Reports

Growth of Children of the Same Race under Different Environmental Conditions

Numerous observations on the rate of physical growth and development of children of different racial groups have been made in recent years, especially in connection with nutritional surveys conducted under the auspices of the World Health Organization and other international agencies in various parts of the world. In general, the children studied have been reported to be somewhat retarded or, in other cases, much retarded in their growth and development as compared with Caucasian children of the same sex and age in the United States. There has been a tendency to attribute the observed retardation, at least in part, to racial differences in the rate at which growth and development proceed. It is believed that the findings here reported briefly indicate the desirability of reexamining the assumption that such racial differences do in fact exist.

We recently compared the stature, weight, sitting height, and skeletal age of 898 American-born Japanese children in California with the corresponding characters of children of the same sex and age in Japan (*1*). As had been anticipated, the California children were found to be significantly taller, heavier, and more advanced in their skeletal development than comparable children in Japan, but the magnitude of the observed differences had not been anticipated.

At every age included in our study (6 to 19 years), the American-born Japanese boys exceeded in average stature the boys of Japan by an amount greater than the increase which has taken place in the average stature of the boys of Japan since the beginning of the present century (Fig. 1). The American-born Japanese girls exceeded the girls of Japan in average stature to a like degree, but only up to the age of 14 years. Thereafter, their superiority in average stature, though considerable, was somewhat less than the average gain in stature for the girls of Japan since 1900 (Fig. 2). This sexual difference is believed to have its basis in the relatively greater increase which has occurred in the average stature of the women as compared with the men of Japan during the last half-century.

Since the ratio of sitting height to stature is usually considered to be a racial character, it was rather surprising to find that, up to about the time of puberty, the American-born Japanese boys and girls were distinctly longer-legged than the children of Japan. Early in adolescence, however, the two groups became almost indistinguishable in ratio of leg length to total height.

It is evident, therefore, that during the prepuberal years the growth of the lower limbs of the Japanese children living in California was greater in proportion to the growth of the rest of their bodies than that of the children of Japan during the same period. This is probably a result of the more rapid growth rate of the California children, which, in turn, seems to be attributable to their more adequate diet and to the other more favorable environmental conditions in which they were reared.

It should be noted that the more rapid growth rate of the American-born Japanese children did not modify significantly the ratio of sitting height to stature of the older children. Our findings, therefore, are consistent with the view that this ratio is a valid racial character of adult Japanese.

A finding of especial relevance to the question of the existence of racial differences in the rate of physical growth and development of children was provided by a comparison of the skeletal age of the American-born Japanese children with that of the Caucasian children of the Brush Foundation study on which the Greulich-Pyle radiographic standards of skeletal development are based (*2*). The latter groups consisted of a large number of healthy children from Cleveland (Ohio) families who were well above average in economic level. In general, these children were taller, heavier, and more advanced in their skeletal development than other groups of children in the United States for whom comparable data were available.

Of the American-born Japanese children, only the 5-, 6-, and 7-year-old boys were found to be significantly retarded in their skeletal development as compared with the Cleveland children of the same sex and age. There was no significant difference in skeletal status between the two groups of boys from 8 to 12 years of age, but from 13 to 17 years the American-born Japanese boys were significantly more advanced skeletally than the Cleveland boys. The skeletal development of the American-born Japanese girls from 10 to 17 years of age was significantly more advanced than that of the Cleveland girls. The two groups of girls did not differ significantly from

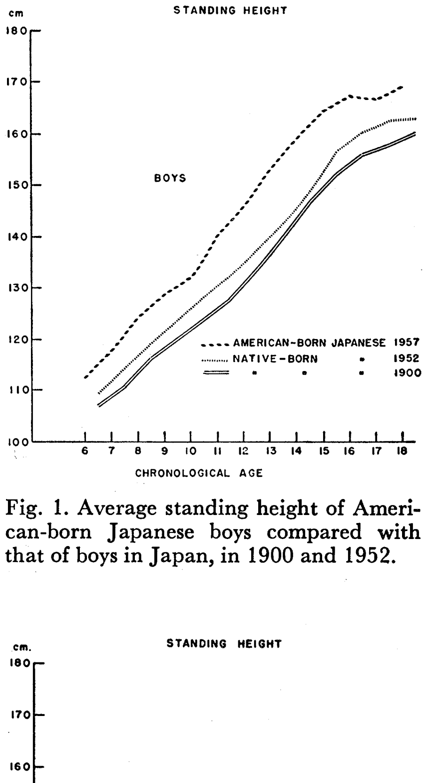

Fig. 1. Average standing height of American-born Japanese boys compared with that of boys in Japan, in 1900 and 1952.

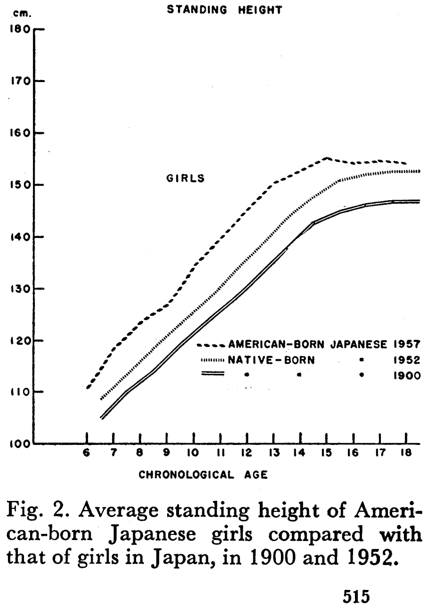

Fig. 2. Average standing height of American-born Japanese girls compared with that of girls in Japan, in 1900 and 1952.

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each other in skeletal status at any other ages included in our study.

The most extensive study of the skeletal development of children in Japan is that reported by Sutow (*3*) and by Sutow and Ohwada (*4*), who assessed hand radiographs made of 1220 boys and 1150 girls of Hiroshima during 1951–52. These were apparently healthy children who served as controls in the Atomic Bomb Casualty Commission's study of the children who survived the atomic bombing of that city. Sutow and Ohwada reported that, on the basis of the Greulich-Pyle radiographic standards, the Hiroshima children were less advanced skeletally than the Cleveland children at every age considered in their study—that is, from 6 to 19 years. Their relative retardation ranged from 6 to 24 months in boys and from 9 to 24 months in girls.

Sutow suggested that the observed retardation in the skeletal development of the Japanese as compared with the Caucasian children might be due, at least in part, to some racial difference in the rate at which normal growth and development proceed in the two groups. However, he stressed as important factors contributing to their relative retardation in skeletal development the deprivations in food and other essentials which the Japanese children had experienced during World War II and the years immediately following its close.

Our findings on the American-born Japanese children do not support the view that the less advanced skeletal status of the children in Japan is attributable to some racial difference between Japanese and Caucasians. It seems more probable that, like their smaller average stature and their relatively shorter legs during childhood, the skeletal retardation of the children in Japan results from a less adequate diet and from other environmental conditions which are not so conducive to optimal growth as those existing in this country.

These findings, especially the observed similarity in skeletal status between the California Japanese and the Cleveland Caucasian children, indicate the need for caution in interpreting the relatively retarded growth and development of children in less favored parts of the world as the expression of some basic genetic difference between them and our own children (*5*).

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References and Notes

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3. W. W. Sutow, *Hiroshima J. Med. Sci.* **2**, 181 (1953).
4. W. W. Sutow and K. Ohwada, *Clin. Pediat. (Japan)* **6**, No. 11 (1953).
5. The study on which this report is based was supported by grant A-624 from the National Institutes of Health and by a grant from the Wenner-Gren Foundation for Anthropological Research.

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Distribution of Incompatibility Alleles among the Complex-Heterozygotes of Oenothera

In earlier papers (*1*), evidence was presented indicating the presence of an incompatibility allele mechanism in oenotheras of the *biennis* group 1, a phylogenetic group of true-breeding translocation heterozygotes. This is a preliminary report (*2*) of the occurrence of incompatibility alleles in other phylogenetic groups of the genus *Oenothera.*

The oenotheras of *biennis* group 1 are composed of two genomes or "complexes" of seven chromosomes each. These are designated as the alpha and beta complexes and are characterized by completely different arrangements of their chromosome ends. As a result, at meiosis a circle of 14 chromosomes occurs, and only two kinds of spores are produced, one carrying the alpha, the other the beta, complex. Such plants, which are naturally self-pollinating, produce only alpha · beta combinations among the offspring. The absence of alpha · alpha or beta · beta combinations among the progeny is attributed to a balanced lethal system. In outcrossing these forms, it becomes apparent that one complex is transmitted to the offspring predominantly through the egg and the other largely through the pollen. This serves as a basis of distinguishing the alpha and the beta complexes, the latter coming through the pollen, the former through the egg.

In the *biennis* group 1 races, the alpha complex carries an incompatibility allele (S_I), while the beta complex carries an allele which has no incompatibility effect (S_f). The S_I allele of the alpha complex serves as a pollen lethal, because in self-pollinations development of pollen carrying the alpha complex will be inhibited by the presence of the same S_I allele in the style. The incompatibility allele mechanism thus acounts for one-half of the balanced lethal system so well known to *Oenothera.*

The incompatibility allele mechanism suggests an attractive hypothesis explaining the origin of the complex-heterozygotes. In two isolated populations showing orthodox cytogenetic behavior, the occurrence of random segmental interchange can, over a period of time, result in the differentiation of the two populations with regard to the arrangement of their chromosome ends. If interchange is extensive enough, the two populations may come to be characterized by completely different segmental arrangements. Let us suppose that one of these populations possesses an incompatibility allele system, while the other does not. If the two populations now come into contact and hybridization occurs between them, the hybrids will be complete translocation heterozygotes, producing only two kinds of spores. One of these will carry an S_I allele; thus, pollen of this type will not develop in a self-pollination, and one type of segregate (alpha · alpha) which is structurally homozygous cannot occur. If megaspore competition occurs, and the complex carrying the S_I allele is the one which succeeds in producing the embryo sacs, the other segregate which is structurally homozygous (beta · beta) will also be eliminated. Thus, such a hybrid will be true-breeding from its inception. In this way, the highly specialized oenotheras could have arisen simply through a single hybridization. Once established, of course, the nature of the cytogenetic mechanism allows the accumulation of recessive detrimental and lethal genes which reinforce the original balanced lethal system of incompatibility alleles and megaspore competition.

The strength of this hypothesis depends to a large extent upon the demonstration of the existence of incompatibility alleles in the other phylogenetic groups of complex-heterozygotes in the subgenus. If incompatibility alleles are found in the alpha complexes of most complex-heterozygotes, the hypothesis would seem to have general significance in explaining the origin of the complex-heterozygote.

Largely through the work of Cleland and his associates, several hundred collections of *Oenothera* from North America have been cytogenetically analyzed and classified accordingly into eight different phylogenetic groups (*3*). A study has been undertaken to survey the complex-heterozygotes among these collections for the presence of incompatibility alleles in their alpha complexes. The particular phylogenetic groups with which work has begun are the *strigosa,* the *biennis* group 2, the *biennis* group 3, and the *parviflora.* Some unforeseen difficulties in obtaining the critical hybrid combinations in many of the crosses has so far limited the collection of data regarding the distribution of incompatibility alleles in these groups. However, certain races (listed in Table 1) have been shown to possess incompatibility alleles.

It is interesting to note that the races *grandiflora* de Vries and Beaufort both