

Original Article

Target Height and Target Range for Japanese Children: Revisited

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Abstract. In 1990, we proposed the equations to calculate target height (TH) and target range (TR) for Japanese, taking account of the positive height secular trend observed over the last ~100 years. However, height difference between generations appears to have become small or negligible in contemporary Japanese populations. Thus, we re-analyzed the Japanese height data, and revised the equations for TH and TR for contemporary Japanese children as follows (cm): Boys, $TH = \{PH + (MH + 13)\} \div 2$, $TR = TH \pm 9$; and Girls, $TH = \{(PH - 13) + MH\} \div 2$; $TR = TH \pm 8$, where PH indicates paternal height and MH maternal height.

Key words: target height, target range, Japanese

Introduction

Height is a quantitative character subject to various genetic and environmental factors (1). In developed countries, including Japan, genetic factors have become the major height determinants, because environmental factors have generally improved to a high degree with few gross variations among individuals. Indeed, heredity, which is defined as the relative contribution of genetic factors to the determination of individual height, is regarded as contributing 80–90% to height in developed countries (2). In this context, parental height can be regarded as an excellent

indication for the genetic factors, because the heights of children correlate well with their parental heights (3).

Tanner *et al.* proposed the concept of target height (TH) and target range (TR), which predict the adult height and its range of variation on the basis of parental height (3). In 1990, Ogata *et al.* proposed the following equations to calculate TH/TR for Japanese (cm): boys, $TH = \{PH + (MH + 13)\} \div 2 + 2$, $TR = TH \pm 9$; and girls, $TH = \{(PH - 13) + MH\} \div 2 + 2$; $TR = TH \pm 8$, where PH indicates paternal height and MH maternal height (4). In these equations, the “2 cm” represents the height difference between generations that has primarily been caused by improvement in environmental factors over the last ~100 years. However, as indicated by the recent cessation of the positive height secular trend, the height difference between generations appears to have become small or negligible in contemporary Japanese populations.

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Thus, we re-analyzed growth parameters utilized in the calculation of TH/TR, and set forth revised equations for the calculation of TH/TR. We further discuss several points regarding the clinical application of TH/TR.

Methods

Theoretically, TH/TR (cm) is obtained by the following equations (3).

Boys: $TH = \{PH + (MH + D)\} \div 2 + d_1$; $TR = TH \pm 2RSD_1 = TH \pm 2SD_1 \div \sqrt{1 - r^2}$.

Girls: $TH = \{(PH - D) + MH\} \div 2 + d_2$; $TR = TH \pm 2RSD_2 = TH \pm 2SD_2 \div \sqrt{1 - r^2}$.

D: adult height difference between sexes; d_1 : adult height difference between male generations; d_2 : adult height difference between female generations; RSD: residual standard deviation; SD_1 : adult height standard deviation in males; SD_2 : adult height standard deviation in females; and r : correlation coefficient between mid-parental height and child's adult height.

To determine the variables utilized in the equations for TH/TR (D, d_1 , d_2 , SD_1 , and SD_2), we examined the heights at 17.5 yr of age on the basis of the annual data from the Ministry of Education, Culture, Sports, Science and Technology, because there are no reliable adult height data in Japan. Furthermore, since there are no data of r , we employed the practical value of 0.63 that is obtained by reducing the relevance of assortative mating and other factors from the theoretical value of 0.71 that is obtained by assuming random mating (3). The generation time was evaluated as roughly 30 yr on the basis of the parental age data at the birth of children from the Ministry of Health, Labour and Welfare; this implies that the secular trend since 1985 is important in the assessment of d_1 and d_2 for contemporary Japanese children ~6 years of age at present (the year 2007), because their parents are predicted to have reached the adult height around the year 1988 (at ~17.5 years of age) and produced children around the year 2001 (at ~30 years of age).

Table 1 Height data at 17.5 yr of age (cm)

Year	Boys		Girls		D
	Height	SD	Height	SD	
1985	170.2	5.60	157.6	4.98	12.6
1986	170.3	5.64	157.7	4.99	12.6
1987	170.3	5.71	157.8	4.97	12.5
1988	170.3	5.65	157.8	5.05	12.5
1989	170.5	5.63	157.8	5.00	12.7
1990	170.4	5.57	157.9	4.99	12.5
1991	170.6	5.62	157.9	5.04	12.7
1992	170.7	5.65	157.9	5.14	12.8
1993	170.7	5.61	158.0	5.19	12.7
1994	170.9	5.68	158.1	5.20	12.8
1995	170.8	5.64	158.0	5.17	12.8
1996	170.9	5.74	158.1	5.23	12.8
1997	170.9	5.76	158.0	5.26	12.8
1998	170.9	5.81	158.1	5.22	12.8
1999	170.9	5.80	158.1	5.22	12.8
2000	170.8	5.83	158.1	5.25	12.7
2001	170.9	5.76	158.0	5.32	12.9
2002	170.7	5.72	157.9	5.26	12.8
2003	170.7	5.72	157.8	5.29	12.9
2004	170.8	5.83	157.9	5.35	12.9
2005	170.8	5.81	158.0	5.28	12.8

SD: standard deviation; D: sex difference in height.

Results

The height data at 17.5 yr of age from the year 1985 to 2005 is shown in Table 1. The height difference between sexes remained constant with a range of 12.5–12.9 cm. The height at 17.5 yr of age also remained fairly constant and, virtually, there was no height change for >10 yr in boys and >15 yr in girls. The height SD also remained constant with a range of 5.60–5.83 cm in boys and 4.97–5.35 cm in girls. Thus, considering the clinical convenience, we determined the “D” as 13.0 cm (the height gain after 17.5 yr of age should be slightly larger in boys than in girls), the “ d_1 ” and “ d_2 ” values as zero, RSD_1 as 4.5 cm, and RSD_2 as 4.0 cm (SD_1 and SD_2 were obtained as 5.71 cm and 5.20 cm based on the median values, and r was regarded as 0.63). Thus, we set forth the

following equations for contemporary Japanese children:

Boys, $TH = \{PH + (MH + 13)\} \div 2$ cm; $TR = TH \pm 9$ cm

Girls, $TH = \{(PH - 13) + MH\} \div 2$ cm; $TR = TH \pm 8$ cm.

Discussion

We re-analyzed the annual height data in Japan, and confirmed virtually no secular height change in recent decades in both sexes. Thus, there appears to be no need to take account of the adult height difference between generations in both boys and girls. Furthermore, we also confirmed that there is no need to change other parameters utilized in the TH/TR equations. On the basis of these findings, we have revised the TH/TR equations for contemporary Japanese children.

While the usefulness of TH/TR has widely been accepted, several matters should be considered in the clinical application of TH/TR (5). First, TH/TR cannot be utilized for a child born to a parent(s) with a mutant major growth gene. For example, it does not make sense at all to use TH/TR in the height assessment of a child born to a father with achondroplasia and a normal mother. Second, there should be no drastic difference in the environmental factors between the two generations. Drastic changes in environmental factors have taken place after the World War II (4), and environmental factors could change drastically in several situations such as neglect. Third, since only mean values are utilized for the equations of TH/TR, the accuracy should be different depending on the parental height. For example, although TH/TR is similar between a child born to parents of average height and a child born to a tall father and a short mother, the height variation must be larger in the latter child than in the former child. Fourth, if the child's height remains within the TR, this does not guarantee that the child has no abnormality of a major growth gene. For example, haploinsufficiency of *SHOX* is known

to reduce the statural height by ~2 SD in patients without dyschondrosteosis (6). Thus, a person with a high original height potential, e.g., the upper limit of TR, can still have a height within the TR under haploinsufficiency of *SHOX*. Lastly, if the child's height is outside the TR, this does not necessarily indicate that the child has an abnormality of a major growth gene. Tall stature above TR and short stature below TR can take place just by chance with the frequency of 2.3%.

In summary, we set forth the TH/TR equations for contemporary Japanese children. It is recommended to use TH/TR in the growth assessment of children, taking account of its limitations.

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