Different Growth Status of Youths Aged 18 from 27 Chinese Minority Nations

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Abstract This study focused on studying the morphological similarities of 27 Chinese minority nations' youths aged 18 by using PCA-Q mode cluster analysis. Six measurements of body size, two indices of body shape and four indices of growth tempo (which were estimated from cross-sectional data of 69,389 subjects aged 7 through 18 by using proportional interpolation method) were used as variables. The values of these variables were normalized into principal component scores, and clustering was done among 27 nations according to the distances determined by their component scores (centroid method). Both for boys and girls, there were seven clusters fused at about 0.2 similarity level. The clusters thus formed not only described the significant differences among themselves but also showed closed associations between the geographic, ecologic and socio-economic differences and youth's growth status. The consistency of clustering tendency between children aged 7 (JI and OHSAWA, 1991) and youths aged 18 of these minority nations was also verified.

Key Words Cluster analysis, Chinese minority nation, Growth, Principal component analysis

Introduction

Many publications have described the worldwide variation of human growth since early 1970s, which have clearly shown that populations differ in their average adult size, tempo of growth and body shape. These differences were due to complicated interactions of many genetical and environmental factors (TANNER, 1982). GREULICH (1976) and MEREDITH (1976) compared the body sizes of children at successive ages among European, African and Asiatic populations, which showed that their growth patterns were quite different. ROBERTS (1969), FRISANCHO et al. (1973) and STINI (1972) analyzed the strong influences of genetics, nutrition and socio-cultural differences upon growth variations among different nations and ethnic groups. EVELETH and TANNER (1990) showed that differences of growth had indeed been brought about in response to the different ecological conditions.

But what about China? Because of the absence of systematic data, the differences of growth of her minority nations were rarely known by
anthropologists all over the world. Our previous study (JI and OHSAWA, 1991) was the first one to show these similarities and dissimilarities concerning the body measurements of those aged 7. However, the significant difference of growth among them and its association with geographic, socio-economic status and living ecology induced our interests in further study.

Thus in the present study, we take the children and youth aged 7 through 18 totally into consideration, and focus on studying the following aspects of 27 minority nations.

(1) How do the young people of these nations show their differences and similarities in body measurements, tempo of growth and body shape?

(2) Is there an association between geographic, socio-economic and ecologic differences on one hand and youth's body measurements and body shape on the other hand?

(3) What are the characteristics of growth of some of these nations?

Materials and Methods

Data were drawn from 69,389 subjects (35,925 boys and 33,464 girls) aged 7 through 18 who participated in the “National Survey on Students Constitution and Health” (Chinese National SSCH Association, 1987). Among them, there were 5,191 subjects (2,770 boys and 2,421 girls) aged 18. They came from 27 minority nations whose sample sizes and geographic distribution are shown in Table 1. For details of their locations, see JI and OHSAWA (1991). Each of the five nations among them, the Meng-gu, Chaoxian, Hui, Wei-wu-er and Zhuang, had an additional subgroup in which all the subjects were selected from city inhabitants. Thus there were 32 subgroups both for boys and girls in total, and in each of the subgroups there were 46–102 subjects by age.

A total of twelve variables were used to reflect growth status of boys and girls: 1) stature, 2) sitting height, 3) body weight, 4) chest girth, 5) biacromial diameter, 6) bililocristal diameter, 7) HWR index (stature/√(body weight)), 8) relative chest girth (100×chest girth/stature), 9) PHV (peak height velocity) age, 10) PHV (cm/yr), 11) PWV (peak weight velocity) age, 12) PWV (kg/yr). Here, variables 1)–8) were calculated from the cross-sectional measurements when the boys and girls were 18 years old. The PHV age and PWV age were determined as the ages when boys and girls had achieved their largest increments of height and weight, respectively. These ages were estimated by the proportional interpolation method using cross-sectional data.

PCA-Q mode cluster analysis from the SPSS Computer Package Program was used in this study (MIYAKE et al. 1977). The details of the analytic procedure are given in our previous study (JI and OHSAWA, 1991). The clustering processes stopped after all the subgroups of boys and girls had merged into a culminating cluster, respectively.

Results

Table 2 shows that both in boys and girls, four principal components were extracted. The total eigenvalues resulting from them were 9.9623 (boys) and 9.6454 (girls), which not only reflected the close relationship among corresponding variables, but also could explain 83.1% and 80.3% of their variables, respectively.

Fig. 1 shows seven clusters of boys formed at a relatively high similarity level (the criterion of similarity used here was 0.2). They merged into a culminating one at the 0.35 similarity level. Fig. 2 shows a similar process of clustering in girls. However, the similarity level which their small clusters fused seemed to be slightly higher than that of boys.

Table 3 compares the growth status within boys' clusters. The boys in each cluster had their own characteristics which were shown not only
| Minority nations | Area¹ | No. of cases² | Minority nations | Area¹ | No. of cases² |
|------------------|-------|--------------|------------------|-------|--------------|
|                  |       | boys (a)     | girls (b)        |       | boys (a)     | girls (b) |
| 1 Meng-gu (urban)| N-E   | 1186         | 66               | 17 Bai | S-W         | 1200      |
| 2 Meng-gu (rural)| N-E   | 1200         | 106              | 18 Tu-jia | S-E       | 1195      |
| 3 Hui (urban)    | N-E   | 1200         | 106              | 19 Ha-ni | S-W         | 1200      |
| 4 Hui (rural)    | N-W   | 1198         | 106              | 20 Ha-sa-ke | N-W   | 1140      |
| 5 Wei-wu-er (urban)| N-W    | 1200         | 106              | 21 Tai   | S-W       | 1134      |
| 6 Wei-wu-er (rural)| N-W   | 1200         | 106              | 22 Li    | S-E       | 1140      |
| 7 Zhuang (urban) | S-E   | 1200         | 106              | 23 Li-su | S-W       | 1140      |
| 8 Zhuang (rural) | S-E   | 1200         | 106              | 24 Wu    | S-W       | 1140      |
| 9 Chao-xian (urban)| N-E   | 1224         | 106              | 25 She   | S-E       | 1199      |
| 10 Chao-xian (rural)| N-E   | 1224         | 106              | 26 La-gu | S-W       | 1199      |
| 11 Zang          | S-W   | 1034         | 56               | 27 Dong-xiang | N-W     | 1200      |
| 12 Miao          | S-W   | 1200         | 106              | 28 No-xi | S-W       | 1157      |
| 13 Yi            | S-W   | 1200         | 106              | 29 Ke-er-ke-zhi | N-W   | 720       |
| 14 Bu-yi         | S-W   | 1198         | 106              | 30 Tu    | N-W       | 1321      |
| 15 Tong          | S-W   | 1200         | 106              | 31 Qiang | S-W       | 1116      |
| 16 Yao           | S-W   | 1115         | 71               | 32 Sa-la | N-W       | 582       |

1) N-W: the north-west of China, S-W: the south-west of China
   N-E: the north-east of China, S-E: the south-east of China
2) (a): the total number of subjects aged 7 through 18, (b): the number of subjects aged 18.
### Table 2. Principal components extracted from twelve variables for boys and girls

| Variables                  | Principal components: Boys | Principal components: Girls |
|----------------------------|-----------------------------|----------------------------|
|                            | P1  | P2  | P3  | P4  |                | P1  | P2  | P3  | P4  |
| V1 Stature                 | 0.8669 |       |     |     | 0.8637 |       |
| V2 Sitting height          | 0.9125 |       |     |     | 0.9212 |       |
| V3 Body weight             | 0.9279 |       |     |     | 0.7671 |       |
| V4 Chest girth             |       | 0.7334 |     |     | 0.8743 |     |
| V5 Biacromial diameter     | 0.7445 |       |     |     | 0.9124 | 0.7760 |     |
| V6 Biliocular diameter     | 0.7581 |       |     |     | 0.6943 | 0.7886 |     |
| V7 PHV age                 |       |       | 0.8816 |     |         |
| V8 PHV increment           |       |       |     | 0.8765 |         |
| V9 PWV age                 |       |       |     | 0.8910 |         |
| V10 PWV increment          |       |       |     | 0.5333 |         |
| V11 HWR index              |       |       |     |       | 0.7606 |         |
| V12 Relative chest girth index | -0.6329 |       |     |     |         |         |
| Eigen values               |       |       |     |     |         |         |
| (%)                       | 4.8350 | 2.0759 | 1.7959 | 1.2555 |         | 3.9296 | 2.6487 | 1.8052 | 1.2646 |
| Total Eigen values (%)     | 40.3% | 17.3% | 15.0% | 10.5% |         | 32.7% | 22.1% | 15.0% | 10.5% |

|                            | P1  | P2  | P3  | P4  |                | P1  | P2  | P3  | P4  |
|-----------------------------|-----|-----|-----|-----|----------------|-----|-----|-----|-----|
|                            | 0.9103 |       |     |     | 0.8245 |       |
|                           | 9.6454 |       |     |     |            |     |

Note: Percentages in parentheses indicate the cumulative percentage of variance explained.
by body measurements and shape but also by its tempo of growth. As shown in the following, the association between socio-economic, ecologic and geographic differences and body measurements was quite the same as that shown by the minority nations' boys aged 7 (Ji and OHSAWA, 1991).

The boys in cluster I and II came from north-west China. Except the urban inhabitants, most of them lived in prairie, plain and grass districts generation after generation. Among them, the Meng-gu (Nos. 1, 2), Hui (Nos. 3, 4) and Ke-er-ke-zhi (No. 29) who lived mainly on dairy products and meats were the greatest in body measurements. The differences of stature, sitting height and body weight between them and those of cluster VI were as high as 8.60 cm, 4.24 cm and 6.01 kg, respectively. Among those in cluster I, the Zang (No. 11) and Ha-sa-ke (No. 20) had those in cluster II, but they could only merge with Wei-wu-er (No. 5, 6), Dong-xiang (No. 27), Tu (No. 30) and Sa-la (No. 32) who lived mainly on wheat and cereals (Chinese National Affairs Committee, 1981). As compared with the boys in cluster II, those in cluster I were slightly lower in stature and body weight but higher in chest girth and its index, which meant they had relatively short but broad body shape. Their adolescent growth spurt occurred late but the PHV and PWV were quite strong.

The boys in cluster III came from south-east China. The only two exceptions were Bai (No. 17) and Na-xi (No. 19) who lived in the prosperous areas of Yunnen province sited in south-west China. The living ecologic condition was relatively good there, and people in these nations lived mainly on rice. Boys there were smaller in body measurements, especially in body weight and chest girth than those of the two clusters above. However, the relatively high HWR index and low chest girth index made them be looking taller and thinner than those of cluster I.

The boys in cluster IV, V and VI came from plateau and mountainous areas of Yunnen, Guizhou and Sichuan provinces sited adjacently in south-west China. Except for the Tai (No. 21) and Ha-ni (No. 19), these nations generally shared a better ecological condition. They lived mainly on corns and other coarse foods (Chinese National Affairs Committee, 1981). Those in cluster IV and V looked similar with each other in many variables, whereas the higher body weight and chest girth of boys in cluster V made them looking much broader than those of cluster IV. The boys in cluster VI, such as the Tong (No. 15), La-gu (No. 26), Wa (No. 24) and Yao (No. 16) belonged to the smallest in body measurements among these 27 nations. But they were rather similar in body shape with those in cluster IV who also lived in the Yun-Gui plateau. Boys in cluster IV, V and VI had rather early PHV ages and PWV ages, though their increments of PWV were much lower than those in the former clusters.

Chao-xian boys (Nos. 9, 10) in cluster VII were lower in stature than those of cluster I and II; whereas their distinctly higher sitting height and biacromial diameter as well as chest girth distinguished themselves from other nations. They had early PHV ages and PWV ages, and their PHV and PWV were quite strong.

The composition of girls' seven clusters (the criterion of similarity used here was about 0.23) was quite similar with that of the boys' but there were some noteworthy exceptions. The Chao-xian girls (Nos. 9, 10) merged with Hui (Nos. 3, 4) into cluster I mainly because of their high sitting height and body weight as well as of the early and strong PHV and PWV. In contrast, the Meng-gu (No. 1, 2) and Ke-er-ke-zhi (No. 29) girls moved into cluster II because of their relatively higher chest girth, lower body weight and later adolescent growth spurt as shown by
Fig. 1. Dendrogram of cluster analysis on growth status in boys of 27 Chinese minority nations.
Fig. 2. Dendrogram of cluster analysis on growth status in girls of 27 Chinese minority nations.
Table 3. Comparison of twelve variables among different clusters for boys

| Cluster | Stature  | Sitting height | Body weight | Chest girth | Biaxial diameter | Bilio-cristal diameter | Chest girth index | HWR index | PHV age | PHV | PWV age | PWV |
|---------|----------|----------------|-------------|-------------|------------------|------------------------|-------------------|------------|---------|------|---------|------|
| I       | 167.49   | 89.72          | 55.22       | 84.54       | 37.09            | 27.20                  | 50.54             | 43.94      | 13.71   | 7.75 | 14.00   | 6.40 |
| (n=7)   | (+ 0.86) | (+ 0.33)       | (+ 1.19)    | (+ 0.48)    | (+ 0.20)         | (+ 0.80)               | (+ 0.35)          | (+ 0.37)   | (+ 0.45) | (+ 0.70) | (+ 0.00) | (+ 0.77) |
| II      | 168.18   | 90.36          | 57.10       | 83.03       | 37.48            | 27.14                  | 49.73             | 43.68      | 12.40   | 7.54 | 13.60   | 6.68 |
| (n=5)   | (+ 0.43) | (+ 0.50)       | (+ 1.15)    | (+ 1.19)    | (+ 0.18)         | (+ 0.25)               | (+ 0.41)          | (+ 0.38)   | (+ 0.48) | (+ 0.70) | (+ 0.48) | (+ 0.74) |
| III     | 165.29   | 88.75          | 52.97       | 81.13       | 37.47            | 26.91                  | 49.39             | 44.02      | 12.67   | 7.88 | 13.00   | 6.38 |
| (n=6)   | (+ 1.16) | (+ 0.89)       | (+ 1.05)    | (+ 0.62)    | (+ 0.29)         | (+ 0.32)               | (+ 0.77)          | (+ 0.46)   | (+ 0.47) | (+ 0.90) | (+ 0.57) | (+ 0.88) |
| IV      | 162.29   | 87.14          | 51.22       | 82.91       | 36.63            | 26.32                  | 50.78             | 43.44      | 12.20   | 7.23 | 13.00   | 5.35 |
| (n=5)   | (+ 1.15) | (+ 0.51)       | (+ 0.56)    | (+ 1.47)    | (+ 0.45)         | (+ 0.33)               | (+ 0.67)          | (+ 0.46)   | (+ 0.47) | (+ 0.90) | (+ 0.57) | (+ 0.88) |
| V       | 162.74   | 88.15          | 53.45       | 84.96       | 36.69            | 26.48                  | 51.50             | 43.01      | 12.50   | 7.02 | 13.25   | 5.45 |
| (n=3)   | (+ 0.75) | (+ 0.44)       | (+ 0.91)    | (+ 0.55)    | (+ 0.32)         | (+ 0.36)               | (+ 0.43)          | (+ 0.18)   | (+ 0.50) | (+ 0.54) | (+ 0.43) | (+ 0.80) |
| VI      | 159.58   | 86.12          | 51.09       | 82.18       | 36.55            | 26.14                  | 51.50             | 43.01      | 12.50   | 7.12 | 13.25   | 5.25 |
| (n=4)   | (+ 0.16) | (+ 0.59)       | (+ 0.76)    | (+ 0.56)    | (+ 0.47)         | (+ 0.14)               | (+ 0.43)          | (+ 0.18)   | (+ 0.50) | (+ 0.54) | (+ 0.43) | (+ 0.60) |
| VII     | 166.93   | 91.57          | 56.97       | 86.50       | 38.30            | 27.05                  | 51.82             | 43.38      | 12.00   | 7.95 | 12.00   | 6.69 |
| (n=2)   | (+ 1.17) | (+ 0.46)       | (+ 0.55)    | (+ 0.10)    | (+ 0.22)         | (+ 0.05)               | (+ 0.42)          | (+ 0.11)   | (+ 0.00) | (+ 0.08) | (+ 0.00) | (+ 0.35) |
Table 4. Comparison of twelve variables among different clusters for girls

| Cluster   | Stature | Sitting height | Body weight | Chest girth | Biacromial diameter | Bilio- cristal diameter | Chest girth index | HWR index | PHV age | PHV | PWV age | PWV |
|-----------|---------|----------------|-------------|-------------|---------------------|------------------------|-------------------|------------|---------|------|---------|------|
| I (n = 4) | 156.85  | (± 1.03)       | 85.74       | 50.78       | 80.62               | 35.04                  | 27.08             | 51.42      | 42.36   | 9.75 | 7.31    | 12.00| 6.16 |
| II (n = 8) | 156.63  | (± 0.93)       | 84.89       | 51.87       | 78.46               | 34.61                  | 27.46             | 50.10      | 42.04   | 11.63| 7.36    | 12.00| 5.81 |
| III (n = 4)| 156.29  | (± 0.74)       | 84.06       | 48.71       | 77.96               | 34.55                  | 26.84             | 49.88      | 42.80   | 11.50| 6.57    | 12.25| 5.90 |
| IV (n = 8)| 153.57  | (± 0.82)       | 82.87       | 47.16       | 77.61               | 34.11                  | 26.46             | 50.51      | 42.52   | 11.28| 6.89    | 12.25| 5.43 |
| V (n = 3) | 154.00  | (± 0.60)       | 83.55       | 50.70       | 81.75               | 34.47                  | 26.63             | 53.30      | 41.61   | 11.50| 6.71    | 12.67| 5.59 |
| VI (n = 4)| 151.00  | (± 0.66)       | 82.03       | 48.71       | 80.26               | 34.03                  | 26.80             | 53.16      | 41.35   | 11.75| 6.22    | 12.25| 5.14 |
| VII (n = 1)| 148.42 | (± 0.17)       | 80.84       | 45.19       | 78.13               | 33.02                  | 25.27             | 52.64      | 41.67   | 11.00| 5.57    | 13.00| 3.77 |
ages of PHV and PWV. Miao (No. 12) and Bu-yi (No. 14) girls merged with Tong (No. 15) and Wa (No. 24) into cluster VI whose body size was quite small. Their PHV ages were nearly two years later than those of the girls in cluster I, and they had less strong PHV and PWV than the latter, too.

The only one case composing cluster VII was La-gu girls (No. 26) whose stature, body weight and sitting height was 8.43 cm, 5.59 kg and 4.90 cm lower, respectively, than those of cluster I. Besides of their late onset of growth spurt, their PHV and PWV were only 5.57 cm/yr and 3.77 kg/yr, respectively.

The variation of body shape among girls' clusters, especially reflected by their HWR index, seemed to be wider than that of boys'. However, although there were significant differences in body size (especially in stature, sitting height and body weight) among clusters I, II, III and IV, they were quite similar with each other in body shape. On the other hand, the similarity of low stature and HWR index as well as high chest girth could be seen between clusters V and VI. Hence the in these two clusters looked much shorter and broader than those of the former ones.

**Discussion**

Six variables on body size (V1 to V6), two variables on body shape (V7, V8) and four variables on adolescent growth spurt (V9 to V12) were used in this study, thus making more principal components extracted. Despite the criterion of similarity used here was 0.2 in boys and 0.23 in girls, seven clusters in both sexes were brought about by interpreting rational classification from the dendrogram, and more clusters merged at the high similarity level than in our previous study (Ji and OHSAWA, 1991). The reasons for selecting so many variables were as follows: 1) The dissimilarities of human growth were more complicated among youths aged 18 than among the children aged 7 (OHSAWA and Ji, 1990). 2) The multi-component analysis might be one of the best methods to show these dissimilarities comprehensively (EVERITT, 1980). 3) The important role of body shape in showing the difference of races. 4) The tempo of growth, especially that shown by the adolescent growth spurt, seems usually to be more sensitive than body measurement to the changes of many environmental factors, such as nutrition, diseases and psychosocial stresses (TANNER, 1982). The results of this study supported these propositions. The girls in cluster I and II, for example, were similar with each other in stature and many other variables of body size. They would be merged into one cluster soon, if only these variables were considered. However, by comparing their chest girth, relative chest girth and PHV age, the girls with different body shape and adolescent growth patterns soon divided into two clusters. The same phenomena could be seen among other clusters, which seemed to have shown the anthropological differences of these minority nations more clearly than in our previous study.

The adding of variables concerning the body shape and tempo of growth gave more details of growth characteristics among various nations. These characteristics seemed to be associated with some factors which were not shown clearly in children aged 7. For example, the Miao (No. 12), Bu-ye (No. 14), Li-su (No. 23) and Qiang (No. 31) live in the Yun-Guan plateau with an altitude of more than 2,000 meters. Their distinctly short but broad body shape as shown by the low HWR index and high chest girth index was similar with those observed in Quechua children living in the Peruvian altiplano (GOLDSTEIN et al. 1976). Whether it is a climate-adaptive character in response to the oxygen-lacking ecological condition needs further study.

Another example could be seen from the Yi (No. 13), Ha-ni (No. 19) and Tai (No. 21). In
contrast with their small body size, these boys and girls both had an early and strong PHV which distinguished them from other nations sited in south-west China, though their PWV were rather low, too. Besides, the distinctly high sitting height, relatively broad body shape and early and strong PHV and PWV of the Chao-xian youths (Nos. 9, 10) may induce the interest of anthropologists. Some cues of these characteristics had already been shown by Chao-xian children aged 7, but became clear only when they had neared their adult size and shape. These characteristics were assumed to be brought about by their hereditary genes rather than by their relatively developed socio-economic status and high cultural level (Chinese National Bureau of Statistics, 1987).

The clustering tendency of present study, both for boys and girls, was quite similar with that of our previous study (J1 and OHSAWA, 1991). Those who merged in the cluster with large body size at age 7, such as Meng-gu (Nos. 1, 2), Hui (Nos. 3, 4), Chao-xian (Nos. 9, 10) and Ke-er-ke-zhi (No. 29), usually formed clusters with large body size at age 18, whereas those who were small in body size at age 7, such as the Tong (No. 15), Wa (No. 24) and La-gu (No. 26) were still small in body size at age 18. This observation could be supported by the PEARSON's correlation coefficients of body sizes between those aged 7 and 18. The coefficients for boys and girls were 0.8653 and 0.6870 for stature, 0.8711 and 0.6908 for sitting height, 0.7846 and 0.6670 for body weight, 0.8142 and 0.7017 for chest girth, 0.5422 and 0.6119 for biacromial diameter and 0.7192 and 0.5478 for biiliocristal diameter, respectively. These results indicate the consistency of children's body size, especially among the boys, during successive growth periods. Moreover, they suggest that in order to improve the growth status of children and youth of Chinese minority nations, the interfering strategies must be taken since the early childhood, because most of the growth retardations had already existed at the age 7. The first steps of the strategies should include the improvement of culture, medical care and maternal-child health as well as of nutritional intake and food structure through health education.

抄 録

中国少数民族青少年の発育状態の差異

季 成葉・大澤清二

本研究は中国27少数民族の18歳の形質データ（身長，座高，体重，胸囲，肩峰幅，腸骨稜幅などの計測データ，体型指数及び7歳から18歳までの男性35, 92名，女性33, 464名の横断的資料から推定された発育速度データを含めた12種類）の類似性を用いて，各少数民族のクラスター分類を行ったものである。分類の手法として，主成分分析得点を手がかりに各民族間の距離行列を求め，重心法によるクラスター分析を施行して各民族の形質の大きさを表現した総合特性値による分類を行った。この結果，男女とも7クラスターに分類された。各クラスターは単に各民族の差異を表現するだけではなく，地理的・生態的・社会経済的な差異と発育の差異が関係していることを示していた。また，既報（J1 and OHSAWA, 1991）のクラスター分析による同一少数民族の7歳児の分類結果との一貫性が認められた。

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