

## Male to female birth ratios over a 35-year period

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### ABSTRACT

**Aim** Along with changes to the human physique recorded over the past decades in certain countries, there are also changes concerning the male-female birth ratio. The aim of this study was to establish the movement of male-female birth ratios and factors affecting the ratio.

**Methods** This retrospective study was conducted in Zagreb, Croatia, in the period from 1985 to 2019 on a sample of 3804 newborns.

**Results** In the 35-year period the ratio of boys and girls at birth did not change significantly. Girls had lower birth weight, and boys had higher birth length. In the war period (1992-1994), a mild increase in the ratio of boys was noted, but not statistically significant. Father's age in the last period examined (2007-2009) showed to be a statistically significant predictor of the child's gender. Namely, the descendants of younger fathers were statistically significantly more frequently girls, while the descendants of older fathers were more frequently boys. Married mothers had higher percentage of male births (51.5%), and a lower percentage (47.1%) by unmarried mothers.

**Conclusion** The changes in birth ratios are particularly pronounced in different age and socioeconomic groups of parents nowadays when the growth of living standards is accompanied by significant changes of the human physique.

**Key words:** Croatia, gender, human body, newborn, parturition

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## INTRODUCTION

Changes of the human physique are evident from the very first pictures and recordings left by our predecessors to this very day. The changes are particularly pronounced nowadays where the growth of living standards is accompanied by significant changes of the human physique, such as changes in height, weight and body mass index (1-3). Changes in the diet are also present, frequently inadequate (4), and there are certain authors who believe that the adoption of good nutritional habits and motor skills should begin in childhood (5) in order to reduce the trend of weight-gain.

In view of the losses of fertilised ova and early pregnancy abortions, it is difficult to establish the exact ratio of conceived "male" and "female" zygotes. That is the reason why as a rule it is the relationship between male and female newborns that is described, which is mostly 100 female newborns to 105-110 male newborns (6).

Gender differentiation passively progresses towards the female phenotype, in other words, the presence of functional testicle is essential for sex differentiation towards male gender (7). These processes are determined by a complex network of genes and its expression (7). Recent advances in techniques and genome-wide epigenetic studies suggest that epigenetic mechanisms could play a role in gonadal sex determination (7).

Over the past several decades, it was recorded that there were less male newborns in developed countries. As of 1970, the proportion of male children in Canada dropped by 2.2 boys per 1,000 newborns, and in the Atlantic region by 5.6 per 1,000 newborns (8). A similar situation exists in Europe where, in the period from 1950 to 1996, it was observed that less male newborns were born in 11 countries, that there was a similar ratio of male-female newborns in 8 countries, and that the ratio of male newborns increased only in 4 countries (9).

Recent inequality between male and female population in some countries, leading to the predominance of males, is thought to be affected by cultural differences, discrimination, nation's policies and widespread violence against women. (10)

Certain authors established that the ratio of male newborns may positively depend on the age of the father (11), and that the ratio of male newborns is greater if the age difference between mother

and father is greater. In women who live in urban areas and who are exposed to higher stress level the release of corticotrophin is elevated, which encourages the release of androgens from the mother's adrenal gland, which might favour the conception of a male child (12). In cases of long economic crises, it was also observed that there is a heightened ratio of male-female newborns (13). Certain racial differences were also observed in California in the period from 1960 to 1996, where it was observed that there was a statistically significant drop in the ratio of births of male children in white men, where the drop was not noted amongst black men, Japanese and Native Americans, while in the case of Chinese an increase in male newborns was noted (14). A similar trend was recorded in Canada (15). The ratio of male newborns rises during the periods of war, probably due to the stress mechanism, and in the period after the war the ratio of female newborns rises (16). The ratio of male newborns depends also on the number of foetuses. In a research conducted on thirty-one million single-foetus births in America, there were 51.6% of boys, but in the case of twins the ratio dropped to 50.9%, in the case of triplets to 49.5%, and in the case of quadruplets to 46.5% (17). In the case of monozygotic-monoamniotic twins, 70% are female, and in the case of Siamese twins 75% are female (18).

We have decided to conduct this research to find out how the ratio of male and female newborns has changed in recent Croatian history. Currently there are studies in the literature on the birth ratio, but there are no studies for such a long period.

The aim of this study was to establish the movement of male-female birth ratio and factors affecting the ratio. The obtained data can be used by anthropologists, demographers, historians and knowledge about the sex ratio in the population could later be interesting to experts in the fields of medicine, marketing, public relations and jobs employers.

## EXAMINEES AND METHODS

### Examinees and study design

This study included 3804 randomly selected mothers, their partners and newborns. Women included in the study gave birth in the Sestre milosrdnice University Hospital Centre over a period of 35 years in four specific periods of

time: 1985-1986 (550 mothers), 1992-1994 (564 mothers), 2000-2002 (570 mothers) and 2007-2009 (730 mothers), 2018-2019 (3804 mothers).

**Methods**

The data were collected by a random selection of the medical history of healthy mothers who had given vaginal birth to full-term babies in single pregnancies. Women and their partners were divided into age groups, and in groups based on their place of living (rural-urban) and degree of education (university or post-secondary school qualifications, secondary school qualifications and low professional qualifications). The mothers' marital status was recorded, as well as and their height, weight, body mass index (BMI), weight-gain in pregnancy, parity. The mass, weight and gender of newborns was also registered.

**Statistical analysis**

In terms of the statistical processing of the results, to test the significance of differences between several groups of results, a nonparametric  $\chi^2$  test was used when the results were expressed in frequencies. In the case of testing the significance of differences between the arithmetic means of several groups of results, the parametric test of one-way or two-way analysis of variance was used. After the analysis of variance, further post hoc tests were done, if necessary, such as Tukey's HSD and Scheffe's tests to establish between which groups of results there was a significant difference ( $p < 0.05$ ).

**RESULTS**

There were no significant differences between the ratio of boys and girls in terms of different periods of time (Figure 1).

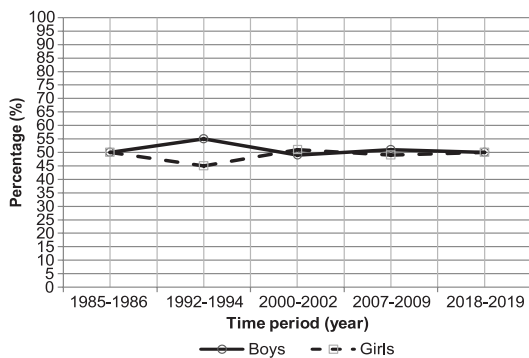


Figure 1. Ratio of boys and girls (%) by time period

The ratio of boys and girls was significantly different in the view of the weight of the babies in all four periods. In all four periods there was the same tendency that girls were born with a lower weight (Figure 2).

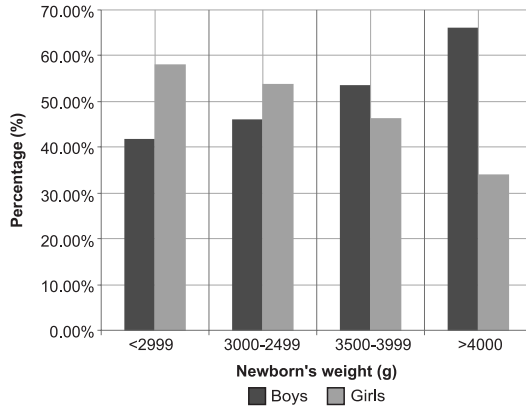


Figure 2. Overall newborns' gender in terms of birth weight for all periods

Boys had significantly longer birth length than girls from 2000-2002 onwards, but the length of newborns did not change significantly over all four periods examined (Figure 3).

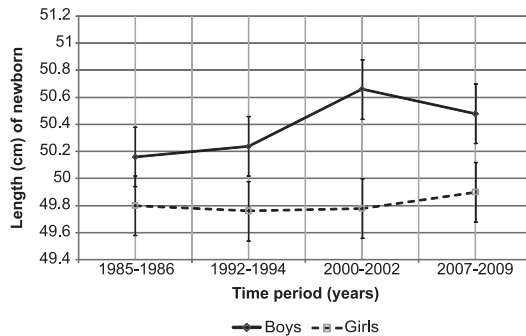


Figure 3. Length (cm) of girls and boys at birth by time period

The ratio of babies of a particular length showed significant difference in view of the gender of the baby in all four periods (Figure 4).

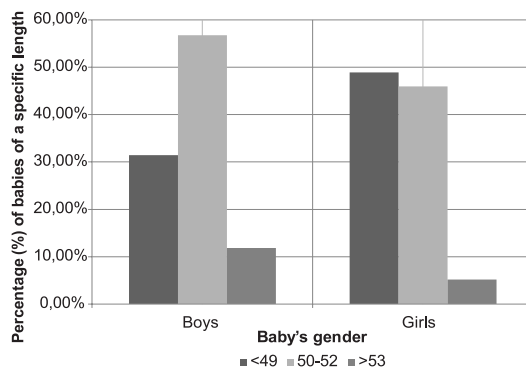


Figure 4. Ratio (%) of newborns of a specific length (cm) in view of the baby's gender for all periods together

The ratio of boys and girls did not differ significantly in view of the age of the mother, in overall or in a specific period.

The ratio of boys and girls was significantly different in terms of the age of the father only in the period 2007-2009, where it proved that in the group of younger fathers there was a greater ratio of girls, and in the group of older fathers a greater ratio of boys (Figure 5).

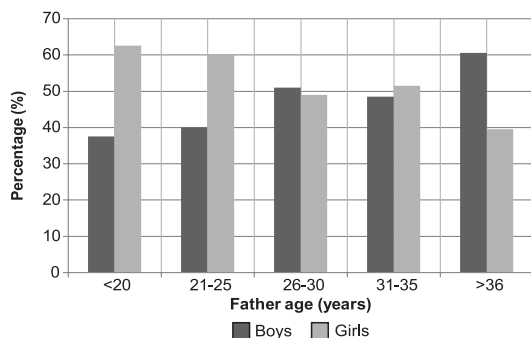


Figure 5. Newborn's gender in view of father's age, for the period 2007-2009

The ratio of boys and girls did not differ significantly in terms of the age difference between fathers, degree of education of the mothers and fathers, the place of living, the marital status of the mother in any of the four periods. Tendency was noted of somewhat more frequent incidence of boys in the case of married mothers, and girls in the case of unmarried mothers.

## DISCUSSION

Similar weight-gain was noted among pregnant women carrying boys and those carrying girls. Although certain authors show that mothers' weight before pregnancy may influence the gender of the child (19), there are no claims that would show a statistically significant difference of the birth of girls or boys depending on weight-gain during mother's pregnancy.

The ratio of boys and girls in our study did not change significantly in different periods. These results could be attributed to the fact that the study was conducted on a sample of healthy women with uncomplicated pregnancies. Authors in the United States of America and the developed countries of Western Europe record a mild drop in the birth of male children (9,20). Whether the decrease in the ratio of male births in developed countries a consequence of sociodemographic development or better socioeconomic and health

conditions, or is it the consequence of changes in the atmosphere and greater contamination of the environment with chemicals, which might eventually lead to an impact on male foetuses, is still not completely clear (9,21). So far, there is no convincing evidence of the association between the impact of the coital rates around the time of conception and offspring sex ratio (22).

In the war period (1992-1994), a mild increase in the ratio of boys was noted in our research, but not statistically significant. During some wars, such as World War One and World War two, and the war in Bosnia (16,23,24), authors noted an increase in the ratio of male births. However, such a tendency is not evident in all wars. For example, during the war between Iraq and Iran, the percentage of births of female children rose (24).

Mother's age, based on research carried out over a period of 35 years, is not one of the more significant predictors of the newborn's gender. Similar results were also published by other researchers after research (25). Nonetheless, other authors (26) published opposite results to the ones mentioned, that is, they found a correlation between mother's age and the higher ratio of births of female children.

As opposed to mother's age, father's age in the last period examined (2007-2009) showed to be a statistically significant predictor of the child's gender. Namely, the descendants of younger fathers are statistically significantly more frequently girls, while the descendants of older fathers are more frequently boys, which according to some research results in statistically significant somewhat greater ratio of births of male children (25).

Professional qualifications of the mother are not one of the statistically significant predictors of the child's gender. Still, we can observe that women having low professional qualifications are somewhat more likely to have girls, and those with secondary school qualifications boys. In terms of women with university qualifications, the percentage of boys and girls is similar. According to some research (25), parents having better socioeconomic status are more likely to have sons.

Mothers from urban areas and mothers from rural areas give birth in a similar ratio to male and female babies. Certain authors, however, presume that in urban areas, the lifestyle, which is frequently more stressful than in the country, might have an impact on the elevated release of gonadotropin,

which stimulates the release of androgens in the adrenal gland of the mother, resulting in the more likely conception of a male child (12). Other authors found that there is a mild decrease in the ratio of male births in large urban centres (27).

There is a higher percentage of male births (51.5%) by married mothers, and a lower percentage (47.1%) by unmarried mothers. The difference, however, did not prove to be statistically significant, but might arise from a well-known fact that a slightly higher percentage of boys are born in better socioeconomic circumstances, and unmarried women still mostly have poorer socioeconomic status than married women.

These results show a long-term detailed picture of changes in the ratio of male and female birth ratios in Croatia during the time period and also

compare these ratios with certain stated factors, what is a novelty and has not been shown so far.

In conclusion, the changes in birth ratios are particularly pronounced in different age and socioeconomic groups of parents nowadays when the growth of living standards is accompanied by significant changes of the human physique. Further research could study the differences in the newborns' gender in countries surrounding Croatia and check whether they follow the same trends.

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## TRANSPARENCY DECLARATION

Conflicts of interest: None to declare.

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