Anthropometric Analysis of the Growth Proportions of the Head and Face in Koreans.

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Abstract

The present study is to identify primarily the morphological characteristics in the growth proportion of the head and face for young Korean (8~24 years) and compare the magnitude of growth changes to the sex-related differences. Total 1,255 were divided into 3 age groups: childhood (8~10 years), adolescence (14~16 years), and young adult (20~24 years). The anthropometric assessments were performed with 11 landmarks on the head and facial dimensions. The standardized frontal and lateral head and face photographs were analyzed the craniofacial growth proportions and morphological features for the comparison of both sexes. The noteworthy differences of anthropometric measurements between sexes with growing were noted on the lower head height (22.6%, 17.8%), midface height (22.0%, 19.6%), lower face height (23.5%, 14.7%), and face length (21.1%, 14.9%), face breadth (14.8%, 11.3%) of males and females, respectively. Whereas the upper head height (7.9%, 6.0%) and upper face height (4.2%, 0%, respectively) were less growing features. The most remarkable changes are the dimension of midface height and lower face height in both sexes. The present study could demonstrate a fundamental example to elucidate the sex-related dimensional differences for the analysis of the growth proportion of both sexes in Koreans.

Introduction

There is a great diversity in racial features regarding the proportions of the body and craniofacial dimensions. The head and face are the most identifiable racial characteristics, and previous studies have investigated race-related differences in various craniofacial regions[1]. In particular, the growth characteristics of the head and face regarding the facial shape, volume, and positioning during development have been differentiated according to race-related variations and sexual dimorphism[2]. Irrespective of age and race, males are generally larger than females[3]. The sexual dimorphism might be greatly affected by factors related to muscle volumes and bone growth in the craniofacial regions[2], and specific outward differences between populations at the age of adolescence of the sexes[4].

Craniofacial anthropometry can provide fundamental objective biological data on craniofacial growth that can be used in clinical research to quantify changes in the wide diversity of human morphology[5]. The morphological growth interactions between the head and face can be specifically identified by craniofacial anthropometry[6]. The interacting morphometric components in the craniofacial regions determine the changes in the face height and other facial characteristics, as correlated with overall skull morphology[7]. While there is substantial evidence that morphological differences of the craniofacial regions are determined by both genetics and the environment, specific databases for changes in dimensional growth proportions in the craniofacial regions during development have received little attention. This information has been presumed hypothetically without being based on exact measurements, with investigations being inhibited by the complexity of making detailed measurements in the craniofacial regions.

Therefore, the purposes of the present study were to construct an anthropometric database of the growth proportions of the head and face in young Koreans and to quantify the growth proportions in the craniofacial region dimensionally and proportionally.

Results

The comprehensive measurement data are listed in Table 2. All dimensions of the head and face were significantly larger in males than in females (independent *t*-test: $p < 0.05$). The most obvious increases in dimensions in both sexes were in the heights of the lower head, midface, and lower face, and the face length and face breadth, particularly during the adolescent period. The upper head height and upper face height showed smaller growth proportions in both sexes (Table 2 and Figs. 2, 3).

Head height.

The overall head height increased during development, by approximately 29 mm (14.9%) in males and 22 mm (11.6%) in females from childhood to young adult ($p < 0.05$). The lower head heights showed the largest increase in both sexes during the adolescent period, by 15 mm (16.1%) in males and 10 mm (11.1%) in females, whereas there was no significant increase in the upper head height [2 mm (2.0%), and 5 mm (5.0%), respectively; Tables 2, 3 and Fig. 2]. These findings indicate that the overall growth of the total head height was caused by the growth of the lower head rather than of the upper head. The difference in height between the upper head and lower head during development was greater in males than in females.

Face height.

The overall face height increased by approximately 24 mm (14.6%) in males and 16 mm (10.0%) in females from childhood to young adult ($p < 0.05$). The midface height and lower face height also increased significantly in both sexes ($p < 0.05$). The midface and lower face heights increased by 13 mm (22.0%) and 8 mm (23.5%), respectively, in males, while the upper face height increased by only 3 mm (4.2%) (Table 3 and Fig. 4). In females, the midface height and lower face height increased by 11 mm (19.6%) and 5 mm (14.7%), respectively, while there was no numerical change in the measured upper face height ($p > 0.05$, Tables 2 and 3). These changes were influenced most by the growth of the midface and lower face in both sexes (Table 3 and Fig. 3).

Length.

The head length in males increased by 11.6%, while the face length increased by 21.1% ($p < 0.05$). The increase in the head length in females of 6.8% was not significant ($p > 0.05$), while the face length increased significantly by 14.9% ($p < 0.05$, Tables 2 and 3). The growth proportion of the face length in both sexes was greater than that of the head length (Table 3).

Breadth.

The head breadth and face breadth increased by approximately 16 mm (11.3%) 19 mm (14.8%), respectively, in males ($p < 0.05$), and by 11 mm (8.1%) and 14 mm (11.3%) in females ($p < 0.05$).

Discussion

The perspective of head height in this study we evaluated that the growth proportions were greatest for the head height in both sexes. The growth of the lower head height was threefold higher than that of the upper head height in both sexes (Table 3). The pattern of the total head height was the same as that for the average of the upper and lower head heights (Fig. 2).

The lower head dimensions are significantly affected by bone deposition on the inferior border of the zygomatic bone and surrounding temporal bone that occurs for vertical craniofacial growth[2,8]. It is particularly interesting that the measurements of the upper and lower head differed significantly with sex. Throughout the adolescent period, the lower head height in males was greater than the upper head height, whereas the upper head in females remained slightly larger than the lower head, and even larger than the upper head height in males. In general, sexual dimorphism begins to become prominent at an age of 12 years. Song et al.[9] found that the head height was approximately 5% greater in males than in females. However, the peripubertal development period typically occurs 2 to 5 years earlier in females than in males[2]. It is reported that the growth of the bone underneath the sphenoid bone is sexually determined by 14 years in females and 17 years in males[10]. This sex-related difference might be attributable to the hormonally induced growth system, which occurs earlier and is more rapid in girls during puberty[11].

In terms of face height, the total face height was overall larger in males than females (Table 2). The growth of the midface and lower face heights dominated in the present study (Table 3), which is consistent with previous reports of these two dimensions being crucially responsible for increased measurements irrespective of race and sex[12,13].

In Koreans, the upper face height is larger than the midface and lower face heights in both sexes. In terms of face growth proportions, the midface, lower face, and upper face heights increased by 22.0%, 23.5%, and 4.2%, respectively, in males, and by 19.6%, 14.7%, and 0% in females (Table 3). These findings for the midface and lower face heights probably involved the growth of orbital contents and the surrounding wall of the orbital cavity and mandible acting via masticatory movements[8]. However, the growth of the upper face was less active in adolescents in the present study, which might be related to the brain size, which would increase steadily to 95% of the adult size during the first 10 years of life, with the growth rate decreasing thereafter[14].

Previous comparative studies of the growth proportions for the maxillary and mandibular heights in Caucasian females during the adolescent period found that the increase in the mandibular height on the lower face was nearly double that of the maxillary height on the midface[15]. However, the present study found similar growth proportions of 10.7% and 11.8% in the midface height and lower face height, respectively, during the same period (Table 3). The extent of the anterior cranial base reportedly differs by race, indicating differences in morphological features and growth proportions of the maxillomandibular relationships between races[16].

Meanwhile, the growth of the midface height was the most noticeable in both sexes in the present study. The midface height increased by 22.0% in males and 19.6% in females, which led to the midface height becoming close to the upper face height (Table 2 and Figs. 3,4). Thus, the growth pattern of the total face height was the most similar to the growth pattern of the midface height among all face height measurements (Fig. 3). It was particularly interesting that the proportional growth between the midface and lower face differed with sex: the lower face and midface heights increased by 23.5% and 22.0%, respectively, in males, in contrast to by 14.7% and 19.6% in females. These findings resemble the reports of Farkas et al.[5] and Battagel[17] that the height of the mandible on the lower face in females increased by 5 mm, compared with by about 8 mm in the midface up to 18 years of age.

Another point of view for head and face length we investigated that the face length increased more than the head length in both sexes. The head and face are overall longer in males than in females. Farkas et al.[13] reported that the face length of Caucasian males increased by about 15 mm up to 16 years of age, whereas the increase was about 9 mm in the present study during the same period.

There was a typical morphological difference between the skull shapes of Caucasians and Koreans. Caucasians tend to have a long oval-shaped head (dolichocephalic) while Koreans tend to have a short more-rounded head shape (brachycephalic). It could therefore be assumed that dimensions in the anteroposterior direction would generally be longer in Caucasians than in Koreans. Anatomically, the lateral surface growth in the zygomaticotemporal region makes the largest contribution to the anteroposterior length[18]. Also, the morphological growth of the ventral surface of the sphenoid causes bone expansion of the cranial base up to the age of 19 years[19,20]. Battagel[17] determined that the face length increased by 1.0 ~ 1.7 mm per year from 6 to 16 years of age. Sequential increases in face length would contribute to changes in the adjacent breadth components in the craniofacial region[6].

In the meantime, as seen our findings of the head and face breadth comparing with other races and sex, breadth-related dimensions generally differ significantly between the sexes[21]. The overall breadth tends to be around 20% larger in males than in females due to difference in the facial musculature and bone growth[3]. The horizontal dimensions of the face have visually noticeable racial differences[5], with the faces of Asians typically being transversely wider and flatter than Caucasian faces[22]. Farkas et al.[13] reported that the face breadth of Caucasian females was an average of 117.3 mm at 8 years of age and increased to an average of 130.6 mm at 16 years of age; the corresponding breadths were 124.1 and 133.1 mm in the present study, which indicates that the face is wider in Koreans than in Caucasians. Moreover, the head is wider than the face in Caucasians[23], whereas the opposite is true in East Asian females[24].

Meanwhile, the difference in head breadth and face breadth between the sexes was smaller than the differences in the other measurements in the present study. The breadth differences between the head and face were 9 ~ 10 mm for all development periods in the present study (Table 2). This can be attributed to the growth of the skull having similar effects on the euryon and zygion. The head breadth (as measured from euryon to euryon) increases vertically and horizontally as the brain size increases, which affects the entire cranial shape and the face breadth[6].

While many similarities were found in the comparative analysis of breadth measurements between Koreans and Caucasians, direct comparisons with other races are made difficult by the use of different types of statistical measurements[1]. Also, it should be remembered that breadth measurements are affected by the morphology varying between different geographical regions[25].

The specific relationships between the growth proportions of the head and face and bone maturation remain unclear. Many authors have hypothesized that these relationships are most likely driven by diverse growth factors in craniofacial regions, such as the amount of masticatory movements, the dietary intake of meat, and the physiological activity level[26].

The present study was subject to a few limitations. First, the mandibular breadth was not measured. Ritz-Timme et al.[27] considered the average mandibular breadth to be the most critical horizontal dimension for growth proportions in craniofacial regions. Second, the body height is related to craniofacial growth, and the proportional growth change between the head and face could vary with race according to the body height[1,28]. Therefore, further investigations should assess diverse measurements in the zygomandibular region as well as statistical correlations between craniofacial growth and body growth.

In conclusion, this study has investigated the craniofacial growth proportions in Koreans aged 8 to 24 years by analyzing data obtained in 2003 survey of the Size Korea project. The study included large quantitative samples in the morphological analysis of a single (Korean) population during the development period. Sex-related differences during the adolescent period present as clear sexual dimorphism, with there being statistically significant differences in measurements and changes in relative growth proportions morphologically and proportionally during development. The findings of this study for craniofacial growth proportions could be useful in various fields related to human morphology.

Methods

Participants.

The measurements performed in the present study were based on the average values obtained in the “Size Korea” project[29] that started in 2003. The anthropometric data of the 1,255 Korean males (n=627) and females (n=628) between the ages of 8 and 24 years were analyzed to obtain information on the growth proportions of the head and face of young Koreans selected at random. Subjects without any distinctive deformity of the head and face were categorized into three age groups: childhood (8~10 years), adolescence (14~16 years), and young adults (20~24 years). The distribution of the subjects is presented in Table 1. All subjects signed informed-consent forms before participating in the project.

Scanning procedures and craniofacial data measurements.

Scanning was performed 2 m from each subject while they were sitting upright with the feet together and instructed to display a neutral facial expression. No photographs were taken, with instead only measurements being made of the height, length, and breadth of the head and face. Distances were measured using 3D software based on 11 landmarks marked on the craniofacial surface. The following dimensions based on the landmarks were measured (Fig. 1):

Head-height dimensions

1. Head height: vertex to menton (v-m)
2. Upper head height: vertex to sellion (v-se)
3. Lower head height: sellion to menton (se-m)

Face-height dimensions

4. Face height: trichion to menton (tri-m)
5. Upper face height: trichion to sellion (tri-se)
6. Midface height: sellion to stomion (se-sto)
7. Lower face height: stomion to menton (sto-m)

Length dimensions

8. Head length: glabella to inion (g-in)
9. Face length: rhinion to tragion (rh-tr)

Breadth dimensions

10. Head breadth: euryon to euryon (eu-eu)
11. Face breadth: zygion to zygion (zy-zy)

Statistical analysis.

To assess the statistical analysis, Microsoft Office Excel (Microsoft Corporation, WA) and SPSS for Windows (SPSS, Chicago, IL) was applied. Differences in the measurements with age or sex were assessed using an independent t-test with analysis of variance. The criterion for statistical significance was set as $p<0.05$.

Declarations

Author contributions

I.S.Y. had the contributions to analysis and interpretation of data, writing the article and designing critically for important intellectual content.

J.A.P. revised it critically for important intellectual content.

H.I.L. contributed to acquisition, data analysis for the article.

K.S.K. revised it critically for important intellectual content, final approval of the version to be published.

W.C.S. had the contributions to conception and design, revised it critically for important intellectual content, final approval of the version to be published.

Additional Information

Competing interests: The authors declare no competing financial interests.

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Tables

Table 1
Distribution of age and sex.

	Childhood	**Adolescence**	**Young adult**	
Sex	(8 ~ 10 years)	(14 ~ 16 years)	(20 ~ 24 years)	Total
Male	158	209	260	627
Female	152	215	261	628
Total	310	424	521	1,255

Table 2

Measurement value according to age and sex group (Unit: mm, Mean ± SD). * means statistically significant difference between the ages in male ($p < 0.05$) and § means statistically significant difference between the ages in female ($p < 0.05$).

		Male			Female		
Measurements	**#**	**Childhood**	**Adolescence**	**Young adult**	**Childhood**	**Adolescence**	**Young adult**
Head height	1	194 ± 27	211 ± 28	223 ± 27	190 ± 24	205 ± 25	212 ± 25
Upper head height	2	101 ± 17	103 ± 16	109 ± 16	100 ± 16	105 ± 15	107 ± 15
Lower head height *§	3	93 ± 12	108 ± 13	114 ± 14	90 ± 10	100 ± 12	106 ± 13
Face height	4	164 ± 24	179 ± 24	188 ± 24	160 ± 21	170 ± 23	176 ± 21
Upper face height	5	71 ± 18	71 ± 19	74 ± 19	70 ± 16	70 ± 17	70 ± 17
Midface height *§	6	59 ± 8	67 ± 9	72 ± 9	56 ± 6	62 ± 7	67 ± 7
Lower face height *§	7	34 ± 7	41 ± 9	42 ± 9	34 ± 6	38 ± 7	39 ± 7
Head length	8	164 ± 21	174 ± 20	183 ± 20	162 ± 18	169 ± 19	173 ± 19
Face length *§	9	76 ± 13	85 ± 12	92 ± 11	74 ± 11	81 ± 10	85 ± 10
Head breadth	10	141 ± 18	149 ± 18	157 ± 18	136 ± 16	142 ± 17	147 ± 16
Face breadth *§	11	128 ± 15	139 ± 17	147 ± 15	124 ± 13	133 ± 15	138 ± 15

Table 3

The comparison of growth proportion between the age of groups (Unit: %). * means statistically significant difference between the ages in male ($p < 0.05$) and § means statistically significant difference between the ages in female ($p < 0.05$).

		Male			Female		
Measurements	**#**	**Childhood ~ adolescence**	**Adolescence~ young adult**	**Total**	**Childhood ~ adolescence**	**Adolescence~ young adult**	**Total**
Head height	1	8.8	6.1	14.9	7.9	3.7	11.6
Upper head height	2	2.0	5.9	7.9	5.0	1.0	6.0
Lower head height *§	3	16.1	6.5	22.6	11.1	6.7	17.8
Face height	4	9.1	5.5	14.6	6.3	3.7	10.0
Upper face height	5	0.0	4.2	4.2	0.0	0.0	0.0
Midface height *§	6	13.6	8.4	22.0	10.7	8.9	19.6
Lower face height *§	7	20.6	2.9	23.5	11.8	2.9	14.7
Head length	8	6.1	5.5	11.6	4.3	2.5	6.8
Face length *§	9	11.8	9.3	21.1	9.5	5.4	14.9
Head breadth	10	5.7	5.6	11.3	4.4	3.7	8.1
Face breadth *§	11	8.6	6.2	14.8	7.3	4.0	11.3

Figures

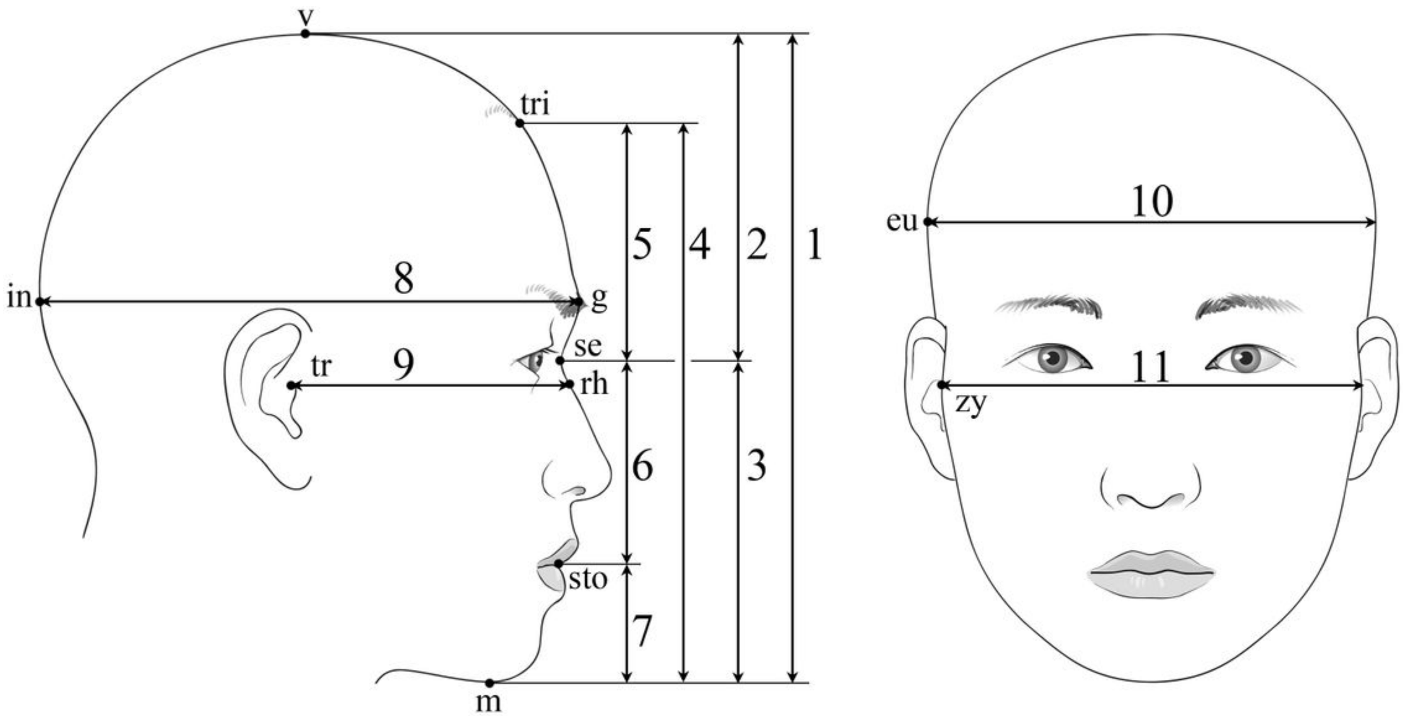

Figure 1

Illustration of the measurement parameters. Landmark of dimension: vertex (v), trichion (tri), glabella (g), sellion (se), rhinion (rh), stomion (sto), menton (m), inion (in), tragion (tr), euryon (eu), zygion (zy).

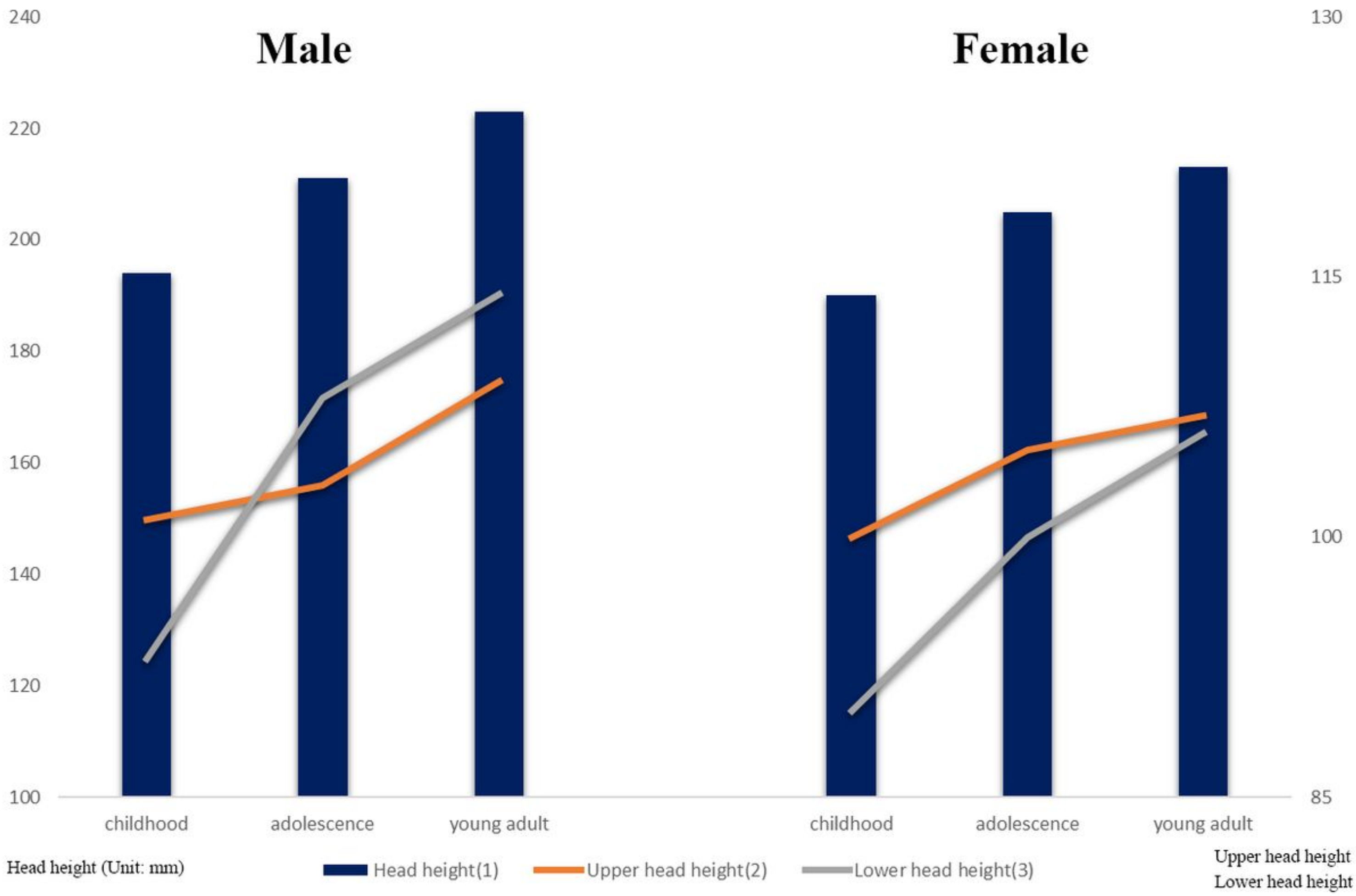

Figure 2

Comparisons of the head height growth measurement between males and females according to the age of groups (Unit: mm).

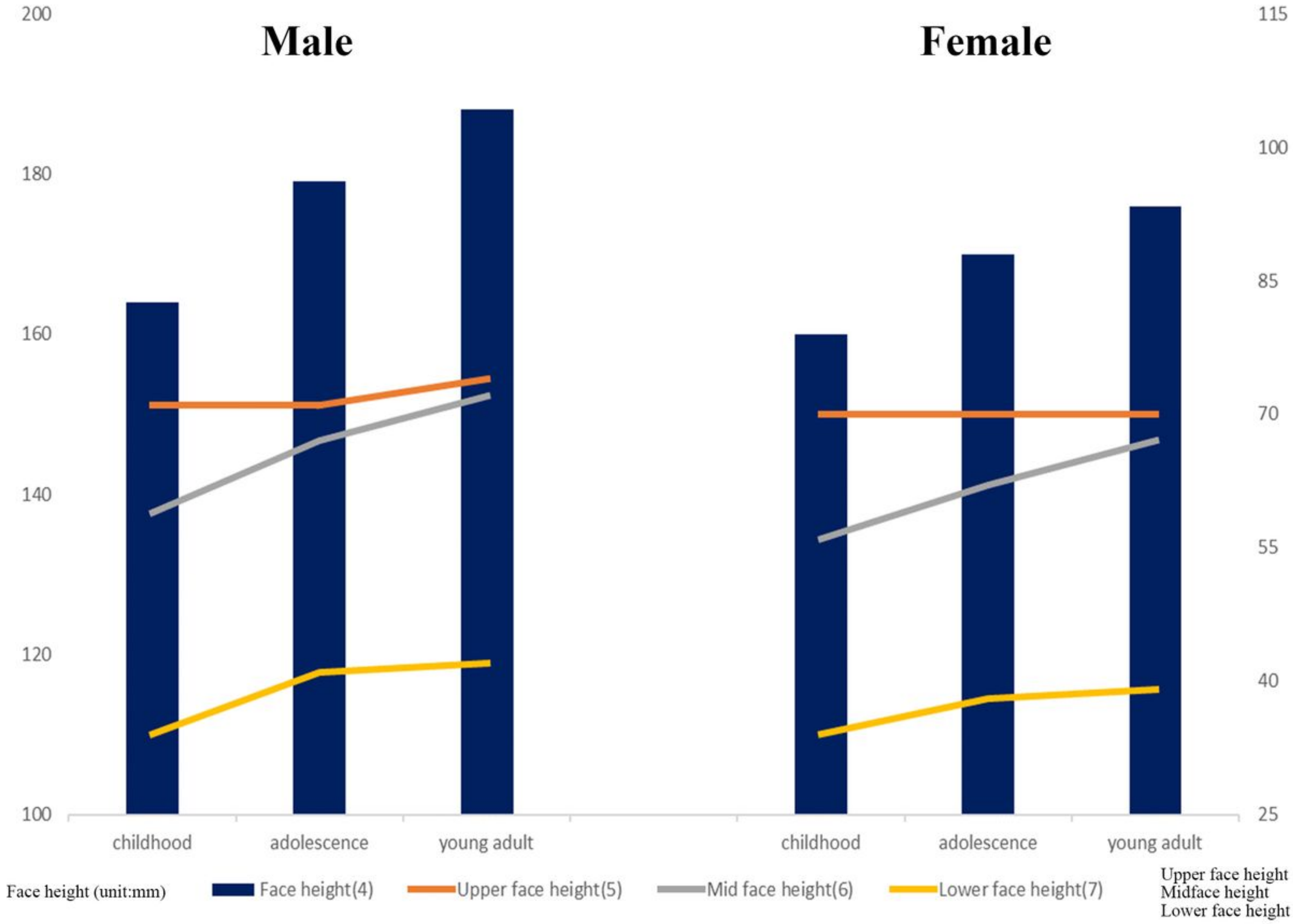

Figure 3

Comparisons of the face height growth measurement between males and females according to the age of groups (Unit: mm).

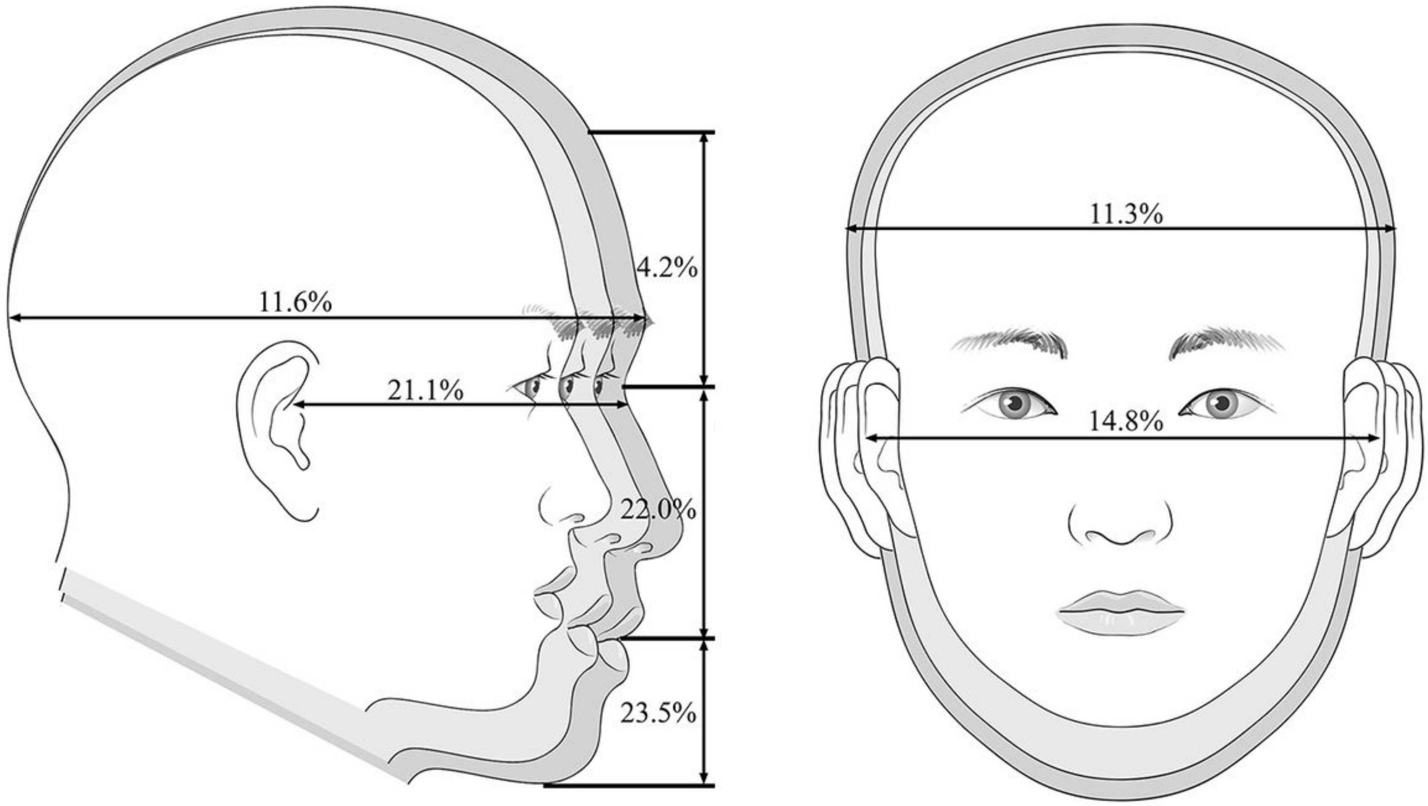

Figure 4

The schematic illustration of the growth proportion of males.