips (TL), physiognomic ear length (PEL), physiognomic ear breadth (PEB), head circumference (HC), facial skin-fold (FS), and auricular height (AH). Following twelve indices were calculated: length-breadth index of head (LBIH), length-height index of head (LHIH), breadth-height index of head (BHIH), transverse frontoparietal index (TFI), physiognomic facial index (PFI), morphological facial index (MFI), transverse cephalo-facial index (TCFI), vertical cephalo-facial index (VCFI), zygomatico-frontal index (ZFI), height-breadth index of nose (HBIN), lip index (LI), physiognomic index of ear (PIE).

1.4 The measurement quality control

Measurements were made strictly in accordance with Martin et al. [15] and Wu et al. [16] (Tables 1–3). Respondents were healthy, native and local Han people of more than three generations. Members of the investigation team were rigorously trained before measurements were taken, and measuring instruments were corrected prior to the survey. All subjects gave their informed consent, and roadside points were set up to survey pedestrians to ensure random sampling. The examinees were required to keep their head positioned on the Eye and Ear plane, which is in a standard

Table 1 Correlation analysis on indices, indicators of male head and facial characteristics with age in Southern China ($\bar{x} \pm S$)[a)]

Index	Han in East China		Han in South China		Han in Central China		Han in Southwest China		Total	
	$\bar{x} \pm S$	r	$\bar{x} \pm S$	r	$\bar{x} \pm S$	r	$\bar{x} \pm S$	r	$\bar{x} \pm S$	r
HL	188.5±6.9	0.032	184.9±7.8	–0.040	189.6±6.6	0.042	186.5±6.2	0.032**	187.7±7.2	0.013
HB	156.2±6.6	–0.246**	155.3±8.6	–0.062*	155.9±6.0	–0.226**	151.4±6.5	–0.246	155.4±7.1	–0.177**
MFB	108.4±6.5	–0.106**	104.9±8.1	–0.102**	107.3±6.1	–0.266 **	107.5±5.0	–0.106**	107.3±6.8	–0.174**
FB	144.8±6.3	–0.142**	144.6±6.5	–0.144**	145.8±6.2	–0.188 **	144.2±5.8	–0.142**	144.9±6.3	–0.142**
BIGB	112.5±7.8	0.063	112.6±6.6	–0.100**	114.8±7.7	–0.037	112.4±6.3	0.063	113.0±7.4	–0.019
IB	33.8±3.7	–0.230**	35.4±3.4	–0.170**	33.2±3.1	–0.207 **	33.5±3.3	–0.230**	34.0±3.6	–0.150**
EBB	91.2±6.0	–0.383**	89.4±6.1	–0.337**	87.5±8.2	–0.249 **	86.7±4.9	–0.383**	89.6±6.7	–0.271**
NB	38.9±3.2	0.129**	39.3±3.2	0.150**	38.9±3.2	0.095 **	37.7±2.9	0.129**	38.9±3.2	0.129**
MB	51.3±4.6	0.276**	51.2±3.9	0.261**	51.7±4.0	0.147 **	50.3±3.7	0.276**	51.2±4.2	0.227**
PFH	190.8±9.4	0.074*	188.7±9.0	0.152**	188.5±10.0	0.205 **	186.8±8.7	0.074*	189.4±9.5	0.134**
MFH	124±7.8	0.022*	124.3±9.1	0.094**	124.8±7.9	0.215 **	130.0±8.6	0.022	124.9±8.4	0.126**
NH	54.4±5.1	–0.019	54.1±4.5	0.130**	54.4±4.5	0.146 **	58.8±4.9	-0.019	54.8±5.0	0.134**
NL	48.0±5.3	–0.024	48.2±5.3	0.079**	47.7±5.3	0.096 **	53.5±5.0	-0.024	48.5±5.6	0.082**
ND	14.6±2.8	0.094	14.0±2.8	0.046	12.7±2.1	0.127 **	14.1±2.1	0.094*	14.0±2.7	0.043**
ULH	15.9±3.0	0.452**	16.3±3.0	0.463**	15.3±2.9	0.493 **	15.3±2.8	0.452**	15.8±3.0	0.466**
LH	16.5±3.8	–0.485**	16.3±3.9	–0.508**	16.2±3.7	–0.411 **	17.4±3.7	–0.485**	16.5±3.8	–0.487**
TL	7.5±2.1	–0.494**	7.8±2.0	–0.433**	7.1±2.0	–0.408 **	8.1±2.1	–0.494**	7.5±2.1	–0.449**
PEL	64.6±5.3	0.344**	64.6±5.3	0.487**	64.0±5.3	0.352 **	62.8±4.5	0.344**	64.3±5.2	0.413**
PEB	32.0±3.3	0.234**	30.6±3.2	0.321**	31.1±3.4	0.142 **	29.5±2.8	0.234**	31.2±3.3	0.215**
HC	561.6±17.8	–0.298**	558.8±16.7	–0.219**	566.1±16.1	–0.207 **	567.3±17.5	–0.298**	562.5±17.4	–0.201**
FS	11.7±3.4	0.149**	10.3±3.7	0.188**	13.0±3.4	0.260 **	12.3±4.1	0.149**	11.7±3.6	0.195**
AH	127.6±10.0	–0.238**	129.1±10.2	–0.119**	125.3±9.6	–0.176 **	125.4±10.8	–0.238**	127.3±10.1	–0.142**
LBIH	82.9±4.4	–0.224**	84.2±6.7	–0.020	82.3±4.0	–0.213 **	81.2±4.2	–0.224**	82.9±5.0	–0.142**
LHIH	67.8±5.5	–0.248**	69.9±6.2	–0.084**	66.1±5.4	–0.183**	67.3±5.9	–0.248**	67.9±5.8	–0.136**
BHIH	81.8±6.5	–0.111**	83.3±6.7	–0.074**	80.4±6.3	–0.060 *	83.0±7.4	–0.111**	82.0±6.7	–0.039**
TFI	69.5±4.3	0.109**	67.6±5.0	–0.062*	68.9±3.9	–0.115 **	71.1±3.7	0.109**	69.1±4.5	–0.047**
PFI	131.9±8.0	0.158**	130.7±7.5	0.239**	129.5±8.1	0.303 **	129.8±7.5	0.158**	130.9±7.9	0.213**
MFI	85.8±6.5	0.090*	86.1±6.4	0.182**	85.7±6.0	0.308 **	90.3±7.0	0.090*	86.3±6.5	0.194**
TCFI	92.8±3.8	0.125**	93.3±4.0	–0.073**	93.6±3.7	0.014	95.3±3.7	0.125**	93.3±3.9	0.044**
VCFI	97.7±9.0	0.205**	96.8±9.5	0.175**	100.2±9.6	0.279 **	104.4±11.6	0.205**	98.7±9.8	0.202**
ZFI	74.9±4.3	0.017	72.5±5.0	–0.020	73.7±4.3	–0.122 **	74.6±3.5	0.017	74.1±4.5	–0.081**
HBIN	72.2±8.3	0.101**	73.2±8.0	0.001	71.9±7.6	–0.038	64.7±7.7	0.101**	71.6±8.4	–0.018
LI	32.4±8.3	–0.541**	32.0±8.3	–0.556**	31.6±7.6	–0.440 **	34.9±8.0	–0.541**	32.4±8.2	–0.526**
PIE	49.8±5.3	–0.020	47.5±4.6	–0.064*	48.8±5.4	–0.117 **	47.1±4.5	–0.020	48.8±5.2	–0.097**

a) **P*<0.05; ***P*<0.01.

standing position. To reduce systematic errors, the members of the investigation team stuck to their own survey project. Measurements were taken twice, and the mean values were used for analysis. However, if measurement differences exceeded 2 mm, a third measurement was taken. Additionally, two members of the investigation team completed each measurement. If differences in their measurements exceeded the 2 mm, the investigation-team leader re-measured the subject to determine the value used for analysis.

1.5 Statistical analysis

Survey data were analyzed using Excel 2003 and SPSS17.0 statistical software. Linear correlation analysis was used to investigate whether the head-facial index and indicator value was correlated with age. Analysis of variance (ANOVA) was used to test whether the difference between the measurement value and the index value within age groups was statistically significant. Before conducting the ANOVA, the homogeneity of variance test was performed within age groups, and non-homogeneous indicators and index values on the numeric conversion before ANOVA. *P*-values less than 0.05 were considered significant. As a precautionary measure, indicators and indexes were judged age-related only if at least 4 of the 5 indicators and indexes (including Han in East China, Han in South China, Han in Central

Table 2 Correlation analysis on indices, indicators of female head and facial characteristics with age in Southern China ($\bar{x} \pm S$)[a)]

Index	Han in East China		Han in South China		Han in Central China		Han in Southwest China		Total	
	$\bar{x} \pm S$	r	$\bar{x} \pm S$	r	$\bar{x} \pm S$	r	$\bar{x} \pm S$	r	$\bar{x} \pm S$	r
HL	179.7±6.7	0.147**	176.9±7.4	0.016	181.1±6.0	0.136**	178.3±5.9	0.111**	179.1±6.9	0.107**
HB	149.2±5.6	−0.211**	147.8±7.7	−0.156**	148.8±5.2	−0.179**	144.9±5.7	−0.297**	148.3±6.3	−0.184**
MFB	105.9±5.9	−0.146**	100.9±8.3	−0.072**	105.0±5.3	−0.165**	106.1±5.1	−0.025	104.5±6.7	−0.101**
FB	137.5±5.9	−0.130**	136.9±5.7	−0.193**	139.0±5.2	−0.146**	136.3±5.2	−0.226**	137.6±5.7	−0.154**
BIGB	106.4±7.2	0.056**	106.7±5.7	−0.093**	109.1±6.9	−0.031	107.9±5.4	0.061	107.2±6.7	0.004
IB	33.0±3.5	−0.042*	34.4±3.2	−0.091**	32.2±3.0	−0.126**	32.5±3.0	−0.278**	33.1±3.4	−0.092**
EBB	87.9±5.5	−0.250 **	85.9±6.0	−0.311**	83.9±8.7	−0.183**	82.8±4.4	−0.398**	86.0±6.6	−0.232**
NB	36.3±3.0	0.254**	36.3±3.0	0.254**	36.2±2.7	0.156**	34.9±2.5	0.315**	36.1±2.9	0.240**
MB	48.9±4.0	0.211**	49.1±3.7	0.369**	49.3±3.7	0.235**	47.6±3.4	0.284**	48.9±3.9	0.236**
PFH	180.7±8.3	−0.050**	179.4±7.7	0.032	179.2±8.5	0.023	178.2±8.5	−0.13**7	179.8±8.3	−0.021
MFH	116.5±7.0	0.130**	115.7±7.7	−0.051*	116.8±7.3	0.217**	122.1±7.5	−0.093**	116.9±7.5	0.071**
NH	51.1±5.0	0.111**	50.1±4.1	−0.022	50.2±4.5	0.048	53.7±4.0	−0.049	50.9±4.7	0.052*
NL	44.5±5.2	0.049**	44±4.7	−0.054 *	43.6±5.5	0.003	48.6±4.2	−0.086*	44.6±5.3	0.000
ND	12.9±2.7	0.020	12.6±3.0	−0.06**7	11.3±2.0	0.111**	12.3±2.0	0.044	12.5±2.7	0.013
ULH	14.7±2.8	0.469**	14.8±2.8	0.517**	13.9±2.7	0.554**	13.8±2.7	0.46**5	14.4±2.8	0.493 **
LH	15.8±3.4	−0.449**	15.5±3.4	−0.482**	15.4±3.3	−0.328**	16.6±3.5	−0.492**	15.7±3.4	−0.436**
TL	7.1±1.8	−0.387**	7.3±1.6	−0.389**	6.6±1.7	−0.297**	7.5±1.9	−0.472**	7.1±1.8	−0.375**
PEL	60.7±5.2	0.501**	61.1±5.3	0.519**	60.1±5.1	0.444**	59.3±4.5	0.477**	60.5±5.2	0.490**
PEB	31.1±3.3	0.379**	29.2±3.1	0.341**	30.4±3.7	0.303**	28.5±2.8	0.332**	30.2±3.4	0.342**
HC	544.9±17.2	−0.092**	539.1±15.1	−0.219**	549.1±14.7	−0.084**	549.1±15.6	−0.189**	544.8±16.4	−0.125**
FS	13.6±2.8	0.260**	12.4±3.0	0.222**	14.5±2.6	0.313**	14.8±3.0	0.173**	13.6±3.0	0.242**
AH	122.9±9.1	−0.114**	123.9±9.9	−0.126**	121.3±9.5	−0.103**	119.4±11.5	−0.181**	122.5±9.7	−0.120**
LBIH	83.1±4.2	−0.267**	83.8±6.7	−0.132**	82.2±3.8	−0.240	81.4±4.2	−0.299**	82.9±5.2	−0.202**
LHIH	68.5±5.4	−0.177**	70.2±6.5	−0.134**	67.0±5.4	−0.155**	67±6.6	−0.215**	68.2±5.9	−0.161**
BHIH	82.5±6.4	−0.006	84±6.7	−0.027	81.6±6.4	−0.025	82.5±8.2	−0.054	84.7±12.1	−0.027
TFI	71.1±4.0	−0.006	68.4±5.5	−0.001	70.6±3.7	−0.037	73.3±3.9	0.198**	70.8±4.9	0.011
PFI	131.6±7.7	0.056**	131.3±7.1	0.035	129.0±6.7	0.128**	130.9±7.4	0.041	126.7±21.5	0.041**
MFI	84.8±6.2	0.183**	84.6±5.8	−0.006	84.1±5.6	0.290**	89.7±6.4	0.042	92.1±33.8	0.014
TCFI	92.3±3.6	0.058**	92.7±4.0	0.032	93.5±3.1	0.022	94.1±3.5	0.082*	90.8±10.5	0.032**
VCFI	95.2±8.5	0.183**	93.8±8.7	−0.101	96.8±8.8	0.235**	103.2±11.6	0.121**	97.5±11.8	0.095**
ZFI	77.1±4.1	−0.048**	73.8±5.5	−0.018	75.6±3.8	−0.052*	77.9±3.5	0.170**	89.0±61.3	−0.017
HBIN	71.6±8.4	0.090**	73.1±8.3	0.102**	72.4±7.6	0.070**	65.3±7.0	0.247**	71.2±8.4	0.102**
LI	32.6±7.6	−0.490**	31.9±7.6	−0.427**	31.5±7.2	−0.387**	35.2±7.8	−0.555**	32.8±7.8	−0.457**
PIE	51.5±5.4	−0.028	48±5.0	−0.034	50.8±5.9	0.004	48.2±4.5	−0.026	52.1±10.0	−0.024*

a) *P<0.05; **P<0.01.

China, Han in Southwest China, and Southern-China Han) were statistically significant.

2 Results

These male indices were negatively correlated with age: HB, MFB, FB, IB, EBB, LH, TL, HC, AH, LBIH, LHIH, BHIH, and LI, showing linear decreases. TFI was both positively and negatively correlated with age depending on the information, so it cannot be judged as exclusively negatively correlated. These indices were positively correlated with age: NB, MB, PFH, MFH, UIH, PEL, PEB, FS, PFI, MFI, TCFI, and VCFI, showing linear increases. The remaining eight indices and indicators were not linearly related with age (Table 1).

These female indices were negatively correlated with age: HB, MFB, FB, IB, EBB, LH, TL, HC, AH, LBIH, LHIH, and LI, showing linear decreases. These indices were positively correlated with age: HL, NB, MB, MFH, ULH, PEL, PEB, FS, VCFI, and HBIN, showing linear increases. The remaining 12 indices and indicators were not linearly related with age. Overall, data from men and women yielded similar results (Table 2).

ANOVA revealed that all differences in index and indicator values observed between age groups were significant except for male HL, and female ND and ZFI. Both male and female head and facial characteristics showed statistically significant changes with age increases. Some indices and indicators varied linearly with increased age, while others varied in V-shaped or inverted V-shaped relationships (Table 3).

3 Discussions

3.1 Indicators and indices negatively correlated with age

Comprehensive results from the correlation and variance analyses of both males and females indicate that as the age of Southern Han increased, the values for head breadth (HB), minimum frontal breadth (MFB), face breadth (FB), interocular breadth (IB), external biocular breadth (EBB), lip height (LH), thickness of lips (TL), head circumference (HC), auricular height (AH), length-breadth index of head (LBIH), length-height index of head (LHIH), and lip index (LI) significantly decreased in a linear fashion ($P < 0.05$).

Hair thickness and the thickness of subcutaneous fat on the side of the head have some impact on HB values. Decreases in HB values are related to thinning of soft tissue of the zygomatic arch. Hair loss also increased with age (especially in the elderly), and dropping of HC values may be related to this.

IB, EBB, LH, and TL are non-bony indicators. As age increased, the number of mongoloid folds dropped significantly, which would cause IB reduction. EBB also decreased with age. Internal structural changes to the eyelid lead to eyelid laxity. Studies have shown that disappearance of fat and elastic fibers lead loose skin and drooping eyelids in older people [17]. Eyes fissions are smaller because of the reductions to EBB are larger than those of IB.

TLs of both males and females were significantly thinner in older subjects. HL thinning and UIH increasing occur together.

LH decline was related to the upper and lower lips. An approximation of lower-lip thickness can be obtained from the difference between LH and upper-lip thickness. Male lower-lip thickness decreased from 9.1 (20-year-olds) to 7.6 mm (60-year-olds), and female lower-lip thickness decreased from 9.4 (20-year-olds) to 7.3 mm (60-year-olds). Combined upper- and lower-lip thinning resulted in decreased HL values.

Although HC is basically an indicator of bone, hair was included while measuring. The mean difference between the male 20-year-old and 60-year-old groups was 9.9 mm, while that for females was 5.6 mm (Table 3). The decrease reached significance after the age of 60 and has a certain relationship with hair thinning associated with age. Because older females still had thick hair, female HC values decreased less than male values.

Height and tragus points declined as age increased. Comparing the 20- and 60-year-old groups, the male mean height dropped 62.3 mm (from 1682.6 to 1620.3 mm) and mean tragus points declined 58.9 mm (from 1553.6 to 1494.7 mm). The rate of reduction in tragus points was less than that of height, which led to the decline in AH values. Head height is an indicator of bone, but the tragus point is a non-bony point, which showed that AH values were negatively correlated with age.

Although male HL values did not change significantly as age increased, those of females increased. Both male and female HB and AH values significantly decreased, explaining the decrease in LBIH and LHIH. As age increased, both male and female lips thinned and MB values became larger, leading to a decline in LI.

3.2 Indicators and indices positively correlated with age

Comprehensive results from the correlation and variance analyses of both males and females indicate that as the age of Southern Han increased, the values for NB, MB, MFH, UIH, PEL, PEB, FS and VCFI significantly increased in a linear fashion.

NB age was positively correlated with the morphological changes of the alar. Comparing 20 and 60-year-old groups, the male MB increased on average by 2.1 mm (from 50.1 to 52.2 mm) and that of females increased 2 mm (from 47.8 to 49.8 mm). The mouth skin laxity related to gape gradually widened.

MFH is the distance between the nasion point and sub-

Table 3 Variance analysis on means of head and facial indices values and indicators in groups of 3 age groups ($\bar{x}$ ±*S*)[a)]

Index	Male total (years old)				Female total (years old)			
	20-	40-	60-	*F*	20-	40-	60-	*F*
HL	187.6±7.1	187.8±7.2	187.5±7.3	1.278	178.4±6.8	179.4±6.8	180.0±7.0	29.799**
HB	156.8±7.2	155.0±6.9	153.5±6.8	107.431**	149.6±6.4	147.7±6.1	147.0±5.9	106.977**
MFB	108.6±7.0	106.9±6.7	105.5±6.3	100.245**	105.1±6.9	104.6±6.5	103.2±6.6	38.105**
FB	145.9±6.3	144.7±6.2	143.3±6.2	79.241**	138.4±5.5	137.5±5.6	136.0±6.0	86.643**
BIGB	113.1±7.2	113.4±7.5	112.0±7.7	15.395**	107.0±6.4	107.7±6.7	106.6±7.2	13.484**
IB	34.7±3.4	33.4±3.5	33.7±3.8	99.725**	33.6±3.2	32.7±3.3	33.0±3.7	45.053**
EBB	91.5±6.4	89.1±6.4	86.7±6.4	273.127**	87.6±6.4	85.6±6.5	83.6±6.4	193.735**
NB	38.5±3.0	39.0±3.3	39.4±3.4	37.959**	35.4±2.7	36.3±2.9	37.1±3.0	187.929**
MB	50.1±4.2	51.8±4.1	52.2±4.2	165.306**	47.8±3.7	49.5±3.7	49.8±4.0	188.231**
PFH	188.0±9.1	190±9.5	191±9.8	51.870**	179.9±7.9	180.0±8.3	179.3±8.9	3.633*
MFH	123.7±8.2	125.4±8.3	126.2±8.6	48.236**	116.2±7.5	117.4±7.3	117.5±7.8	25.292**
NH	54.2±5.0	54.8±5.0	56.0±5.0	58.795**	50.7±4.6	50.8±4.6	51.6±5.1	18.657**
NL	48.1±5.5	48.5±5.6	49.4±5.6	23.458**	44.6±5.2	44.4±5.2	45.0±5.5	5.732**
ND	13.9±2.7	14.1±2.7	14.2±2.8	6.477**	12.4±2.6	12.5±2.7	12.4±2.7	1.142
ULH	14.3±2.6	16.3±2.8	17.7±2.7	802.154**	13.0±2.4	14.9±2.5	16.4±2.6	963.120**
LH	18.3±3.2	16.0±3.5	13.8±3.7	832.300**	17.1±2.8	15.5±3.1	13.3±3.6	713.821**
TL	8.4±1.9	7.3±1.9	6.2.0±2.0	636.446**	7.7±1.6	7.0±1.7	6.0±1.9	480.403**
PEL	62.0±4.6	65.0±4.9	67.1±5.3	557.774**	57.9±4.3	61.1±4.6	64.4±5.0	978.687**
PEB	30.5±3.2	31.5±3.3	32.1±3.4	136.086**	29.0±3.1	30.7±3.3	31.8±3.5	384.902**
HC	565.8±16.8	562.5±17	555.9±17.6	153.573**	546.5±15.6	545.0±16.4	540.9±17.5	55.951**
FS	11.0±3.5	12.2±3.6	12.2±3.6	97.227**	12.8±2.7	14.1±2.9	14.3±3.0	220.126**
AH	129.0±9.9	126.3±10.2	125.7±10	68.387**	124.0±9.6	121.4±9.5	121.6±10.0	56.891**
LBIH	83.7±5.1	82.6±4.9	82.0±4.9	59.763**	84.0±5.1	82.5±4.8	81.8±4.6	119.921**
LHIH	68.8±5.7	67.3±5.9	67.1±5.8	59.321**	69.6±5.9	67.8±5.7	67.6±6.0	85.359**
BHIH	82.4±6.6	81.6±6.8	82.0±6.7	8.390**	83.0±6.6	82.3±6.7	82.8±7.0	7.217**
TFI	69.3±4.6	69.0±4.4	68.8±4.3	6.440**	70.3±4.6	70.9±4.5	70.3±4.6	12.003**
PFI	129.1±7.6	131.5±7.8	133.4±7.9	153.139**	130.1±7.0	131.1±7.4	132.0±7.8	33.601**
MFI	84.9±6.3	86.8±6.4	88.2±6.7	127.184**	84.0±6.1	85.5±6.0	86.5±6.4	88.849**
TCFI	93.1±4.0	93.5±3.8	93.4±3.7	5.305**	92.6±3.6	93.1±3.6	92.6±3.8	19.259**
VCFI	96.4±9.2	99.8±9.7	101.0±10.1	132.455**	94.2±8.9	97.2±9.2	97.2±9.8	93.119**
ZFI	74.5±4.6	73.9±4.5	73.7±4.1	17.536**	76.0±4.7	76.1±4.6	75.9±4.6	0.776
HBIN	71.7±8.4	71.8±8.5	70.8±8.1	6.940**	70.3±8.1	72.1±8.3	72.5±8.6	49.217**
LI	36.8±7.1	31.1±7.1	26.5±7.3	1005.072**	36.0±6.6	31.6±6.7	26.9±7.5	884.973**
PIE	49.3±5.2	48.6±5.2	48.1±5.4	26.080**	50.2±5.4	50.3±5.5	49.6±5.9	8.184**

a) *$P<0.05$; **$P<0.01$.

mental point. The nasion point is a bone point, while the submental point is non-bony. As age increases, submental adipose tissue increases and the soft tissue thickens [17], which explains the increase of MFH.

Comparing age groups, upper-lip skin height increased 3.4 mm in both males and females (male, 14.3 to 17.7 mm; female, 13.0 to 16.4 mm). Similarly, male and female ULH increased by 3.4 mm (male, 14.3 to 17.7 mm; female, 13.0 to 16.4 mm). ULH-value increase is related to the structural changes of the subcutaneous tissue.

As age increases, fat and elastic fibers in of the ears and palate decrease and skin sags [17], which may cause the increase in ear size that is observed with age. However, whether the increase in ear size is due to continued slow growth throughout life or by sagging of ear skin needs further study.

FS value was also positively correlated with increased age, indicating that Southern Han males and females accumulated subcutaneous facial fat. Because MFH positively correlated with age, AH negatively correlated age. VCFI is the ratio between MFH and AH, thus it positively correlated with age.

3.3 Indicators and indices that had no clear correlation with age

Both male and female BIGB, NH, NL, ND, ZFI, and PIE had no correlation with age. Male HL and HBIN had no correlation with age, while those of females correlated positively. Female PFH, BHIH, PFI, MFI, and TCFI had no clear correlation with age, while male GFH and BHIH positively correlated with age, PFI, MFI, and TCFI positively correlated with age. These results reflect gender differences in the changes to the face with age.

These indicators and indices that had no correlation with age can be used for comparisons between different age distributions among populations.

3.4 Changes of physiognomic facial characteristics of Han in Southern China

From the analysis above we can conclude that as age increases, the following physiognomic characteristics of Southern Han change: HL, MFB, and FB decrease, the head turns longer, narrower and lower, HC becomes smaller, facial height increases, the distance between the eyes becomes smaller, eye fissures become smaller, the upper and lower lips become thinner, NB gets wider, the mouth narrows and elongates, the distance between the nose and mouth increases, ears become longer and wider, and the cheeks become fuller.

Lu et al. [18] considered that female faces are easier to remember and that changes in the characteristics of the female faces occur more than in male faces. This paper shows that there is no significant difference in the quantity of changes in head-face morphological characteristics quantities between males and females.

3.5 Preliminary analysis of the reasons for the changes in head and facial features

Through the analysis of Han, Li, Miao, and Hui physical characteristics of Hainan, Wu et al. [3] found that lip thickness and upper-lip skin height change with age. Age is positively correlated with the height of the upper-lip skin and mouth width, and negatively correlated with lip thickness. In a study of age-related changes in physical characteristics of the Hui minority, Zheng et al. [4] found that most of the indicators that were tested showed significant changes contained soft tissues. Wu et al. [3] pointed out that because of the effects of aging, most of the factors that are positively related to age contain soft tissues. Chen et al. [19] thought the thickness of head and facial soft tissues of the Tujia minority were significantly different depending on both age and gender. The soft tissues of the head and face are different between subgroups of Chinese people.

We believe that changes in head and facial features caused by age are due to the body's inherent variation over time. Specifically, head and facial skin, subcutaneous fat, elastic fibers, and cells with other functions have physiological changes. For example, auricles become larger. Because of genetic factors, age, changes in nutrition level, and physiological status, soft tissues change more obviously than bone tissue in adults. The accumulation of fat, the slow changes of bone and connecting tissues lead to gradual changes in the external morphology of the human body. Many human-morphology indicators are also genetics indicators, and the laws governing some of the changes seen with age have some genetic basis. To explore the mechanism of this change more deeply, research in the field of molecular genetics must be undertaken. In recent years, Chinese scholars have begun to study the Chinese population from the level of the genome [20–22]. Here we have analyzed the variation in head and facial features from a macro perspective that can complement, but not substitute, studies done at a micro level.

Luojinsky et al. [23] thought that we can draw a universal conclusion through researching racial characteristics that change with age. In fact, age trends are very similar across races. Since all people share morphological characteristics, the results of this study reflect to some extent the physical laws governing changes in human head and facial features. However, some morphological characteristics differ greatly across races. For example, the size of the external naris and the thickness and shape of the lips relate to temperature adaptations [24]. Recently, Chinese scholars [25] have proved that the cemetery in a water village of Hotan Prefecture, Xinjiang, China, contains a mixed group of East and West races from Eurasia that can be traced back to 1000 BC. Because studying multiple ethnicities is complicated, this article focused on Southern Han. Whether the results of this study apply to other ethnic groups in China needs to be further explored.

4 Conclusions

Changes in head and facial features caused by age are due to the body's inherent variation over time. Specifically, head and facial skin, subcutaneous fat, elastic fibers, and cells with other functions undergo physiological changes. Rules that govern age-related variation in some indices have a certain genetic basis. The main conclusions are:

(1) As age increases, the following physiognomic characteristics of Southern Han change: HL, MFB, and FB decrease, the head turns longer, narrower and lower, HC becomes smaller, facial height increases, distance between the eyes becomes smaller, eye fissures become smaller, upper and lower lips become thinner, NB gets wider, the mouth narrows and elongates, distance between the nose and mouth increases, ears become longer and wider, and cheeks become fuller.

(2) Correlation analysis and ANOVA show that as age increases, HB, MFB, FB, IB, EBB, LH, TL, HC, AH, LBIH, LHIH, and LI values decrease linearly and significantly in South-China Han.

(3) Analysis also shows that in the same population, as age increases, NB, MB, MFH, ULH, PEL, PEB, FS, and

VCFI values increase linearly and significantly.

(4) BIGB, NH, ND, ZFI, and PIE were uncorrelated with age in either male or female South-China Han, while HL and HBIN were uncorrelated with age only in males.

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