Acta Genet Med Gemellol 44: 163-168 (1995)

Annual Variation of Sex Ratio in Twin Births and in Singletons in Brazil

B. Beiguelman[1], C. Franchi - Pinto[1], G. M. D. Dal Colletto[2], H. Krieger[2]

[1] *Department of Medical Genetics, School of Medicine, UNICAMP, Campinas, SP, Brazil;* [2] *Department of Parasitology, University of S. Paulo, S. Paulo, SP, Brazil*

Abstract. The annual variation of the sex ratio (SR) of 1385 twin births was analyzed and compared to that of 85909 singletons. These births referred not only to live births but also to stillbirths in two southeastern Brazilian maternity hospitals from 1984 to 1993. While the annual variation of the SR of singletons was very small, that of twin births was extremely high, due to the significant heterogeneity of the annual data. It is suggested that the large SR annual variation of the twin birth might be a consequence of the variation of male or female monozygotic twins.The hypothesis that twin births show a lower sex ratio than singletons could not be supported by the present data.

Key words: Sex ratio, Twin births, Singletons, Maternal age, Monozygotic and Dizygotic Twins

INTRODUCTION

The SR at birth shows a great variability in human populations, ranging from about 101 to 113 males per 100 females. As the number of males exceeds significantly that of females either among spontaneous and provoked abortions or stillborn children [8, 16, 24] the excess of males at birth cannot be attributed to a surplus of female deaths before birth. This would also mean that the SR at the time of fertilization would be higher than that observed among the newborn children. This phenomenon may be attributed to a greater fertilizing capacity of spermatozoa bearing a Y chromosome, since such spermatozoa occurs less frequently (45%) than those lacking it [3] and, in spite of this difference, an excess of males at birth is observed in all populations.

The day of the menstrual cycle when insemination occurs is also a factor that may influence the SR of humans, as a male child is more likely to be conceived from a coitus occurring early in the cycle than later [10, 11, 12, 14]. This is also the explanation why a higher coital rate increases the conception of a male child, since it rises the probability of insemination early in the menstrual cycle [6, 12, 19, 20].

Several authors have concluded that twin births show a lower SR than singletons [2, 4, 7, 9, 13, 17, 22, 23], but some others could not confirm this tendency [18, 21]. The present paper aims to compare the annual variation of the SR in twin births at two maternity hospitals from southeastern Brazil with that observed in a control group of singletons, and to speculate about some interpretations of the variability of this ratio.

MATERIALS AND METHODS

The annual variation of the SR of 1385 twins born from 1984 to 1993 in the State of São Paulo, Brazil, was compared to that of 85909 singletons. The variation of the twin births SR according to both the proportion of monozygotic (MZ) pairs among them and to the maternal age was also investigated. All the singletons and 763 pairs were born at a maternity hospital in Campinas (Maternidade de Campinas), and the remaining 622 at the Hospital Santa Catarina in the city of São Paulo. These deliveries included live births and stillborn children. Only fetuses with 500 g or less were excluded and classified as abortions, since this weight corresponds to a gestation age between 20 and 22 weeks, as well as to 25 cm fetal length [5].

The SR, calculated as the number of males per 100 females, was obtained by $100(2a + b)/(2c + b)$ for twin births, where a, b, c are the numbers of MM, MF and FF pairs, respectively. Among the singletons the SR was obtained by 100 M/F. Since SR does not follow a normal distribution, the correlation coefficients between this and other variables were obtained by calculating Spearman's correlation coefficient (r_s), while the comparisons of proportions were made by applying the chi-square test. The frequency of monozygotic pairs was estimated according to the classical Weinberg's rule [25].

RESULTS

Table 1 shows the data on the annual distribution of the SR of single (85909) and twin births (1385) from 1984 to 1993 in Campinas (763) and São Paulo (622).The distribution of the estimated frequencies of MZ pairs and the SR of twin deliveries in Campinas (757) and São Paulo (549) according to maternal age are shown in Table 2.

In Table 1 it is seen that the sex ratio of the singletons born from 1984 to 1993 has shown a small variation (S.D. = 3.0) when the mean value was estimated as 104.6 males per 100 females. In contrast, either the twins born in Campinas (101 M:100 F, on the average) or those born in the city of São Paulo (107.1 M:100F , on the average) have shown an extremely high variation in the period (S.D. = 20.4 for the series of Campinas and S.D. = 29.7 for the series of São Paulo). This variation is reflected in the chi-squares for the comparisons of the annual SRs with the corresponding mean. Thus, while among the singletons no annual SR value differed significantly from the mean (104.6 M:100 F) and no heterogeneity was detected, in the two series of twin births some annual SR values exhibited significant differences from the mean: twice in the series of Campinas (1984 and 1989) and five times in the series of São Paulo (1984, 1985, 1988, and 1989), as pointed out in Table 1. Moreover, each series has shown significant heterogeneity

Table 1 - SR of single and twin deliveries classified according to sex in maternity hospitals of Campinas and São Paulo from 1984 to 1993, and comparison of the annual SRs to the corresponding mean

Year	Singletons			Twins-Campinas				Twins-S. Paulo				Twins-Total			
	M	F	SR	MM	MF	FF	SR	MM	MF	FF	SR	MM	MF	FF	SR
1984	4498	4261	105.3	15	22	39	52.0*	10	13	19	64.7*	25	35	58	56.3*
1985	4626	4559	101.5	31	21	26	113.7	30	14	20	137.0*	61	35	46	123.6*
1986	4693	4579	102.5	32	24	30	104.8	26	17	30	89.6	58	41	60	97.5
1987	3868	3776	102.4	23	19	22	103.2	34	14	19	157.7*	57	33	41	127.8*
1988	4560	4300	106.0	25	31	27	95.3	30	26	20	130.3*	55	57	47	110.6
1989	4432	4304	103.0	30	19	21	129.5*	18	22	30	70.7*	48	41	51	95.8
1990	4287	3876	110.6	25	15	27	94.3	29	15	22	123.7	54	30	49	107.8
1991	4091	3841	106.5	35	19	30	112.7	21	13	20	103.8	56	32	50	109.1
1992	4230	4186	101.1	36	16	32	110.0	19	10	19	100.0	55	26	51	106.3
1993	4614	4328	106.6	25	19	27	94.5	20	20	22	93.8	45	39	49	94.2
Total	43899	42010	104.5	277	205	281	99.0	237	164	221	105.3	514	369	502	101.7
Mean			104.6				101.0				107.1				102.9
S.D.			3.0				20.4				29.7				19.7

* indicates a level of significance of the chi-square test of at least 5%.

($\chi^2 = 35.08$; 9 D.F.; $p < 0.001$ for Campinas, and $\chi^2 = 74.07$; 9 D.F.; $p < 0.001$ for São Paulo).

The series of Campinas and São Paulo were pooled since no significant heterogeneity could be detected when their SR distribution were compared ($\chi^2 = 14$; 9 D.F.; $0.10 < p < 0.20$). In the pooled data the annual SR variation remained very high (S.D. = 19.7), and significant differences between the mean (102.9 M: 100 F) and the annual SR values have been observed three times (1984, 1985, and 1987). On the other hand, a heterogeneity test applied to this data revealed that the annual distribution of SR from 1984 to 1993 cannot be accepted as homogeneous ($\chi^2 = 34.07$; 9 D.F.; $p < 0.001$).

The heterogeneity of the annual SR variation of twin births was also demonstrated by applying Woolf's test [26] for comparing the annual SRs of singletons with those of twin births in the pooled data. Besides confirming the high heterogeneity of the data ($\chi^2 = 28.10$; 9 D.F.; $p < 0.001$), this test has shown that twin births have no effect on sex ratio ($\chi^2 = 0.547$; 1 D.F; $0.30 < p < 0.50$). Otherwise stated, the present data does not favor the hypothesis that twin births show a lower SR than singletons. This would mean that the comparisons of SR of pooled data on twin births with that on singletons mentioned in pertinent literature should be reviewed.

According to the data on Table 2, maternal age is negatively correlated with both the SR of twin births and the theoretical frequency of MZ twins, since in both cases

Table 2 - Percentage of MZ pairs and SR of 1306 twin births distributed according to maternal age groups

Age group	MM	MF	FF	%MZ	SR
< 20	35	13	29	66.2	116.9
20-25	100	64	125	55.7	84.1
25-30	172	125	147	43.7	111.9
30-35	114	103	122	39.2	95.4
35-40	37	38	48	38.2	83.6
≥ 40	8	10	16	41.1	61.9

$r_s = -0.83$ ($p = 0.04$). This might indicate that the shifting towards females of twin births SR when maternal age increases is a consequence of the predominance of dizygotic (DZ) pairs as maternal age rises [1]. Nevertheless, the correlation coefficient between the percentage of MZ pairs and SR twin births was not significant at the 5% level ($r_s = 0.60$; $p = 0.21$).

It can be suggested that the large annual SR variation exhibited by twin births might be a consequence of the annual variation of the proportion of male or female MZ twins. Since MZ pairs are almost always MM or FF, an important variation, that might be at random, favoring one or another sex would have a striking effect. The pooled data on Table 1 favors this interpretation. As a matter of fact, consider that in each year, besides excluding the MF pairs, a number corresponding to half MF twins would be subtracted equally from the MM and FF pairs. In this case, according to Weinberg's rule, the remainder MM and FF twins would represent theoretically the MZ twin births, among whom both the annual SR variation (S.D. = 41.6) and the chi-square for heterogeneity are extremely high ($\chi^2 = 140.76$; 9 D.F.; $p < 0.001$). This result suggests that conclusions on the SR of MZ pairs based on pooled samples should also be reviewed for excluding the possibility of heterogeneity. At any rate, the SR favoring males in the theoretical distribution of MZ twins (mean = 109.4 M:100 F) is in disagreement with earlier suggestions [13, 15] that MZ twins have a sex ratio favoring females.

CONCLUSIONS

The present study allows the following conclusions concerning the SR of singletons and twins born in southeastern Brazil from 1984 to 1993:

1. the annual SR of singletons (Mean = 104.6 M:100 F) was homogeneous and has shown a small variation (S.D. = 3.0);
2. the annual twin births SR (Mean = 102.9 M:100 F) was heterogeneous and have shown an extremely high variation (S.D. = 19.7), which prevents to compare the SR of pooled data on twin births with that on singletons;

3. maternal age was negatively correlated with both the SR of twin births and the theoretical frequency of MZ pairs, but the percentage of MZ twins was not significantly correlated with the SR of twin births;
4. the large annual SR variation of twin births might be a consequence of the sex variation of MZ pairs.

Acknowledgements: This study received support from CNPq, CAPES and FAPESP.

REFERENCES

1. Allen G, Parisi P (1990): Trends in monozygotic and dizygotic twinning rates by maternal age and parity. Further analysis of Italian data, 1949-1985, and rediscussion of US data, 1964-1985. Acta Genet Med Gemellol 39: 317-328.
2. Barr A, Stevenson AC (1961): Stillbirths and infant mortality in twins. Ann Hum Genet 25: 131-140.
3. Beatty RA (1974): Genetic aspects of spermatozoa. In Coutinho, EM, Fuchs, FC (eds.): Physiology and Genetics of Reproduction, Part A. New York: Plenum Press, pp 183-196.
4. Beiguelman B, Villarroel-Herrera HO (1992): Sex ratio of twins in a southeastern Brazilian population. Rev Brasil Genet 15: 707-711.
5. Belitzki R, Fescina R, Ucieda F (1978): Definiciones y terminologias aplicables al periodo perinatal. Recomendaciones de la Organización Mundial de la Salud y Modificaciones de la FIGO. Publicación Científica del CLAP N° 757: 136-147.
6. Bernstein ME (1958): Studies in the human sex ratio: a genetic explanation of the wartime increase in the secondary sex ratio. Am J Hum Genet 10: 68-70.
7. Bertranpetit J, Marin A (1988): Demographic parameters and twinning: a study in Catalonia, Spain. Acta Genet Med Gemellol 37: 127-135.
8. Ciocco A (1940): Sex differences in morbidity and mortality. Quant Rev Biol 15: 59-73; 192-210.
9. Czeizel A (1974): Unexplainable demographic phenomena of multiple births in Hungary. Acta Genet Med Gemellol 22 (Suppl.): 214-218.
10. Guerrero R (1970): Sex-ratio: a statistical association with the type and time of insemination in the menstrual cycle. Int J Fertil 15: 221-225.
11. Gerrero R (1974): Association of the type and time of insemination within the menstrual cycle with the human sex-ratio at birth. N Engl J Med 291: 1056-1059.
12. James WH (1971): Cycle day of insemination, coital rate and sex ratio. Lancet 1: 112-114.
13. James WH (1975): Sex ratio in twin births. Ann Hum Biol 2: 365-378.
14. James WH (1976): Timing of fertilization and sex ratio of offspring. A review. Ann Hum Biol 3: 549-556.
15. James WH (1980): Sex ratio and placentation in twins. Ann Hum Biol 7: 273-276.
16. Lee S, Takano K (1970): Sex ratio in human embryos obtained from induced abortion: histological examination of the gonad in 1,452 cases. Amer J Obstet Gynecol 108: 1294-1296.
17. Mellender-Araújo, A (1973): Estrutura populacional e malformações congênitas na população de Porto Alegre. Doctoral Thesis, Federal University of Rio Grande do Sul, Brazil.
18. Pedreira CM, Peixoto LIS, Ito-Rocha, LMG (1959): Estudo da gemelaridade na população de Salvador, Bahia. Anais I Reunião Brasil. Genet Hum (Curitiba): 137-140.
19. Renkonen KO (1964): Problems connected with the birth of male children. Acta Genet 14: 177-185.

20. Renkonen KO (1970): Heterogeneity among first post-nuptial deliveries. Ann Hum Genet 33: 319-321.
21. Rola-Janicki A (1974): Multiple births in Poland in 1949-1971. Acta Genet Med Gemellol 22 (Suppl.): 202-209.
22. Stocks P (1952): Recent statistics of multiple births in England and Wales. Acta Genet Med Gemellol 1: 8-13.
23. Susanne C, Corbisier JV (1969): Les naissances gémellaires en Belgique (1960-1961). Acta Genet Med Gemellol 18: 294-320.
24. Tietze C (1948): A note on the sex ratio of abortions. Human Biol 20: 156-160.
25. Weinberg W (1901): Beiträge zur Physiologie und Pathologie der Mehrlingsgeburten beim Menschen. Pflügers Arch f Ges Physiol 88: 346-430.
26. Woolf B (1955): On estimating the relation between blood group and disease. Ann Hum Genet 19: 251-253.

Correspondent: Prof. Dr. Bernardo Beiguelman, Departamento de Genética Médica, Faculdade de Ciências Médicas, C.P. 6111, UNICAMP. 13081-970 Campinas, SP, Brazil.