

Contemporary Chronological Changes in the Japanese Mandible Using Cephalometric X-Ray



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Abstract

The chronological changes of the mandible have been investigated from 1920s to 1960s in modern Japanese people [1]. In the present study, by adding data from the 1980s and 1990s to their results, more detailed analysis of the recent chronological changes of the mandible was conducted. The materials are X-ray cephalographs of orthodontic patients of both sexes, consisting of measurements of maximal mandibular length (Gn-Cd), mandibular body length (Pog-Go), mandibular ramus height (Cd-Go), and mandibular angle (Gonial angle). On the recent changes in the mandible of people (1980s and 1990s), the overall size of the mandible tended to increase in males, while it remained the same in females, and the sex difference was increasing. In the various parts of the mandible showed an increasing trend in Gn-Cd in both sexes, with a tendency for the male-female difference to increase from 1930s (II). Pog-Go also showed an increasing trend in both males and females. Cd-Go was decreasing in both sexes. Gonion angle tended to increase in both sexes, especially in females, where the mandibular angles were more obtuse. The mandibular angle was negatively correlated with Pog-Go and Cd-Go, especially the smaller the Pog-Go, the more obtuse the mandibular angle became. Considering the time scale, there is a 40-fold gap between the approximately 2,400 years from the Yayoi era to the end of the Edo era and the 60 years from the 1930s to the 1990s. The mandibular changes that have appeared over the past 2,400 years have been equally evident in the present 60 years. This showed how rapidly drastic reduction the postwar changes have occurred.

Keywords: Chronology; Cephalometric X-Ray; Mandible; Anthropology; Human bones; Paleoanthropology

Introduction

The faces of today's young Japanese become slender and slim, and seem to have changed considerably compared to those of the prewar period. Especially nowadays, when viewed from the side, the lower jaw is straight down at an angle, and when viewed from the front, it looks like a V-shape.

Kaifu [2] investigated chronologically the changes in the mandible from an anthropological perspective on human bones from the Jomon era to modern humans. However, the modern people he dealt with were human skeletal material collected before 1950, which does not provide a sufficiently accurate picture of the situation of recent Japanese people. Inoue et al. [1,3] used radiographs to study ancient humans and prewar and postwar residents born between the 1920s and 1960s. According to their research, the mandibular body length of modern people based on

the Meiji era was reported to be slightly larger, but the mandibular ramus height and maximum mandibular length are smaller. Moore et al. [4], in their study of facial skeletons and food in England, found that over the centuries the mandible has become smaller and the mandibular angle more obtuse, which they attributed to changes in diet with softening of food in modern society.

The purpose of this study was to analyze in more detail the chronological changes of the mandible from the postwar period to the recent times in combination with the results of paleoanthropological studies.

Materials and Methods

The materials used were X-ray cephalometric photographs of patients (the majority aged 18 years and older) born in

the 1980s and 1990s attending a certain orthodontic clinic in Nagoya, and the distance and angle of the mandible were measured. The measurements included maximal mandibular length (Gn-Cd), mandibular body length (Pog-Go), mandibular ramus height (Cd-Go), and mandibular angle were used for the measurements. A caliper (1/100 mm: Mitutoyo Co. Ltd.) was used for the measurements. The sum of Gn-Cd, Pog-Go, and Cd-Go was added to the analysis as the total size of the entire mandible (Total). Correlation coefficients were calculated from the total measurements for the 1980's and 1990's, including both sexes.

The results of the present study were compared with those of Inoue et al. [5,6], who used radiographic cephalometric data from the Generation I (born 1924-1926), Generation II (born 1934-1936), Generation III (born 1944-1946), Generation IV (born 1954-1956), and Generation V (born 1964-1966) of residents of Nagoya in Aichi Prefecture. Generation I was excluded from

this survey due to the insufficient number of materials. For convenience of this study, Generation II was used as the 1930s (II), Generation III as the 1940s (III), Generation IV as the 1950s (IV), and Generation V as the 1960s (V). Student's t-test was used to test significance of differences.

Results

Table 1 shows mandible measurements for the 1980s and 1990s, and Table 2 shows the significance of the differences between the generation gaps. Both males and females showed greater values for Gn-Cd and Pog-Go for those born in the 1990s than for those born in the 1980s, but there were no significant differences. The same was true for the mandibular angle (Table 2). Cd-Go showed smaller values in males and females born in the 1990s than those born in the 1980s, and there were significant differences between these two generations for males ($P < 0.05$), but not for females.

Table 1: Basic statistics of Mandibular shape (in mm) and Gonial angle (°).

| | Year of birth | Gn-Cd | Pog-Go | Cd-Go | Total | Gonial angle |
|--------|---------------|-------------------|------------------|------------------|--------------------|-------------------|
| Male | 1980s | 128.12(8.98, 25) | 82.72 (6.79, 25) | 66.88 (5.67, 25) | 277.72 (18.92, 25) | 122.16 (9.10, 25) |
| | 1990s | 129.45 (5.65, 33) | 84.13 (5.56, 33) | 64.61 (4.14, 33) | 278.18 (12.79, 33) | 124.89 (7.10, 33) |
| Female | 1980s | 119.78 (5.96, 32) | 77.88 (4.45, 32) | 59.75 (5.04, 32) | 257.40 (13.31, 32) | 125.81 (6.63, 32) |
| | 1990s | 120.31 (5.51, 39) | 78.67 (4.56, 39) | 58.50 (4.45, 39) | 257.47 (12.67, 39) | 127.14 (6.45, 39) |

mean (sd, n)

Table 2: Significance of sex differences between measurements in the 1980s and 1990s.

| | Year of birth | Gn-Cd | Pog-Go | Cd-Go | Total | Gonial angle |
|--------|---------------|--------|--------|--------|--------|--------------|
| Male | 1980s |] n.s. |] n.s. |] * |] n.s. |] n.s. |
| | 1990s | | | | | |
| Female | 1980s |] n.s. |] n.s. |] n.s. |] n.s. |] n.s. |
| | 1990s | | | | | |

] : t-test between 1980s and 1990s.

*: $P < 0.05$,

n.s. = not significant

Table 3 shows the significance of sex differences in the measurements from 1930s to 1990s. Gn-Cd, Pog-Go, Cd-Go, and gonial angle were significantly greater for males than females for most measurements from 1930s (II) through the 1990s. On the other hand, in the mandibular angle, females showed a trend toward larger angles at all ages than males, with significant differences ($P < 0.05$) seen in 1930s (II) and the 1980s. Table 4 shows the mean values of mandibular shape (Gn-Cd, Pog-Go, Cd-Go) and Gonial angle for males and females from 1930s (II) to 1960s (V). Figures 1 through 5 are drawn separately from the male and female counterparts for measurements from the 1930s through the 1990s. Figure 1 is a line graph showing secular changes of Gn-Cd for the results of archaic humans and for that of the moderns of both sexes from 1930s (II) to the 1990s. The

archaic humans data including both males and females are represented by pink lines (—). From 1930s (II) to 1960s (V), the values for males increased slowly, while those for females remained constant at around 120 mm. In the present day (1980s and 1990s), both males and females have an upward trend, with males having a significantly ($P < 0.01$) longer Gn-Cd than females. The archaic human bones continued to increase from the early Jomon to the Kofun era, and then declined from the Kamakura to the Muromachi eras. However, it increased to 124 mm in the Edo era.

The Pog-Go graphs for ancient and modern humans are shown in Figure 2. Pog-Go continued a gradual upward trend from the 1930s (II) to the 1950s (IV), with a sharp increase for males after the 1960s (V), but little change for females. In modern times,

this distance was significantly ($P < 0.01$) longer for males than for females, with an upward trend for both sexes. In archaic humans, it continued to rise from the early Jomon era to the Kofun era, then declined until the Edo era.

Table 3: Significant sex differences in mandibular shape and gonial angle.

| Year of birth | Gn-Cd | Pog-Go | Cd-Go | Gonion angle |
|---------------|-------|--------|-------|--------------|
| 1930s(II) | ** | * | ** | * |
| 1940s(III) | ** | ** | ** | n.s. |
| 1950s(IV) | ** | n.s. | ** | n.s. |
| 1960s(V) | ** | ** | ** | n.s. |
| 1980s | ** | ** | ** | * |
| 1990s | ** | ** | ** | n.s. |

* : $P < 0.05$, ** : $P < 0.01$
n.s. = not significant

Table 4: Mean values of mandibular shape (Gn-Cd, Pog-Go, Cd-Go) and Gonial angle for both sexes from 1930s (II) to 1960s (V).

| | Measurements | 1930s (II) | 1940s(III) | 1950s(IV) | 1960s (V) |
|--------|--------------|------------|------------|-----------|-----------|
| Male | Gn-Cd | 126.0 | 127.3 | 127.3 | 128.0 |
| | Pog-Go | 80.3 | 81.1 | 80.4 | 82.5 |
| | Cd-Go | 68.5 | 67.3 | 67.1 | 66.8 |
| | Gonion angle | 119.1 | 121.0 | 122.7 | 120.8 |
| Female | Gn-Cd | 120.5 | 120.6 | 119.5 | 119.3 |
| | Pog-Go | 77.3 | 77.5 | 78.6 | 78.2 |
| | Cd-Go | 61.8 | 61.4 | 59.2 | 59.3 |
| | Gonion angle | 123.3 | 123.9 | 122.3 | 123.3 |

Gn-Cd, Pog-Go, and Cd-Go (in mm)
Gonial angle (°)

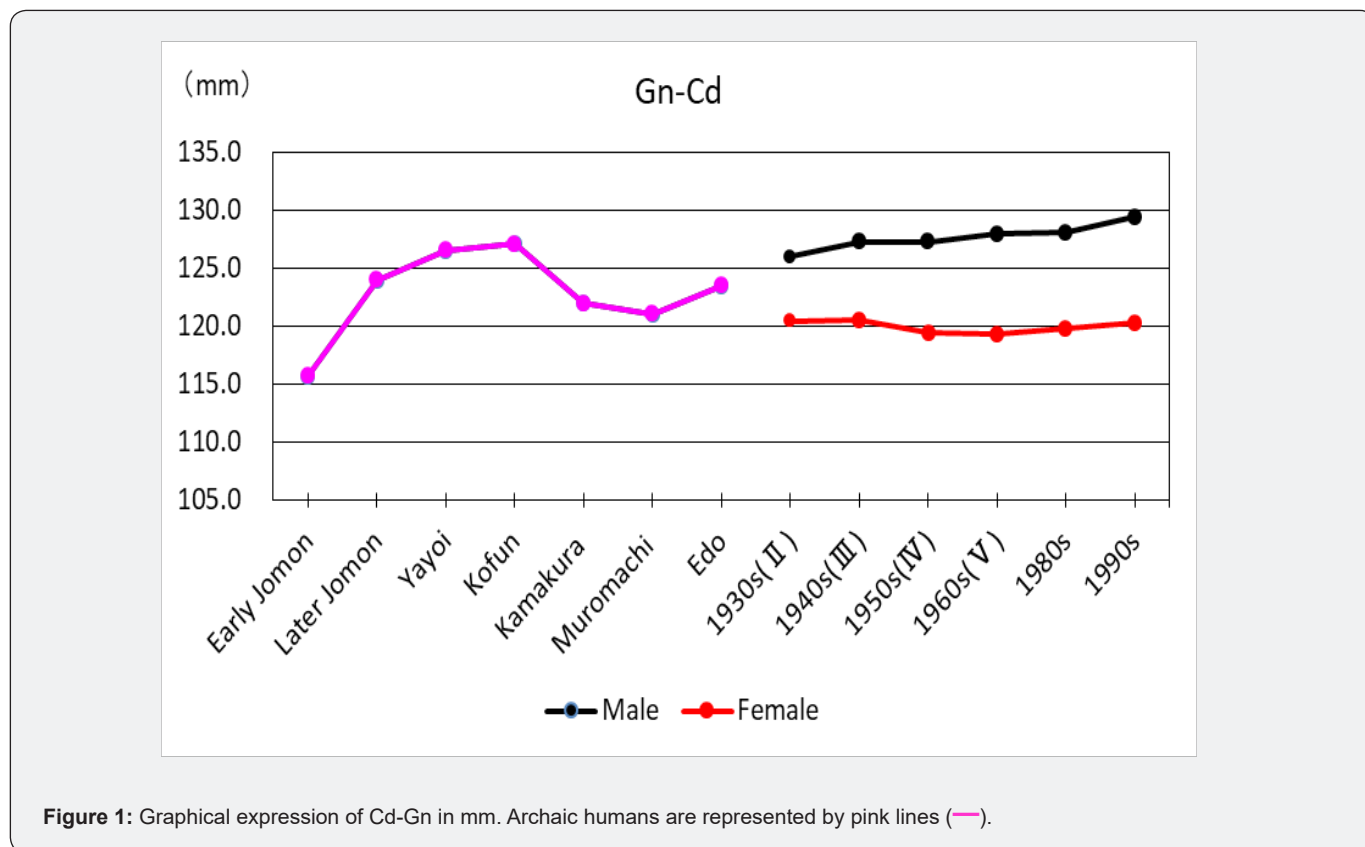


Figure 1: Graphical expression of Cd-Gn in mm. Archaic humans are represented by pink lines (—).

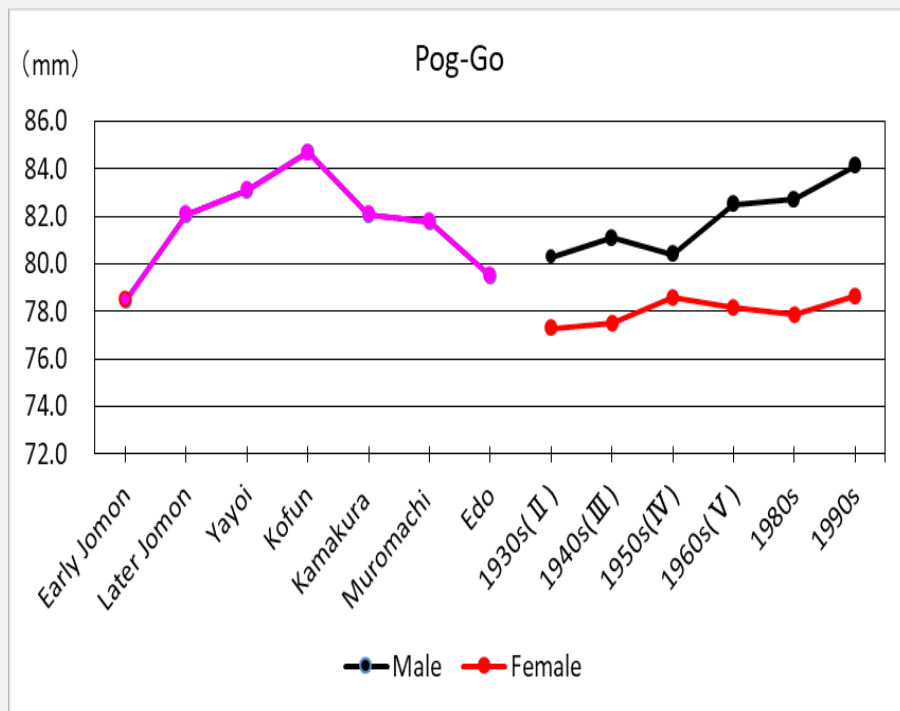


Figure 2: Graphical expression of Pog-Go in mm. Archaic humans are represented by pink lines (—).

This graph shows Cd-Go for ancient and modern humans (Figure 3). The Cd-Go showed a downward trend in both sexes from 1930s (II) to 1960s (V), and the difference between the sexes remained almost constant at about 6 mm throughout this

period. Even today, Cd-Go is rapidly declining. The ancient people continued to increase from the early Jomon era to the Yayoi era, subsequently declined until the Muromachi era, and increased to the level of the Yayoi and Kofun eras in the Edo era.

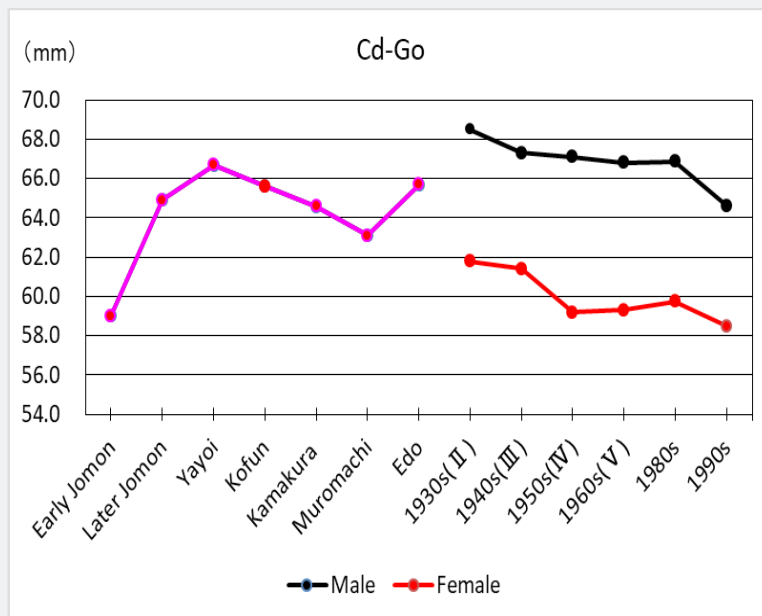


Figure 3: Graphical expression of Cd-Go in mm. Archaic humans are represented by pink lines (—).

Figure 4 is a graph showing Total (Gn-Cd + Pog-Go + Cd-Go). From 1930s (II) to 1960s (V), Total tended to increase in males, but decreased in females. In the present day, the total size of the mandible was maintained in both sexes, with males being at least

15 mm larger than females throughout this period. In the archaic humans, this value increased from the early Jomon era to the Kofun era, subsequently declined until the Muromachi era, and then increased again in the Edo era.

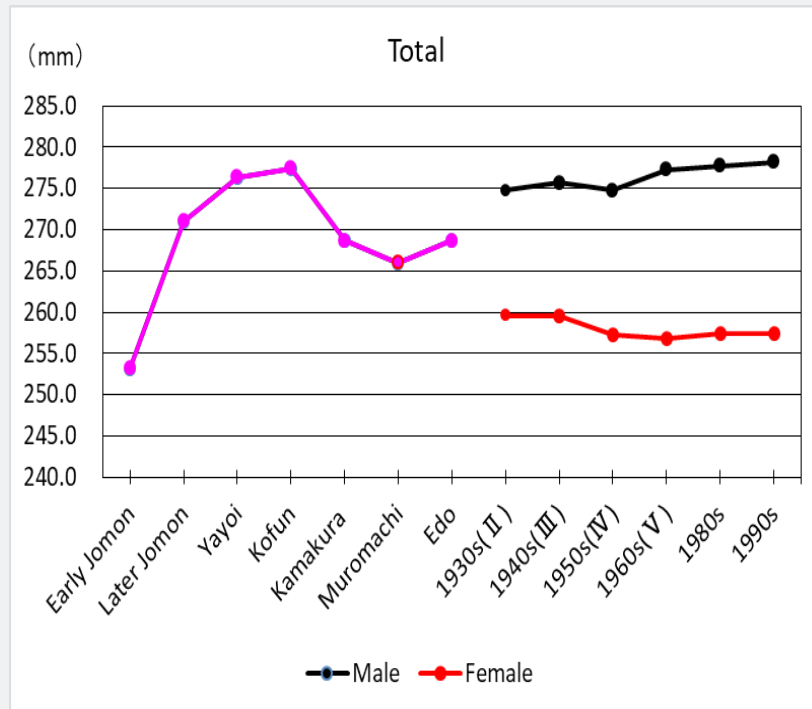


Figure 4: Graphical expression of Total in mm. Archaic humans are represented by pink lines (—).

The secular change in the mandibular angle is shown in Figure 5. The gonial angle for males increased from 1930s(II) to 1950s (IV), and then declined in 1960s(V). For females, it was on an upward trend from 1930s(II) to 1940s(III), but declined in 1950s (IV). Thereafter, in the present day, there has been an upward trend, and both sexes increased sharply, with the gonial angle becoming more obtuse for females compared to that in males. However, significant sex differences were found only in the 1930s (II) and 1980s. In the archaic humans, the range varied from 117° to 120° from the early Jomon era to the Muromachi era, but an increase to 121° was observed in the Edo era.

Correlation between measurements

Correlation coefficients were calculated for the measurements including both sexes in the 1980s and 1990s (Table 5). The relationship between Gn-Cd and Pog-Go was the most intensely related among the three measures, followed by Gn-Cd and Cd-Go, and the weakest between Pog-Go and Cd-Go. In relation to gonial angle, Pog-Go and Cd-Go were negatively and significantly related.

Discussion and Conclusion

Inoue et al. [3] took radiographic cephalographs of residents from the 1920s to the 1960s at five locations in Japan to

investigate tooth to denture base discrepancy. In the present study, the mandible of a recent Japanese population during the 1980s and 1990s was investigated and compared with the results of Inoue et al. [1,3,5,6]. As for changes in stature, the average stature of a 17-year-old male in 1900 was 157.9 cm, but in 1996 it had increased to 170.9 cm, clearly indicating a rapid increase in height and a very good physique in less than 100 years. A comparison between prewar and postwar periods reveals quite large differences in tooth size [7] and in the frequency of missing third molars [7]. Al-Jewair et al. [8] found that mandibular size is strongly correlated with upper body length. This would predict that an increase in stature would lead to an increase in mandibular size. One reason for this is the change in diet between the prewar and postwar periods in Japan. A glance at the dietary changes between the prewar and postwar periods (World War II ended in 1945) shows that from the prewar period to 1950, the average life expectancy was short, in the 50's, due to insufficient intake of total protein and fat. However, after 1950, the intake of animal protein stabilized, and the average life expectancy increased significantly, leading to a society with a long life expectancy. The rapid economic growth that began in 1955 continued for nearly 20 years until the outbreak of the oil crisis in 1973, and the dietary habits of the general population stabilized along with the economic recovery.

Even after the collapse of the bubble economy in the mid-1970s, life was relatively stable and the general people became more conscious of the environment. Today, the average life expectancy

has increased to over 80 years. Both the food we eat daily and the nature of our lifestyle have changed dramatically compared with the prewar period.

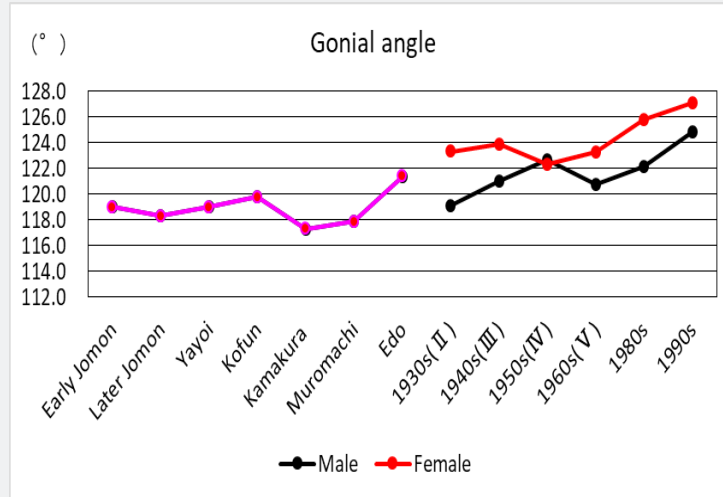


Figure 5: Graphical expression of Gonial angle (°). Archaic humans are represented by pink lines (—).

Table 5: Correlation coefficient between mandibular measurements.

| | r | Significance tests |
|--------------------|---------|--------------------|
| Gn-Cd vs Pog-Go | 0.8144 | ** |
| Gn-Cd vs Cd-Go | 0.7094 | ** |
| Pog-Go vs Cd-Go | 0.5429 | ** |
| Gn-Cd vs G. angle | -0.0079 | ns |
| Pog-Go vs G. angle | -0.3482 | ** |
| Cd-Go vs G. angle | -0.4885 | ** |

** : P<0.01
ns = not significant

In the postwar period, Japanese people’s diet changed from hard and chewy foods such as dried foods like “Surume (dried squid)” and scallops, nuts, and dried fruits to soft and quickly chewable foods like “Ramen” and Udon noodles, sweet and easy-to-chew cakes and puddings, and fruits like bananas. As a result, the masticatory muscles, especially the masseter muscles, have become weakened due to functional degradation. This effect has also been seen in the morphology of the mandible.

Focusing on the recent changes (1980s and 1990s) in the mandible over time in the young, the overall mandible (Total) since 1950s (IV) has been larger in males, but has remained virtually unchanged in females. The various parts of the mandible show an increasing trend in Gn-Cd in both sexes, with a tendency for the male-female difference to increase from 1930s (II). Pog-Go also shows an increasing trend in both males and females. Cd-Go is decreasing in both sexes. Gonion angle tends to increase in both

sexes, especially in females, where the mandibular angles are more obtuse. In addition, mandibular angle is negatively correlated with Pog-Go and Cd-Go, especially the smaller the Cd-Go is, the more obtuse the mandibular angle becomes. In short, the recent appearance and shape of the mandible shows an increase in maximal mandibular length and mandibular body length in males and females and a decrease in mandibular ramus height and an enlargement of the mandibular angle.

Considering the time scale, there is a 40-fold gap between the approximately 2,400 years from the Yayoi era to the end of the Edo era and the 60 years from the 1930s to the 1990s. For example, the gonion angle shows that archaic humans have fluctuated within a range of 4° over a period of 2,400 years, but this range has increased by 6° over the past 60 years. This indicates that the modern Japanese have undergone a more rapid change in a shorter period of time than the archaic humans.

Takeuchi [9] investigated the relationship between long bones and growth and reported results that support the idea of Wolff’s (1892) law that “in response to mechanical stress, bone is formed in the site and direction that can most efficiently support the applied external force.” According to his research, the long bones of the lower legs of long-term bedridden patients did not differ much from those of the healthy group, but the width and circumference were smaller. The masseter muscle, one of the masticatory muscles, is weakened by daily eating of soft foods, a scenario that has resulted in a blunted angle between the mandibular branch and the mandibular body.

Inoue et al. [1] and Kaifu [2] also pointed out that the reduced development of masticatory muscles (masseter muscles) attached to the mandible in modern Japanese may be due to soft foods. Beecher, Corruccini [10] reported in animal studies that the mandible was affected by a soft or hard diet, and Ito et al. [11,12] reported that mandibular ramus height was significantly lower and the mandibular angle was significantly more open in mice raised on a kneaded diet than on a solid one. Corruccini, Beecher [13] found significant differences in occlusion between squirrel monkeys (*Saimiri sciureus*) raised on natural and artificial soft diets, and Kikuta [14] and Takigami [15] reported that a kneaded diet caused a reduction in mandibular ramus height and a more open mandibular angle [16,17].

The present results indicate that even after the 1980s, the mandible continues to show an increase in maximal mandibular length and mandibular body length, a decrease in mandibular ramus height, and an enlargement of the mandibular angle. The fact that the mandibular changes that have appeared over the past 2,400 years are equally evident in the current 60 years shows how rapidly and drastically the postwar changes have decreased.

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