Journal of
PHYSIOLOGICAL
ANTHROPOLOGY
and Applied Human Science

Secular Trends of Sizes at Birth in Japanese Healthy Infants Born between 1962 and 1988

Kazuyo Oishi[1], Sumihisa Honda[2], Noboru Takamura[1], Yosuke Kusano[3], Yasuyo Abe[1], Kazuhiko Moji[4], Tai-ichiro Takemoto[5], Yasuaki Tahara[6] and Kiyoshi Aoyagi[1]

1) *Department of Public Health, Nagasaki University Graduate School of Biomedical Sciences*
2) *Department of Radiation Epidemiology, Nagasaki University Graduate School of Biomedical Sciences*
3) *Human Service and Community Development, Nagasaki Wesleyan University*
4) *Research Center for Tropical Infectious Diseases, Institute of Tropical Medicine, Nagasaki University*
5) *Department of Health and Nutrition, Nagasaki International University, Faculty of Health Management*
6) *Department of School Health and Health Promotion, Faculty of Education, Nagasaki University*

Abstract Body sizes at birth are important clinical indicators widely used for evaluation of prenatal growth. Japan had significant socioeconomic improvement around the 1960s, and these environmental changes may influence physiologically prenatal growth. Furthermore, in Japan, measurements of size at birth for birth certificates are weight and height. Thus, we can refer to annual data on weight and height, but not on head and chest circumference at birth. In this study we measured the weight, height, and head and chest circumference at birth among 6,563 Japanese singleton healthy infants, annually in 1962 and 1988, and examined secular trends of these anthropometric measurements. The boys consistently exceeded the girls in all four variables. Birth weight and height increased significantly from the 1960s to '70s, but did not differ between the '70s and '80s in both boys and girls. Secular trends of head and chest circumference were different from them. In both boys and girls, head and chest circumference increased significantly from the '60s to the '70s, but decreased significantly from the '70s to the '80s. No difference of head circumference during the '60s and '80s was found, but the difference of chest circumference was found. Size at birth was likely to increase from the '60s to '70s in Japan. These findings suggest that the environmental changes such as socioeconomic improvements influence the prenatal growth. *J Physiol Anthropol Appl Human Sci 23 (5): 155–161, 2004* http://www.jstage.jst.go.jp/browse/jpa

Keywords: size at birth, weight, height, head circumference, chest circumference, secular trend, environmental adaptability

Introduction

Body sizes (weight, height, and head and chest circumference) at the birth of newborn infants are important clinical indicators widely used for evaluation of prenatal growth (Ayatollahi and Shahsawary, 2002; Fok et al., 2003). Infants with either too low or too high birth weights have higher mortality and morbidity than those with appropriate weight for gestation, and they also have increased risk of complications such as peripartum asphyxia, birth trauma, congenital malformations, and hypoglycemia (Koops et al., 1982; Susser et al., 1972; Wilcox and Russell, 1983; Wilcox and Skjaerven, 1992; Williams et al., 1982).

Body size is determined by the results of both environmental and genetic factors, not a single factor (Eveleth, 1986). Considering environment, high and middle socioeconomic status may provide the mother with better nutrition, and help her to take better advantage of health and medical services than mothers in the lower levels. Urbanization may also provide food supply, medical services, clean water, and sanitation facilities. Japan had significant socioeconomic improvement around the 1960s, and these environmental changes may have influenced physiologically prenatal growth.

In Japan, measurements of size at birth for birth certificates are weight and height (Statistics and Information Department, Minister's Secretariat, Ministry of Health, Labor and Welfare, 2004). Thus, we can refer to annual data on weight and height. However, since the head and chest circumference at birth were recorded only every ten years (Mother's and Children's Health and Welfare Association, 2002), annual data on head and chest circumference were not available.

We measured the weight, height, and head and chest

circumference at birth annually during 1962 and 1988 among Japanese healthy infants, and examined secular trends of these anthropometric measurements.

Subjects and Methods

A total of 8,037 infants were born in a municipal maternity home in a local city (Sasebo, Nagasaki prefecture, Japan) during 1962 to 1988. Among them, those whose sex was unknown (n=199), twins (n=60), and newborns of gestation below 37 weeks (n=571) and above 41 weeks (n=644) were excluded from the analysis. We studied a total of 6,563 singleton Japanese newborns (3,402 boys and 3,161 girls) of gestation 37–41 weeks, and all of them were healthy. The number of subjects in each successive year and decades is shown in Table 1. Gestational age was calculated from the last menstrual date using the mother's menstrual cycle and menstrual history.

Birth weight was measured using a weighted scale, which was accurate to 50 g and calibrated before each measurement. Height (recumbent length) was measured with the infant lying supine on a firm table, having a measuring stick inserted along one edge. The soles of the feet were held firmly against a fixed upright placed at the zero mark. A movable upright crosses the table above the head and was brought firmly against the vertex. Head and chest circumference were measured using an inelastic tape measure. The head circumference was the maximum circumference around the head over the glabella and supraorbital ridges anteriorly, and the top of the occipital bone posteriorly. The chest circumference was made in midrespiration, at the level of the xiphoid cartilage or substernal notch, in a plane at right angles to the vertebral column. All measurements were carried out after the infant had been thoroughly dried and the umbilical cord cut within an hour by a midwife.

Table 1 Number of subjects in each successive year and decades.

Year	Boys	Girls	Total
1962	2	0	2
1963	245	250	495
1964	308	278	586
1965	305	276	581
1966	151	161	312
1967	1	0	1
1970	225	200	425
1971	216	216	432
1972	250	209	459
1973	233	209	442
1974	233	203	436
1975	203	170	373
1976	158	140	298
1977	135	123	258
1978	107	106	213
1979	110	114	224
1980	103	107	210
1981	88	68	156
1982	60	55	115
1983	59	94	153
1984	72	51	123
1985	48	48	96
1986	32	32	64
1987	35	29	64
1988	23	22	45
1960s	1,012	965	1,977
1970s	1,870	1,690	3,560
1980s	520	506	1,026
Total	3,402	3,161	6,563

Statistical Methods

Large fluctuations were observed in the year-specific means of anthropometric measurements, especially in the '80s when the number of study subjects was rather small (see Table 1). To eliminate noise fluctuation and explore secular trends of anthropometric measurements at birth (i.e. birth weight, height, head circumference and chest circumference) between 1962 and 1988, we used the smoothing method of moving averages for three years and displayed them on graphs. Anthropometric measurements were compared among the groups of the study period (i.e. the period of 1962–1969 ('60s), period of 1970–1979 ('70s) and period of 1980–1988 ('80s)) by using the analysis of covariance, adjusting for gestational age. No interaction terms between groups of study period and gestational age were statistically significant. Data analysis was conducted using SAS software.

Results

Eighty-eight percent of the mothers were housewives, and the mean (SD) age of the mothers was 27.1 (4.3) years old. The proportion of housewives and mean age of the mothers were similar in three compared cohorts: '60s, '70s and '80s. Table 2 shows the proportion of first-, second-, third-, and fourth or above born infants among '60s, '70s and '80s. In total, two-thirds of the infants were either first- (34.8%) or second- (35.6%) born infants. Para 3 infants constituted 21.4%, and a small number (8.2%) were para 4 or above. However, these proportions were different among '60s, '70s and '80s; first born infants decreased according to successive decade.

Fig. 1 shows the moving averages of birth weight, height, head circumference and chest circumference for three years of the boys and girls. The boys consistently exceeded the girls in all four variables.

Birth weight (Fig. 2 and Table 3) and height (Fig. 3 and Table 3) increased significantly from the '60s to '70s, but did not differ between the '70s and '80s in both boys and girls. Secular trends of head and chest circumference were different from those of weight and height. In both boys and girls, head and chest circumference increased significantly from the '60s to '70s, but decreased significantly from the '70s to '80s. No difference of head circumference between the '60s and '80s

Table 2 The proportion of first-, second-, third-, and fourth or above born infants among '60s, '70s and '80s.

	1960s		1970s		1980s		Total	
	No.	%	No.	%	No.	%	No.	%
First	783	42.2	1,177	33.5	263	25.8	2,223	34.8
Second	585	31.5	1,310	37.3	379	37.2	2,274	35.6
Third	356	19.2	753	21.4	260	25.5	1,369	21.4
Fourth or above	131	7.1	276	7.9	117	11.5	524	8.2
Unknown	122	—	44		7	—	173	—

was found (Fig. 4 and Table 3), but the difference of chest circumference was found (Fig. 5 and Table 3).

We compared the birth weight and head circumference of our infants in '80s with those obtained from British infants in the Oxford area between 1978 and 1984 (Yudkin et al. 1987). The 50th percentile of the British infants of either sex was substantially higher than those of our infants (Table 4).

Table 3 Comparison of sizes at birth between the 1960s (1962–69) and 1970s (1970–79), 1960s and 1980s (1980–88), and 1970s and 1980s (ANCOVA).

	1960s vs. 1970s	1960s vs. 1980s	1970s vs. 1980s
Boys			
Weight	$p<0.001$	$p<0.001$	$p=0.532$
Height	$p<0.001$	$p=0.001$	$p=0.769$
Head circumference	$p<0.001$	$p=0.607$	$p<0.001$
Chest circumference	$p<0.001$	$p<0.001$	$p<0.001$
Girls			
Weight	$p<0.001$	$p=0.001$	$p=0.559$
Height	$p<0.001$	$p<0.001$	$p=0.688$
Head circumference	$p<0.001$	$p=0.648$	$p<0.001$
Chest circumference	$p<0.001$	$p=0.002$	$p<0.001$

Discussion

In Japan, measurements of size at birth for birth certificates are weight and height (Statistics and Information Department, Minister's Secretariat, Ministry of Health, Labor and Welfare, 2004), and head and chest circumference at birth were available every ten years (Mother's and Children's Health and Welfare Association, 2002). We measured weight, height, and head and chest circumference at birth between 1962 and 1988 among Japanese healthy infants in a local city (Sasebo, Nagasaki prefecture, Japan), and showed secular trends of these anthropometric measurements. All measurements increased from the '60s to the '70s. However, the trends of each measurement were somewhat different between the '70s and '80s; birth weight and height did not differ, but head and chest circumference decreased.

Nutritional status in Japan dramatically changed between the 1960s and '70s. According to a national nutritional survey, in Japan (Ministry of Health, Labor and Welfare, Japan, 2002), animal fats and protein intake increased. The intake of animal fats and protein was 14.3 g and 28.5 g, in 1965 and 26.9 g (an 88% increase) and 38.9 g (36% increase) in 1975, respectively. Dunn (1985) reported that the small size of infants born in developing countries is to a large extent the result of environmental factors such as maternal malnutrition. The increase in size at birth may be influenced by the nutritional changes. In addition, nutritional status substantially has not changed between the '70s and '80s, which may explain why there was no increase in weight and height at birth between the two periods. However, we could not explain the decrease in head and chest circumference between the '70s and '80s, only by a trend of nutritional status. The western lifestyle (more use of chair, less tatami mats) has become widespread in Japan after World War II, which may contribute to the decrease in head and chest circumference through the changes in mother's shape of the pelvis. Further study is needed to clarify why head and chest circumference decreased between the '70s and '80s.

Our results showed that the boys consistently exceeded the girls in all four variables. Similarly, a study in Iran showed that weight, height, and head and chest circumference in boys were higher than in girls (Ayatollahi and Shahsawary, 2002). Similar research results were also reported in other regions such as Europe (Guihard-Costa et al., 1997), Canada (Arbuckle et al., 1993), Africa (Bhat et al., 1989), Australia (Guaran et al., 1994) and China (Fok et al., 2003). Similarly, sizes at birth in boys are greater than those in girls worldwide.

Body size at birth in every ten-year nationwide survey in Japan included weight, height, and head and chest circumference in 1960, 1970, 1980 and 1990 (Mother's and Children's Health and Welfare Association, 2002). Weight at birth in both genders increased after 1960, attained peak value in 1980, and decreased in 1990. Height at birth in boys increased from 1960 to 1970, and decreased thereafter. On the other hand, height at birth in girls decreased from 1960. Head and chest circumference in either sex did not change substantially between 1960 and 1990. Some findings were consistent with our results, but others were not. These discrepancies may be due to the healthy infants and smaller sample size of our study.

We compared the birth weight and head circumference of our infants with those obtained from British infants in the

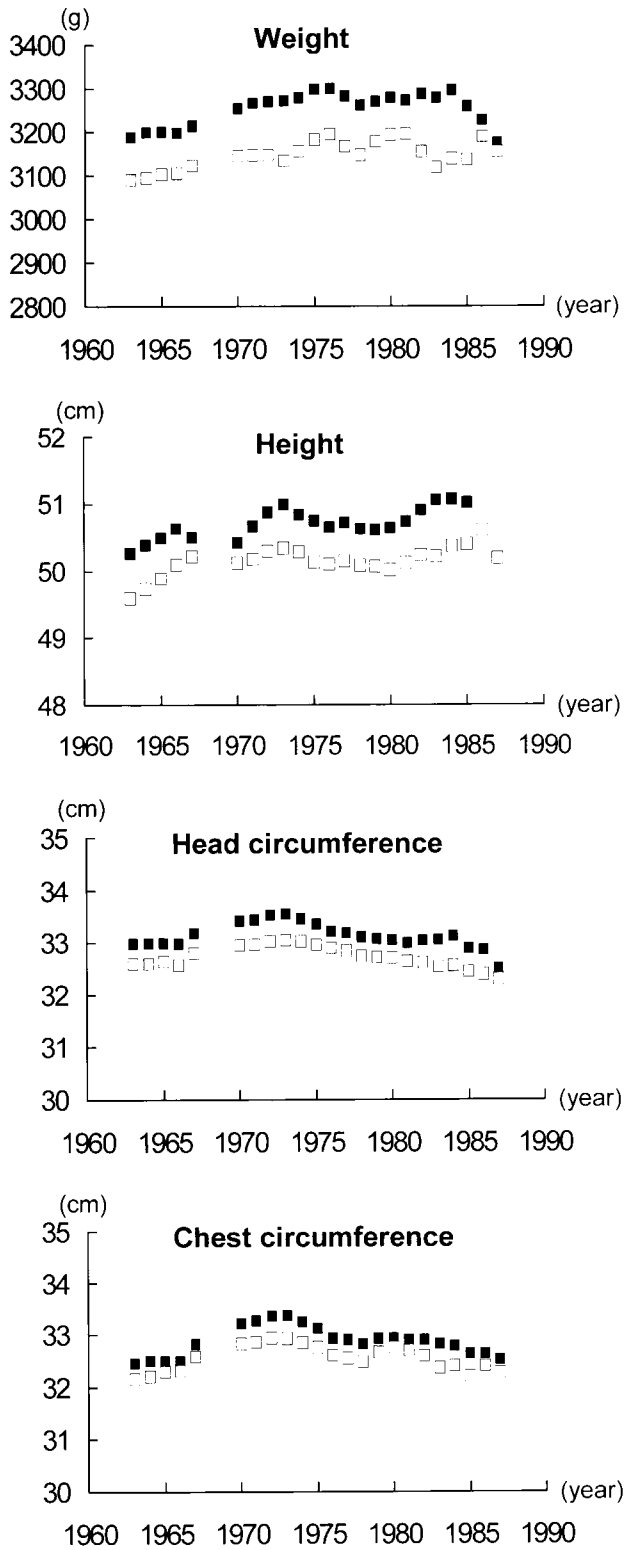

Fig. 1 The moving averages of weight, height, and head and chest circumference for three years. Closed and open square indicate those of boys and girls, respectively.

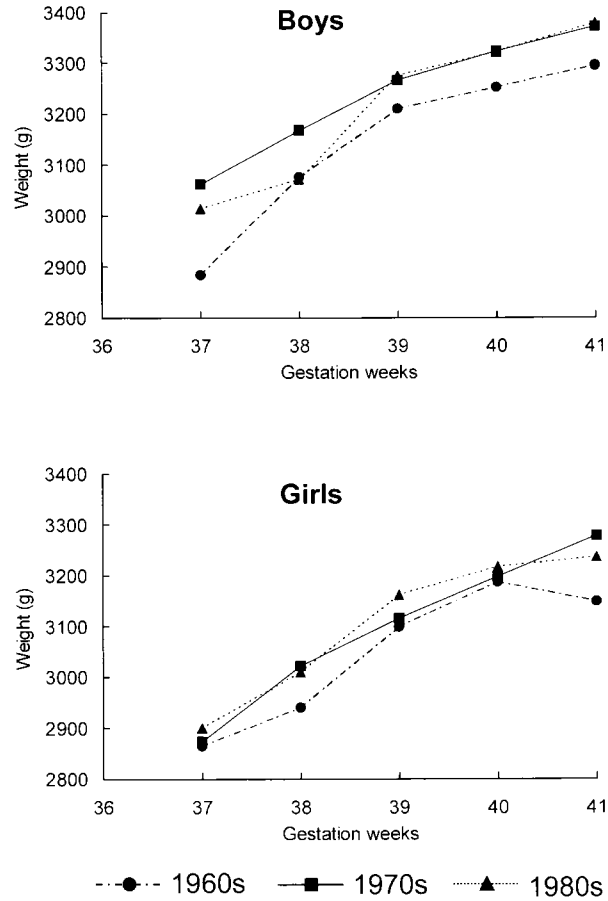

Fig. 2 Comparison of weight among the groups of the study period.

Oxford area. The British infants of either sex were substantially greater than our infants. It thus appears that, compared with white infants, there is a genuine genetic predisposition that leads to the smaller size of Japanese infants.

Fok et al. (2003) reported the gestational age-specific birth weight, height and head circumference of Chinese in Hong Kong during 1998 and 2000, and compared them with those during 1982 and 1986. Comparison between the 1982–1986 cohort showed a significant secular trend towards the birth weight increasing. Moreover, the trend was small, but significant, for height and head circumference. Over time, the region has evolved from an industrial city to a commercial and financial center. Associated with this change has been a rapid improvement in the standard of living and health indices, including infant and neonatal mortality. At the same time, the population has experienced an increasing growth rate from 1.1% in 1991 to 2.4% in 1996, and a falling birth rate from 11.7 per thousand in 1991 to 7.4 per thousand in 1999. A similar secular trend in birth weights of term infants has been observed in the Norwegian population (Skjaerven et al. 2000). Furthermore, Japan had socioeconomic improvement around the 1960s, which contributed to our finding that size at birth

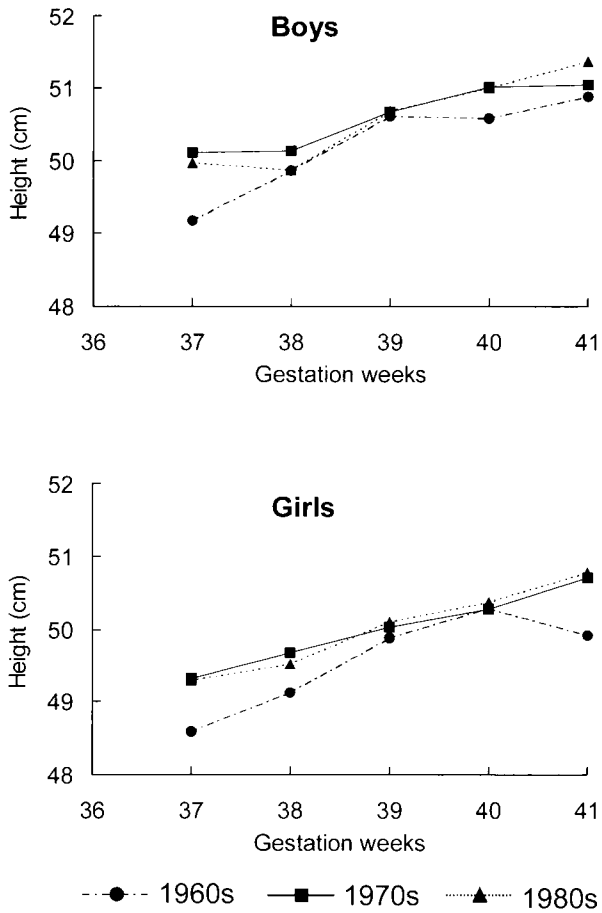

Fig. 3 Comparison of height among the groups of the study period.

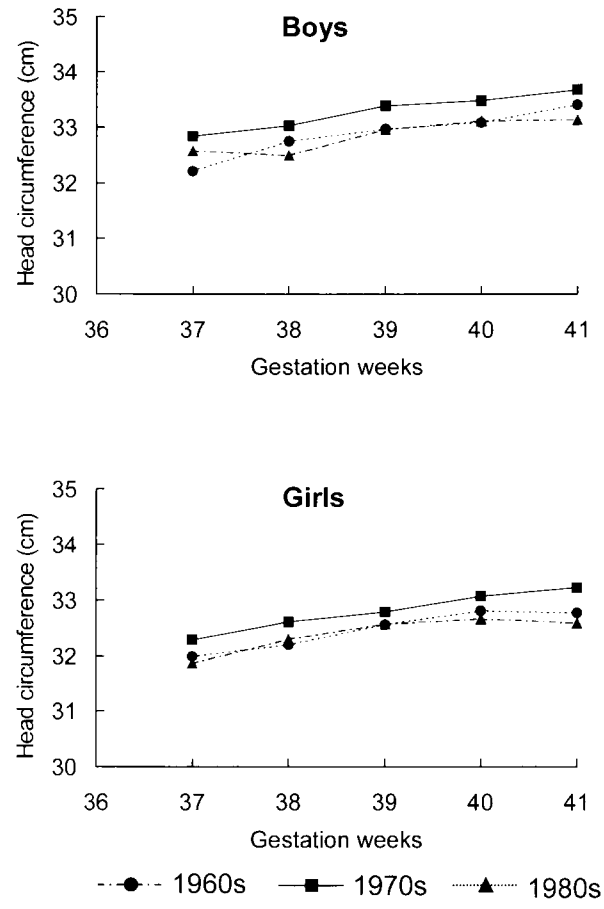

Fig. 4 Comparison of head circumference among the groups of the study period.

increased from the '60s to '70s. Socioeconomic changes may play an important role in the determination of size at birth (Eveleth, 1986).

For the most part, shape had been considered to be genetically determined, but for Japanese it was influenced by the environment (Eveleth, 1986). Analysis of Japanese data from 1959, 1967, to 1977 showed that an increase in height in adults over twenty years old seems to be due entirely to an increase in leg length that resulted in a different adult body shape in 1977 than in 1957 (Tanner et al., 1982). Our results showed that infants in the '80s had smaller head circumference relative to height compared with those in the '60s. Furthermore, head circumference/height ratio among 5–6 year boys and girls decreased from 1970 to 1990 in nationwide survey in Japan (Mother's and Children's Health and Welfare Association, 2002). This decrease in head circumference, as well as the increase in leg length, might have occurred in Japanese during that period possibly through environmental factors. Although it is unclear why infants in the '80s had smaller heads, it may be influenced by the spread of western lifestyle.

In this study, the proportions of first-, second-, third-, and fourth or above born infants were different among '60s, '70s and '80s; first-born infants decreased according to successive decade. In Japan, the delivery increased in hospital or clinic and decreased in maternity home from '60s to '80s (Statistics and Information Department, Minister's Secretariat, Ministry of Health, Labor and Welfare, 2004), which may influence the decrease of first-born infants in maternity home.

Japan had significant socioeconomic improvements around the 1960s. Size at birth (weight, height, and head and chest circumference) was likely to increase from the '60s to '70s in Japan, which may have resulted from environmental changes such as socioeconomic improvements including nutritional change. As Tanner (1986) says: "Growth is a mirror of the condition of society." It would be necessary to pay attention to the changes in size at birth in order to clarify the effect of environment on prenatal growth.

Acknowledgement We thank the midwives of the Sasebo municipal maternity home for their valuable assistance in conducting the study.

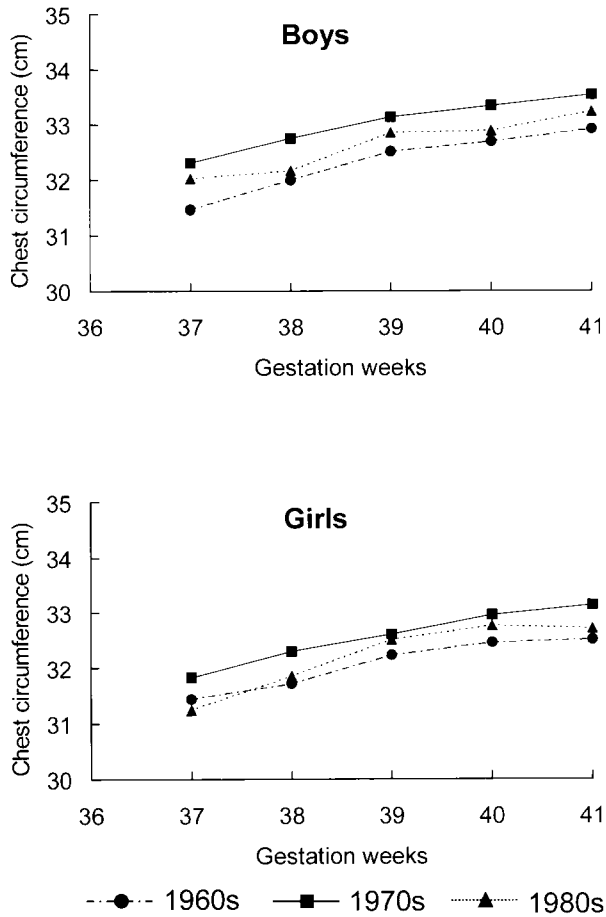

Fig. 5 Comparison of chest circumference among the groups of the study period.

Table 4 Differences of the 50th percentiles of gestation-specific weight (g) and head circumference (cm) at birth between Japanese and British infants.

Gestation (weeks)	Our results in Japan	British*	Difference
Weight			
Boys			
37	2970	3030	60
38	3040	3200	160
39	3300	3350	50
40	3300	3470	170
41	3370	3550	180
Girls			
37	2960	2910	−50
38	3000	3070	70
39	3180	3210	30
40	3240	3330	90
41	3200	3420	220
Head circumference			
Boys			
37	32.5	34.2	1.7
38	33.0	34.6	1.6
39	33.0	35.0	2.0
40	33.0	35.3	2.3
41	33.0	35.4	2.4
Girls			
37	32.0	33.5	1.5
38	32.0	34.0	2.0
39	32.5	34.3	1.8
40	32.5	34.6	2.1
41	32.5	34.7	2.2

* Yudkin, P.L. et al. (1986)

References

Arbuckle TE, Wilkins R, Sherman GJ (1993) Birth weight percentiles by gestational age in Canada. Obstet Gynecol 81: 39–48

Ayatollahi SM, Shahsawary S (2002) Sizes at birth in Shiraz, Iran. J Trop Pediatr 48: 245–247

Bhat GJ, Mukelabai K, Shastri GN, Tamina C (1989) Anthropometric parameters of Zambian infants at birth. J Trop Pediatr 35: 100–104

Dunn PM (1985) A perinatal growth chart for international reference. Acta Paediatr Scand Suppl 319: 180–187

Eveleth PB (1986) Population difference in growth. In Falkner F, Tanner JM eds. Human growth, A comprehensive treatise. Plenum Press, New York, 221–239

Fok TF, So HK, Wong E, Ng PC, Chang A, Lau J, Chow CB, Lee WH (2003) Updated gestational age specific birth weight, crown-heel length, and head circumference of Chinese newborns. Arch Dis Child Fetal Neonatal Ed 88: 229–236

Guaran RL, Wein P, Sheedy M, Walstab J, Beischer NA (1994) Update of growth percentiles for infants born in an Australian population. Aust N Z J Obstet Gynaecol 34: 39–50

Guihard-Costa AM, Grange G, Larroche JC, Papiernik E (1997) Sexual differences in anthropometric measurements in French newborns. Biol Neonate 72: 156–164

Koops BL, Morgan LJ, Battaglia FC (1982) Neonatal mortality risk in relation to birth weight and gestational age: update. J Pediatr 101: 969–977

Ministry of Health, Labor and Welfare, Japan (2002) The National Nutrition Survey in Japan, 2000. Dai-ichi Shuppan, Tokyo [*In Japanese*]

Mother's and Children's Health and Welfare Association (2002) Maternal and Child Health Statistics of Japan. Equal Employment, Children and Families Bureau, Ministry of Health, Labor and Welfare, Tokyo [*In Japanese*]

Skjaerven R, Gjessing HK, Bakketeig LS (2000) Birthweight by gestational age in Norway. Acta Obstet Gynecol Scand 79: 440–449

Statistics and Information Department, Minister's Secretariat Ministry of Health, Labor and Welfare (2004) Vital Statistics of Japan. Health and Welfare Statistics Association, Tokyo [*In Japanese*]

Susser M, Marolla FA, Fleiss J (1972) Birth weight, fetal age and perinatal mortality. Am J Epidemiol 96: 197–204

Tanner JM (1986) Growth as a mirror of the condition of

society: secular trends and class distinctions. In Demirjian A ed. Human growth—a multidisciplinary review. Taylor Francis, London, 3–34

Tanner JM, Hayashi T, Preece MA, Cameron N (1982) Increase in length of leg relative to trunk in Japanese children and adults from 1957 to 1977: comparison with British and with Japanese Americans. Ann Hum Biol 9: 411–423

Wilcox AJ, Russell IT (1983) Birthweight and perinatal mortality: II. On weight-specific mortality. Int J Epidemiol 12: 319–325

Wilcox AJ, Skjaerven R (1992) Birth weight and perinatal mortality: the effect of gestational age. Am J Public Health 82: 378–382

Williams RL, Creasy RK, Cunningham GC, Hawes WE, Norris FD, Tashiro M (1982) Fetal growth and perinatal viability in California. Obstet Gynecol 59: 624–632

Yudkin PL, Aboualfa M, Eyre JA, Redman CW, Wilkinson AR (1987) New birthweight and head circumference centiles for gestational ages 24 to 42 weeks. Early Hum Dev 15: 45–52

Received: June 25, 2004
Accepted: August 19, 2004

Correspondence to: Kiyoshi Aoyagi, Department of Public Health Nagasaki University Graduate School of Biomedical Sciences, 1–12–4 Sakamoto, Nagasaki 852–8523, Japan
Phone: +81–95–849–7067
Fax: +81–95–849–7069
e-mail: kiyoshi@net.nagasaki-u.ac.jp