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Trends in male:female ratio among newborn infants in 29 countries from five continents

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We have analysed trends in male:female ratios among newborns between 1950 and 1990 in 29 countries from five continents. The numbers of liveborn males and females over the period 1950–1994 were derived from the World Health Organization (WHO) database. Countries for which reliable data were available included 20 major European countries (excluding the former Soviet Union, Albania and a few small countries), Canada, the USA, selected countries of Central and South America, Japan, Australia and New Zealand. From the original numbers of males and females, we computed the proportion of males among liveborns for each country and for selected broader areas within Europe. In most countries the proportion of male liveborns was constant during the study period. In particular, the proportion of male newborns in the European Union was 0.515 in 1950–1954, 0.514 in 1970–1974 and 0.514 in 1990–1994. In the USA, corresponding values were 0.513, 0.513 and 0.512. In Japan the ratios were 0.513 in 1950–1954, 0.516 and 1970–1974 and 0.514 in 1990–1994. Decreasing ratios were observed in some northern and eastern European countries plus Greece and Portugal and, particularly, in Mexico. In contrast, the proportion of male liveborns tended to increase in southern Europe and Australia. Overall, among the 29 countries considered, the proportion of males declined in 16, increased in six, and remained stable in seven.

Key words: intercountry comparison/male–female ratio/temporal trends

Introduction

It has been reported that the male proportion of newborns in the Netherlands (Van der Pal-de Bruin *et al.*, 1997) has decreased by about 0.08/1000 births per year over the past 40 years. Likewise, in Denmark a decrease in male:female ratio of newborns was observed from the late 1950s, after an increasing ratio from 1850 to 1950 (Møller, 1996). In Germany an effect of war on sex ratio was observed, with a rapid increase of sex ratio from 0.51 to 0.52 during both wars, and a decline thereafter (Van den Broek, 1997). However, no change in the male:female ratio was reported during the period 1926–1990 in Italy (Parazzini *et al.*, 1997), and the sex ratio of liveborns has been stable in England and Wales since 1990, after a fall during the previous two decades (James, 1996c).

The reduction in male proportion among newborns in Denmark and the Netherlands has been interpreted in terms of new reproductive hazards. In fact, genetic determinants apart (James, 1996a), exposure to environmental oestrogens or other pollutants, or changed coital rates (Dickinson and Parker, 1996) have been suggested as affecting sex ratios. Other possible reasons for the changed sex ratio include longer interpregnancy intervals (James, 1996b; Martin, 1997), the role of prenatal diagnosis and the consequent selective elimination of males, who are more frequently affected by congenital diseases, the increasing number of later pregnancies (Parazzini *et al.*, 1997), the change in family size, which may play some role in the sex ratio too and, possibly, the increased survival of very low birth weight females, who show higher survival rates compared with males. These factors may act on different periods of the reproductive process, such as at implantation or later in pregnancy. For example, a higher male:female ratio has been suggested in conditions characterized by non-optimal maturation of the oocyte (Jongbloet *et al.*, 1996; Mittwoch, 1996).

In consideration of the interest in the issue and of the inconsistency of published data, it is important systematically to analyse the trends and pattern in sex ratios at birth in different areas of the world. Thus, we considered worldwide data on sex ratios at birth between 1950 and 1990 in 29 countries included in the World Health Organization (WHO) mortality database.

Materials and methods

The numbers of liveborn males and females over the period 1950–1994 were derived from the WHO database. There were 29 countries for which reliable data were available. These included 20 major European countries (excluding the former Soviet Union, Albania and a few small countries), Canada, the USA, selected countries of Central and South America, Japan, Australia and New Zealand. From the original numbers of males and females, we have computed the proportion of males among liveborns for each country and for selected broader areas within Europe. To facilitate data presentation and increase the precision of the estimates, we have considered three successive calendar quinquennia, separated by two decades.

Results

Table I presents the proportion of male liveborn babies in 1950–1954, 1970–1974 and 1990–1994 and the number of

Table I. Proportion of male newborn babies in various countries, 1950–1994

Country	Proportion of male newborn babies in:			No. of newborn babies per year, 1990–1994 (×1000)
	1950–1954	1970–1974	1990–1994	
Austria	0.514	0.514	0.514	90.5
Belgium	0.514	0.514	0.513	123.8
Bulgaria	0.516	0.515	0.514	105.2
Denmark	0.515	0.514	0.514	63.4
Finland	0.512	0.511	0.510	65.7
France	0.512	0.513	0.513	762.4
Germany	0.517	0.514	0.514	905.7
Greece	0.520	0.517	0.516	102.2
Hungary	0.517	0.516	0.513	125.7
Ireland	0.514	0.514	0.517	53.0
Italy	0.513	0.514	0.515	580.8
Netherlands	0.516	0.512	0.512	198.0
Norway	0.515	0.514	0.515	60.9
Poland	0.517	0.516	0.513	545.8
Portugal	0.517	0.515	0.514	116.4
Romania	0.514	0.514	0.513	314.7
Spain	0.514	0.514	0.517	401.4
Sweden	0.516	0.515	0.513	123.9
Switzerland	0.513	0.515	0.513	83.9
United Kingdom	0.514	0.515	0.513	798.6
Northern Europe[a]	0.514	0.516	0.513	1165.7
Central Europe[b]	0.515	0.514	0.513	2164.2
Southern Europe[c]	0.515	0.515	0.516	1200.8
Eastern Europe[d]	0.517	0.515	0.513	986.2
European Union[e]	0.515	0.514	0.514	4385.8
Canada	0.514	0.515	0.514	405.5
USA	0.513	0.513	0.512	4083.6
Argentina	0.510	0.510	0.510	699.9
Mexico	0.514	0.508	0.505	2692.9
Uruguay	0.510	0.510	0.510	56.5
Venezuela	0.510	0.510	0.510	529.0
Japan	0.513	0.516	0.514	1221.6
Australia	0.513	0.513	0.514	259.9
New Zealand	0.514	0.512	0.513	60.2

[a]Includes Denmark, Finland, Ireland, Norway, Sweden, United Kingdom.
[b]Includes Austria, Belgium, France, Germany, Netherlands, Switzerland.
[c]Includes Greece, Italy, Portugal, Spain.
[d]Includes Hungary, Poland, Romania.
[e]Includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, Sweden, United Kingdom.

newborn babies per year around 1990 (×1000) in each country and broader European geographic area.

In most countries the proportion of male liveborns was approximately constant during the study period. In particular, the proportion of male newborns in the European Union, accounting for about 4.4 million births per year in 1990, was 0.515 in 1950–1954, 0.514 in 1970–1974 and 0.514 in 1990–1994. In the USA, accounting for 4.1 million births, corresponding values were 0.513, 0.513 and 0.512. In Japan, where about 1.2 million births per year were registered, the ratios were 0.513 in 1950–1954, 0.516 and 1970–1974 and 0.514 in 1990–1994. Decreasing ratios were observed in some northern and eastern European countries plus Greece and Portugal and, particularly, in Mexico, accounting for about 2.7 million births per year, where the proportion of male newborn babies decreased from 0.514 in 1950–1954 to 0.505 in 1990–1994. In contrast, the proportion of male liveborns tended to increase in southern Europe and Australia. Overall, among the 29 countries considered, the proportion of males declined in 16, increased in six, and remained stable in seven.

Discussion

The findings from this comprehensive analysis indicated that no consistent worldwide trend has been observed in the sex ratios at birth over the last four decades, although in a few northern and eastern European countries and, mostly, in Mexico the male proportion among newborns has been decreasing, whereas it has been increasing in southern Europe and Australia.

These trends considered liveborns, and consequently did not represent male:female ratios at conception. Mechanisms that may affect differently the frequency of spontaneous or induced abortions or the risk of fetal death in males and females may explain the observed decreasing trend in some countries. For example, some congenital diseases (e.g. haemophilia) are more frequent in males than in females, and an increasing availability of perinatal diagnosis may cause a decrease of male liveborns and, consequently, a decrease in male:female ratio. However, the availability of prenatal diagnosis is probably different in western and eastern Europe as compared to north America and Mexico, and, in any case, the effect of prenatal diagnosis should not have affected the proportion of males before the early 1980s.

Likewise, stillbirth rates are higher in males than in females. Thus, the decrease of stillbirth rates observed worldwide (Kalter, 1991) may cause an increase in the proportion of liveborn males on total live births. However, an analysis conducted in Italy did not suggest that the risk of stillbirth in males, in comparison with females, changed over time (Parazzini *et al.*, 1987). The impact of this potential mechanism should therefore be limited, if any.

After hormonally induced ovulation an excess of female births has been observed (James, 1987); this factor may explain some documented trends in male proportion observed over the last 15 years. Twin births, which are associated with assisted reproduction may also show a lower proportion of males than singleton births (Beiguelman *et al.*, 1995). Maternal nutrition has also been reported to affect sex ratio. Pregnant female mice maintained on a consistent low-food diet gave birth to a lower proportion of males than did control females fed *ad libitum* (Meikle and Thornton, 1995).

With respect to environmental exposure, offspring of fathers who were occupationally exposed to alcohol and lead were reported to show lower sex ratio (Dickinson and Parker, 1994). The organochlorinated pesticide dichlorodiphenyltrichloroethane (DDT), and its metabolite dichlorodiphenyldichloroethylene (DDE), because of their oestrogenic activity, have also been implicated (Sharpe and Skakkeback, 1993), and it is of interest that mean serum concentration of DDE is about tenfold higher in women in Mexico than in the USA (Lopez-Carrillo *et al.*, 1997). A vast amount of data on chronic or acute exposure to radiation failed to provide unequivocal evidence for an effect of radiation on the sex ratio (Dickinson and Parker, 1996).

There is a potential limitation of this analysis which should be considered. First of all we have analysed trends over a 45-year period (1950–1994); thus we cannot draw any conclusion on broader secular trends, as reported by others (Moller, 1996). Furthermore, quality of data reported in the WHO database can differ over the 45 considered years and in various countries. For example, liveborn babies may not be registered, especially if they die very early after birth; this practice was certainly more common in the 1950s than in the 1990s, and may have been different according to sex and country. More generally, it is possible that birth registration is less exhaustive, for example, in South America than in the USA or western Europe, and that under-registration differs by gender. In any case the size and the direction of these potential biases or errors is difficult to evaluate and quantify.

Despite these limitations, the present analysis offers a comprehensive overview of trends in sex ratios at birth in various areas of the world. The differences observed suggest that the determinants of male:female ratio may vary with respect to geographical area.

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