Facial characteristics of the prehistoric and early-modern inhabitants of the Okinawa islands in comparison to the contemporary people of Honshu

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Abstract Modern inhabitants of the Okinawa islands have been supposed to represent a relatively close genealogical connection to the prehistoric Jomon and the indigenous Ainu, when compared with people living on Japan’s main island (Honshu). However, several previous studies have also clarified some morphological facial traits discernible between the early-modern Okinawans and the Jomon of Honshu. In the present study, to further evaluate the Jomon–Okinawan relationship, we compared facial forms between skeletal samples from the Okinawa islands and Honshu, both in the Jomon and early-modern periods. Results of the comparisons showed that the Okinawa Jomon tended to possess a flatter interorbital region than the Honshu Jomon, but most measurements did not significantly differ between the two Jomon groups. This confirms that people sharing both Jomon culture and fundamental facial features lived throughout almost the entire Japanese archipelago, including the Okinawa islands. Results also demonstrated that the early-modern Okinawans had a significantly lower and broader face with transversely broader and flatter interorbital region than the early-modern Honshu Japanese. Such facial characteristics of the early-modern Okinawans qualitatively matched those of the Okinawa Jomon. However, compared with the Okinawa Jomon, the early-modern Okinawans exhibited an absolutely taller/narrower face and a further flatter nasal root. This could stem in part from a certain amount of population flow from surrounding regions during historic periods, as suggested by many earlier studies. Nevertheless, the results obtained in this study indicate that, comparatively, modern Okinawan people have retained physical traits including facial forms of the Jomon who survived in the same southernmost islands of the Japanese archipelago. Geographical variations of modern Japanese phenotypes should also be accounted for partly by those of the ancestral Jomon characteristics that were manifested by the end of the Jomon period.

Key words: Jomon, facial flatness, Ryukyu, Japanese population history

Introduction A number of studies have investigated geographical variations in physical and genetic traits of the modern Japanese, and have clarified some attributes showing a geographical cline that peripherally spreads from the western part of Japan’s main island (Honshu) across the Japanese archipelago (e.g. Ueda, 1935; Tagaya and Ikeda, 1976; Kanda, 1978; Ikeda and Tagaya, 1980; Watanabe et al., 2004; Hammer et al., 2006; Yamaguchi-Kabata et al., 2008; Matsukusa et al., 2010). This is interpreted, in association with the population history of the Japanese, as a reflection of regional differences in the levels of admixture between hunter-gatherer-fishers in the Jomon period (c. 13000–2350 BP) and subsequent immigrants thought to have come from the Asian continent in the Yayoi period (c. 2350–1650 BP). A dominant genetic influence of the Yayoi immigrants on the modern people living in Honshu is generally supposed (e.g. Dodo and Ishida, 1990; Hanihara, 1991, 1993; Nakahashi, 1993; Omoto and Saitou, 1997; Omoto and Saitou, 1997; Pietrusewsky, 1999). In contrast, a lesser extent of admixture has been presumed for the native inhabitants of the northernmost and southernmost regions of the Japanese archipelago, Hokkaido and the Ryukyu island chain, respectively (Figure 1). Specifically, the indigenous Ainu people in Hokkaido are currently inferred as being the phylogenetically closest to the Jomon people, from the bulk of anthropological evidence (e.g. Brace et al., 1989; Dodo

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groups from different periods and regions, and found that the early-modern Okinawans did not exhibit some facial characteristics that are manifested in both Jomon and Ainu (e.g. an anteriorly prominent glabella and a strongly elevated nasal ridge). The early-modern Okinawans indeed had a transversely flatter nasal root than even the modern Honshu-Japanese (Dodo et al., 2000).

The circumorbital morphology varies considerably among worldwide major human groups, and has also been studied to evaluate intergroup kinships (Woo and Morant, 1934; Gill et al., 1988; Ishida, 1992; Ishida and Dodo, 1997; Hanihara, 2000). Recently, Smith (2009) compared the morphological and molecular genetic data of many modern human groups, and demonstrated that the three-dimensional circumorbital form, as well as the cranial basal shape, has significant correlation with the genetic intergroup distances. Since the Yayoi immigrants possessed a remarkably ‘flat’ face in contrast to the Jomon, temporal and geographical variations in the Japanese facial flatness have often been interpreted in association with levels of admixture between the two ancestral groups (e.g. Nakashashi and Iizuka, 1998; Kawakubo, 2007; Okazaki and Nakashashi, 2011). In this context, the flat face of the early-modern Okinawans may be regarded as indicating genealogical remoteness to both Jomon and Ainu groups (cf. Dodo et al., 2000).

However, most previous studies that assessed the Jomon–Okinawan relationship employed Jomon samples excavated from Honshu, and only a limited number of studies have investigated the conditions of the Jomon from Okinawa (Matsushita and Ohta, 1993; Oyamada et al., 1995; Wakebe et al., 1996; Doi, 2003). It is therefore still unclear whether the southern Okinawa-Jomon shared facial features with the Honshu-Jomon, although the craniofacial form of the northern Hokkaido-Jomon is reported to generally fall within the Honshu-Jomon range of variation (Yamaguchi, 1981; Matsumura et al., 2001). Wakebe et al. (1996) examined facial forms of the prehistoric Okinawan individuals dated between the Late Jomon and Early Yayoi periods (c. 4000–2250 BP), and pointed out their significantly flat face in comparison to the Jomon of Honshu. In light of this, the transversely flat face of the early-modern Okinawans (Matsushita et al., 1988; Dodo et al., 2000; Fukumine et al., 2001) may largely result from retention of a Jomon trait in Okinawa, rather than substantial reformation of the population.

Thus, facial forms of the prehistoric inhabitants of the Okinawa islands can be clues both to explore the southern limit of the Jomon people with morphologically ‘homologous’ faces in the Japanese archipelago (cf. Matsumura et al., 2001; Mizoguchi, 2010) and to re-evaluate the Jomon–Okinawan connection (cf. Dodo et al., 2000). In order to assess these issues, we quantitatively compared facial skeletons from the Okinawa islands and Honshu in both Jomon and early-modern periods, with particular attention to the interorbital form.

Materials and Methods

The skeletal specimens used in the present study are listed in Table 1. Adult male samples without apparent skeletal

Figure 1. Map of the Japanese archipelago.
deformation and pathological traits were selected. The sex of the Jomon and early-modern Okinawan samples was evaluated from pelvic morphology, and from appendicular morphology in the cases that lacked sufficiently preserved associated pelvic remains. In the present study, to match the names of the prehistoric periods between Honshu and Okinawa, we provisionally employed the names of ‘Jomon’ and ‘Yayoi,’ instead of ‘Kaizuka,’ which is occasionally used specifically to describe the Okinawan prehistoric age (Okinawa Prefectural Culture Promotion Foundation, 2003). Okinawan prehistoric samples spanning from the Late to Final Jomon period (c. 4000–2350 BP) were chosen for analysis. However, the specimens derived from the Mashiki-Azamabaru site are dated from the Final Jomon to Early Yayoi period (c. 3000–2250 BP). Therefore, we refer to the used Okinawan collection as the ‘Okinawa Jomon/Yayoi’ in this study. The Jomon materials from Honshu, referred to as the ‘Honshu Jomon,’ span from the Middle to Final Jomon period (c. 5000–2350 BP).

The ‘early-modern’ Okinawan samples are thought to span a chronological age of approximately 1700–1900 AD. The major part of this collection consists of individuals from Kume Island (the second largest island in the Okinawa islands), but earlier studies have shown little significant differences in craniofacial and nonparametric characteristics between individuals from Kume Island and Okinawa Island (Suda, 1940, 1950; Dodo et al., 1998; Pietrusewsky, 1999; Fukumine et al., 2001, 2006). The materials of the early-modern Okinawan come from anatomy department collections made by the University of Tokyo from approximately 1890 to 1910 AD. The age at death of the Honshu Japanese specimens ranged from 20 to 40 years (mean = 28.0, SD = 5.9), according to archival records.

Linear measurements were taken with a digital caliper, principally following Martin’s definitions and methods (Knußmann, 1988; Baba, 1991), as illustrated in Figure 2a and b. Facial height index was defined as the ratio of upper facial height (M48) to biorbital breadth (M43). The ratio of interorbital breadth (M49a) to the biorbital breadth was also derived. Nasal height was determined as the distance from the nasion (n) to the subspinale (ss) instead of the nasospina- le (ns). The nasal height index was defined as the ratio of the nasal height to nasal breadth (M54). The simotic index was defined as the ratio of the simotic subtense to the chord.

Circumorbital forms in profile were investigated by use of the three-dimensional digitizer Microscribe G2X (Immersion Co.) and the coordinate analysis software 3D-GADES (developed by Shinya Matsukawa). Essentially referring to Martin’s definitions (Knußmann, 1988; Baba, 1991), the following anatomical landmarks were taken: glabella (g), nasion (n), subnasion (sbn), rhinion (rhi), subspinale (ss), staphyline (sta), maxillonaso frontale (mnf), and the most lateral point of the nasal aperture. The subnasion and rhinion were defined as the most strongly curved point and the most anterior point on the crest of the nasal bones, respectively (see Figure 2c). The coordinates of all the landmarks were projected onto the midsagittal plane, which was defined as passing through the nasion, subnasion, and staphyline. A facial reference line was then set to pass the mnf and the most lateral point of the nasal aperture (the two landmarks were each averaged between right and left sides). Prominence distances were defined as the minimum distances from the reference line to glabellar and nasal landmarks on the midsagittal plane (Figure 2c). Specifically, to evaluate the relative prominence of the glabella, the glabella index was determined as the ratio between the prominence distance of glabella and the interorbital breadth. For assessing the shape of the profile, we also calculated angles between the reference line and n–rhi [Angle (1)] in Figure 2d), the reference line and sbn–rhi [Angle (2)], g–n and sbn–rhi [Angle (3)], and n–sbn and sbn–rhi [Angle (4)].

Two-tailed Mann-Whitney’s U-test was conducted for comparisons between the materials from Okinawa and Honshu in both Jomon and early-modern periods. In addition, to summarize the measured dataset and present an overview of individual positions within the total variation, principal component analysis (PCA) was performed using a total of 15 variables of the linear and angular measurements (see Table 2). Individuals with more than six missing values were excluded for the PCA, but missing values were, if present for the employed specimens, complemented with values estimated by stepwise multiple regression using available variables. To include the linear and angular variables in the same analysis, the PCA was conducted with a correlation matrix derived from standardized (Z-score) values. Although PCA assumes variables with normal distribution, we chose to use the 15 variables including three variables (the simotic subtense, the prominence distance of nasion, and the angle between g–n and sbn–rhi) whose normality was rejected by the

<table>
<thead>
<tr>
<th>Sample name</th>
<th>n</th>
<th>Sex</th>
<th>Date</th>
<th>Site</th>
<th>Location</th>
</tr>
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<tr>
<td>Okinawa Jomon/Yayoi</td>
<td>14</td>
<td>Male</td>
<td>c. 4000–2250 BP</td>
<td>Bugeido, Furuzamami, Gushikawajima, Mashiki-Azamabar, Hobi, Kasori, Matsudo, Nakazawahama, Ohora, Sanganj, Tsugumo, Ubayama, Yosekura</td>
<td>NU, OPAC, OPMAM UMUT</td>
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<tr>
<td>Honshu Jomon</td>
<td>20</td>
<td>Male</td>
<td>c. 5000–2350 BP</td>
<td>Hobijii, Kasori, Matsudo, Nakazawahama, Ohora, Sanganj, Tsugumo, Ubayama, Yosekura</td>
<td>NU, OPAC UMUT</td>
</tr>
<tr>
<td>Early-modern Okinawans</td>
<td>30</td>
<td>Male</td>
<td>c. 1700–1900 AD</td>
<td>Kujichi, Yacchi-no-gama</td>
<td>OU, OPAC UMUT</td>
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<tr>
<td>Early-modern Honshu Japanese</td>
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<td>Male</td>
<td>c. 1900 AD</td>
<td>Collection made</td>
<td>OU, UMUT</td>
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<tr>
<th>Sample name</th>
<th>n</th>
<th>Site</th>
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<td>Okinawa Jomon/Yayoi</td>
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<td></td>
<td>Ubayama, Yosekura</td>
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<tr>
<td>Honshu Jomon</td>
<td>30</td>
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<td>NU, OPAC UMUT</td>
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<td>Early-modern Okinawans</td>
<td>28</td>
<td>Collection made</td>
<td>OU, OPAC UMUT</td>
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</table>

n, sample size. NU, Nagasaki University; OPAC, Okinawa Prefectural Archaeological Center; OPMAM, Okinawa Prefectural Museum and Art Museum; UMUT, The University Museum, The University of Tokyo.
Kolmogorov–Smirnov test ($P < 0.05$), in order to obtain an overall trend of facial forms from the all linear and angular measurements. This should not substantially affect results of the PCA, considering the robustness of general linear models. These statistical analyses were carried out using the software SPSS 10 (SPSS Inc.). Statistical significance of $P < 0.05$ is referred to in describing the results.

**Results**

Descriptive statistics of the measurements are listed in Table 2. Results of the indices examined are shown as box plots in Figure 3. Comparisons of the prehistoric samples showed that the Okinawa Jomon/Yayoi and the Honshu Jomon were not significantly different in most cases. This may be due in part to the small sample size, but suggests their overall facial resemblance (see Figure 4). However, the interorbital breadth, including the simotic chord, tended to be both absolutely and relatively larger in the Okinawa Jomon/Yayoi, whereas the simotic subtense was conversely greater in the Honshu Jomon. This resulted in the significantly greater simotic index in the Honshu Jomon. The prominence distances of the glabellar and nasal landmarks were generally shorter in the Okinawa Jomon/Yayoi (see Figure 5). In fact, the glabella index value was significantly smaller in the Okinawa Jomon/Yayoi, indicating their weak glabellar prominence.

Comparisons of the early-modern people from Okinawa and Honshu showed that the Okinawans had a relatively low/broad face compared to the Honshu Japanese (Figure 4), as shown by the significantly lower values of the facial and nasal height indices in the Okinawans (Figure 3). This
### Table 2. Descriptive statistics of measurements

<table>
<thead>
<tr>
<th></th>
<th>Okinawa (Jomon/Yayoi for Okinawa)</th>
<th>Honshu Early-modern</th>
<th>Okinawa</th>
<th>Honshu</th>
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<tr>
<td><strong>n</strong></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
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<td>Upper facial height (n–av, M48)</td>
<td>10</td>
<td>67.3</td>
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<tr>
<td>Biorbital breadth (fmt–fmt, M43)</td>
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<td>108.6</td>
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<tr>
<td>Interorbital breadth (d–d, M49a)</td>
<td>8</td>
<td>23.9</td>
<td>2.2</td>
<td>18</td>
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<tr>
<td>Nasal height (n–ss)</td>
<td>9</td>
<td>52.9</td>
<td>3.4</td>
<td>18</td>
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<tr>
<td>Nasal breadth (M54)</td>
<td>10</td>
<td>26.7</td>
<td>1.5</td>
<td>18</td>
</tr>
<tr>
<td>Simotic chord (Minimum nasal breadth, M57)</td>
<td>8</td>
<td>10.1</td>
<td>1.5</td>
<td>18</td>
</tr>
<tr>
<td>Simotic subtense</td>
<td>8</td>
<td>3.4</td>
<td>1.3</td>
<td>18</td>
</tr>
<tr>
<td>Prominence distance of glabella</td>
<td>10</td>
<td>6.5</td>
<td>1.8</td>
<td>17</td>
</tr>
<tr>
<td>nasion</td>
<td>10</td>
<td>3.4</td>
<td>1.4</td>
<td>18</td>
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<tr>
<td>subnasion</td>
<td>8</td>
<td>5.1</td>
<td>1.6</td>
<td>19</td>
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<td>rhinion</td>
<td>6</td>
<td>12.2</td>
<td>2.6</td>
<td>17</td>
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<td>27.8</td>
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<td>the reference line and sbn–rhi</td>
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<td>40.7</td>
<td>8.5</td>
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<td>g–n and sbn–rhi</td>
<td>6</td>
<td>121.1</td>
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<td>n–sbn–rhi</td>
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<td>151.9</td>
<td>5.2</td>
<td>17</td>
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<td>Facial height index (upper facial height/biorbital breadth)</td>
<td>10</td>
<td>0.63</td>
<td>0.03</td>
<td>16</td>
</tr>
<tr>
<td>Nasal height index (nasal height/breadth)</td>
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<td>2.01</td>
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<tr>
<td>The ratio of interorbital to biorbital breadth</td>
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<td>0.22</td>
<td>0.01</td>
<td>18</td>
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<tr>
<td>The ratio of simotic chord to interorbital breadth</td>
<td>5</td>
<td>0.44</td>
<td>0.06</td>
<td>17</td>
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<tr>
<td>Simotic index (simotic subtense/chord)</td>
<td>8</td>
<td>0.33</td>
<td>0.10</td>
<td>18</td>
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<tr>
<td>Glenbia index (Prominence distance to glabella/biorbital breadth)</td>
<td>6</td>
<td>0.27</td>
<td>0.05</td>
<td>16</td>
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</tbody>
</table>

n, sample sizes. A value with one or two asterisks on the right shoulder is significantly larger than that of the other area. Significance level: *P < 0.05; **P < 0.01.

*Measurements used for principal component analysis (PCA).

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![Figure 3. Index measurements. Upper and lower margins of box plots represent the 75th and 25th percentiles, respectively. The median is the line bisecting the box. Asterisks represent significance levels: *P < 0.05; **P < 0.01.](image-url)
stemmed mainly from a difference in the facial height rather than the facial breadth. Furthermore, it was found that the interorbital breadth was both absolutely and relatively greater in the early-modern Okinawans. Associated with this horizontally broad interorbital region, their simotic index value was significantly less than that of the Honshu Japanese. Analyses of the profile showed that the prominence distances did not differ between the two groups in all the cases. The angle between the reference line and sbn–rhi was larger in the Okinawans, while the angles of both n–sbn–rhi and g–n/sbn–rhi were conversely greater in the Honshu Japanese. These results suggested that the crest of the nasal bones was sagittally more curved in the early-modern Okinawans, and therefore their infraglabellar recess appeared relatively deep (Figure 5).

Results of the PCA are listed in Table 3 and displayed in Figure 6. The first four principal components represented greater than 1.0 of eigenvalue, and in total contributed 73.9% to the total variation. The first principal component (34.4% of the contribution) is chiefly related to the facial breadths and the elevation of the nasal crest, leading to greater PC1 scores in the two Jomon groups (Figure 6A). Both second and third principal components (17.0% and 14.1%, respectively) are associated with the facial heights and the angles of the nasal root region. The early-modern Honshu Japanese had a comparatively high face with shallow and open infraglabellar notch, resulting in their much greater scores for PC2. The fourth principal component (8.4%) appears related to the facial breadth and the flatness of the glabellar region.

Figure 4. Frontal views of facial skeletons.
The facial comparisons between the Okinawa Jomon/Yayoi and the Honshu Jomon did not exhibit significant differences in most measurements, indicating general similarity of their facial frameworks (Figure 4). This is also illustrated by the results of the PCA (Figure 6), and is consistent with previous descriptive remarks on the Jomon people of the Okinawa islands (Matsushita and Ohta, 1993; Doi, 2003, 2004). The results therefore support that people who shared both Jomon culture and basic facial features did live throughout the Japanese archipelago including the Ryukyu region. However, compared with the Honshu Jomon, the Okinawa Jomon/Yayoi tended to show greater and lesser values in the simotic chord and subtense, respectively, resulting in a significantly lower simotic index value. Furthermore, the prominence of the glabellar and nasal root regions was relatively weak in the Okinawa Jomon/Yayoi, as seen in the profiles of Figure 5. These findings suggest that the Jomon had an overall flatter face in Okinawa than in Honshu, which also accords with previous observations (Wakebe et al., 1996; Nagashima and Wakebe, 2003). Nevertheless, this minor distinction would not refute the previous view that the extent of geographical diversity of the Jomon craniofacial form was modest relative to intra-group variations of other East Asian groups including the modern Japanese (Dodo, 1982; Yamaguchi, 1982; Kondo, 1994; Matsumura et al., 2001; Matsumura, 2007; Hamihara and Ishida, 2009; Ishida et al., 2009).

Suda (1940) undertook an anthropometric survey on the faces of live inhabitants of Okinawa Prefecture, and asserted that a low/broad facial proportion and a low nasal height are noteworthy features of this population. This has been subsequently corroborated by somatometric and skeletal studies (Miyake, 1940; Naito, 1976; Tagaya and Ikeda, 1976; Doi, 2003). The results of the present study also showed the significantly lower face of the early-modern Okinawans than that of the early-modern Honshu Japanese. With the facial flatness, the lower value of the simotic index in the early-modern Okinawans was found to stem principally from the broader interorbital region. Furthermore, the analysis of the profile showed the nasal bone of the early-modern

### Table 3. Principal component analysis of the facial measurements

<table>
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<th>PC1</th>
<th>PC2</th>
<th>PC3</th>
<th>PC4</th>
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<tbody>
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<td>Upper facial height</td>
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<td>0.74</td>
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<td>Biorbital breadth</td>
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<td>Interorbital breadth</td>
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<td>0.67</td>
<td>0.49</td>
<td>0.10</td>
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<tr>
<td>Nasal breadth</td>
<td>0.44</td>
<td>0.16</td>
<td>−0.29</td>
<td>0.32</td>
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<tr>
<td>Simotic chord</td>
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<tr>
<td>Prominence distance of nasion</td>
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<td>Prominence distance of subnasion</td>
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</tr>
<tr>
<td>Angle of the reference line and sbn–rhi</td>
<td>0.48</td>
<td>0.61</td>
<td>−0.12</td>
<td>0.04</td>
</tr>
<tr>
<td>Eigenvalue</td>
<td>5.2</td>
<td>2.5</td>
<td>2.1</td>
<td>1.3</td>
</tr>
<tr>
<td>%VAR</td>
<td>34.4</td>
<td>17.0</td>
<td>14.1</td>
<td>8.4</td>
</tr>
</tbody>
</table>

### Discussion

The facial comparisons between the Okinawa Jomon/Yayoi and the Honshu Jomon did not exhibit significant differences in most measurements, indicating general similarity of their facial frameworks (Figure 4). This is also illustrated by the results of the PCA (Figure 6), and is consistent with previous descriptive remarks on the Jomon people of the Okinawa islands (Matsushita and Ohta, 1993; Doi, 2003, 2004). The results therefore support that people who shared both Jomon culture and basic facial features did live throughout the Japanese archipelago including the Ryukyu region. However, compared with the Honshu Jomon, the Okinawa Jomon/Yayoi tended to show greater and lesser values in the simotic chord and subtense, respectively, resulting in a significantly lower simotic index value. Furthermore, the prominence of the glabellar and nasal root regions was relatively weak in the Okinawa Jomon/Yayoi, as seen in the profiles of Figure 5. These findings suggest that the Jomon had an overall flatter face in Okinawa than in Honshu, which also accords with previous observations (Wakebe et al., 1996; Nagashima and Wakebe, 2003). Nevertheless, this minor distinction would not refute the previous view that the extent of geographical diversity of the Jomon craniofacial form was modest relative to intra-group variations of other East Asian groups including the modern Japanese (Dodo, 1982; Yamaguchi, 1982; Kondo, 1994; Matsumura et al., 2001; Matsumura, 2007; Hamihara and Ishida, 2009; Ishida et al., 2009).

Suda (1940) undertook an anthropometric survey on the faces of live inhabitants of Okinawa Prefecture, and asserted that a low/broad facial proportion and a low nasal height are noteworthy features of this population. This has been subsequently corroborated by both somatometric and skeletal studies (Miyake, 1940; Naito, 1976; Tagaya and Ikeda, 1976; Doi, 2003). The results of the present study also showed the significantly lower face of the early-modern Okinawans than that of the early-modern Honshu Japanese. With the facial flatness, the lower value of the simotic index in the early-modern Okinawans was found to stem principally from the broader interorbital region. Furthermore, the analysis of the profile showed the nasal bone of the early-modern
Okinawans to be sagittally more curved, accompanying the forward projection of the lower nasal bone (see Figure 5). These results suggest that the Okinawan face should not necessarily appear ‘flat’ from a lateral view when compared with the Honshu Japanese. In addition, the remarkably low nasal height of the Okinawan living face (Suda, 1940) can be explained by the combined effects of the overall low face and the sagittally curved nasal bone, since facial and nasal heights in the living body are often measured using the sellion, the most receding midsagittal point on the nasal crest, instead of the skeletal landmark of the nasion (Miyake, 1940; Knussmann, 1988; Baba, 1991).

Thus, facial forms appear to have considerably differed between the people of Okinawa and Honshu in the early-modern age. It should be noted, however, that the specimens examined were early-modern ones, which is of importance considering that faces further became relatively narrow and high with increasing stature in both Okinawa and Honshu during the last hundred years (Omori, 1976). This recent change in the facial proportions can co-vary with the interorbital flatness (Suzuki, 1969; Kouchi and Mochimaru, 2006; Kawakubo, 2007), and therefore it remains to be seen whether the ‘present’ Okinawans still possess the same facial characteristics as the individuals examined in this study.

The above comparisons in the two time periods indicate that the Jomon and early-modern inhabitants of the Okinawa islands shared some facial traits: the low/broad face, the comparatively broad interorbital region, and the concomitant small value of the simiotic index (Figure 3). However, when compared with the Okinawa Jomon/Yayoi, the early-modern Okinawans tended to show a relatively high/narrow face with a further flat nasal root. This difference is qualitatively comparable to the facial shift from the Jomon to the modern Japanese in Honshu, and may result from a southward population influx from the main islands of the Japanese archipelago during medieval times (e.g. Asato, 1996; Doi, 2003; Higa et al., 2003; Manabe et al., 2008, 2011). Nevertheless, the results indicate that the early-modern Okinawans had facial features seen in both Okinawa Jomon/Yayoi and early-modern Honshu Japanese, as plausibly illustrated by the PCA result (Figure 6A). It is therefore potentially hypothesized that, even with a certain level of admixture, the modern Okinawans should comparatively retain physical traits including facial forms of the prehistoric Jomon who survived in the same southernmost islands of the Japanese archipelago. In addition, phenotypic and genetic variations seen among regional groups in Japan, perhaps including differences between the Okinawans and Ainu (cf. Dodo et al., 1998, 2000), should be explained not only by levels of genetic retention but also partly by geographical variations of the ancestral Jomon features that had been manifested by the end of the Jomon period.

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