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ORIGINAL ARTICLE

Academic mothers have a pronounced seasonal variation in their offspring sex ratio

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Abstract

OBJECTIVES: Environmental and socio-demographic factors can influence the variation of the human sex ratio at birth (SRB = the ratio of males to males plus females). In particular, findings of seasonal, parental education, birth order, and maternal age effects on the SRB are not always in agreement, and a number of works report minimal variation.
SETTING: Here, we investigated the seasonality of SRB in academic and non-academic mothers employed at the University of Vienna, and who gave birth between 1963 and 2000 (n = 1932 births).
METHODS: All data were available from an anonymous employee database.
RESULTS: Both groups, academic and non-academic mothers do not differ between their overall SRB. In academic mothers the SRB is significantly (P = 0.004) increased during the springtime and decreased during the summertime. Although in non-academic mothers the trend is comparable, it is far less pronounced and not significant (P = 0.345). When a multiple logistic model was applied to the data of academic mothers the only significant influencing factor on the SRB is the season, while birth order of children and mothers' age at childbirth has no effect. None of the three independent variables influence the SRB in non-academic mothers.
MAIN FINDINGS: These findings suggest a more flexible SRB rate in academic mothers than in non-academics within the seasons.
CONCLUSION: We conclude that the significant seasonal variation of the SRB in academic women cannot be merely interpreted as an effect of socio-economic status but more likely as the interaction between socio-economic and environmental working conditions.

Introduction

Whether an influence of seasonal and socio-demographic factors on the sex ratio at birth in humans (SRB = male to male plus female live-births) exists, is still a theme open to discussion [1, 2]. Roenneberg and Aschoff [3] found a seasonal component in human reproduction based on biological factors. In line with a seasonal influence on the SRB increases during early summer and decreases during autumn and winter were found in the United States population [4]. More recent results identified an annual rhythm in the SRB for the German population [5] demonstrating two peaks in May and December and two nadirs in March and October. From these results it can be proposed that elevated male birth rates during the springtime seem to be biological useful since men born in spring have a better reproductive success compared to those born in autumn [6].

Alternatively, socio-demographic factors like socio-economic status, birth order of children, and mothers' age at childbirth have been described as additional key variables influencing the SRB. People with higher socio-economic status tend to have more male infants [7] as has been shown in royal families and in parents representing the upper social stratum [8, 9].

In a study about women in the modern Venezuelan society higher educational status was associated with elevated SRB values [10]. However, such a relationship was not observed in the population of the United States when maternal [11] or parental education [12] defined the socio-economic status. Due to that, effects of the mothers' age and the birth order of children on SRB variation were inconsistent in several studies [11–14].

Interestingly, so far no study focused on the seasonal variation of SRB in relationship to the mothers' educational status. In the present work we examined the total and seasonal variation of SRB in a population of mothers working at the University of Vienna – belonging to the same ethnical group – with regard to their different educational levels and therefore dissimilar socio-economic status. Because high socio-economic status tends to be related to increased male birth rates we expected excessive total SRB values for academic women. Regarding to the seasonal variation of the sex ratio in live born offspring shown in entire populations and increased SRB values for better educated mothers, we anticipated first, a significant seasonal variation of SRB in both groups, and second, elevated male birth rates for academics during springtime compared to non-academics. Furthermore, we controlled for effects of children's birth order and mothers' age at childbirth on the SRB.

Materials and Methods

In this study, the anonymous employee database of the University of Vienna was used to analyze differences in the seasonal sex ratio at birth (SRB = male to male plus female live-births). Data on live-born offspring of the current working staff were available from 1963–2000 with the effective date of January 1, 2001. A total of 1932 births from 1184 mothers were analyzed. As a variable of socio-economic status the educational attainment was used to classify the women as academic or non-academic mothers. Both groups were represented in the scientific and administrative fields. Beside the seasonal influence on SRB other socio-demographic parameters like the birth order of children and the mothers' age at childbirth were used as independent variables. The total numbers of single and multiple births are listed in Table 1 which is the bases for the three group classification of the variable birth order of children. The mothers' age at childbirth was grouped into four categories (≤ 24, 25–29, 30–34, ≥ 35 years; according to Nonaka and colleagues [15]). The mean number of children for academic mothers was 1.54 and for non-academics 1.55. The median age of academics at the birth of their sons was 32 (25% = 28; 75% = 35) compared to 27 (25% = 23; 75% = 30) years for non-academics; the median age at the birth of daughters in academics was 31 (25% = 28; 75% = 34) and for non-academics was 27 (25% = 23; 75% = 30) years.

On the basis of their births both male and female offspring were classified into four groups representing the four seasons: born in winter (21 December to 20 March), spring (21 March to 20 June), summer (21 June to 22 September), and autumn (23 September to 20 December). We performed comparisons among these groups using the Kruskal-Wallis H test. All pairwise calculations were tested with the Mann-Whitney U test for two unrelated samples (post-hoc, Bonferroni corrected). Multiple logistic regressions were used to analyze seasonal, birth order of children, and mothers' age at childbirth influences on SBR in academic and non-academic mothers. Statistical analyses were carried out with the software package SPSS 10.0 for Windows.

Results

A comparison between the SRB of academic and non-academic mothers showed no difference ($Z = -0.584$, $P = 0.559$). Academics had an SRB of 0.5370 and non-academics of 0.5514 (Table 2). The seasonal variation in total SRB, calculated from all mothers (Figure 1; $\chi 2 = 12.302$, d.f. = 3, $P = 0.006$) showed an increase during springtime. Subsequent pairwise comparisons of the seasons resulted in a significant difference between spring- and summertime ($Z = -3.365$, $P = 0.006$). All other calculations were statistically insignificant. Similar to this variation, the calculated distribution of the seasonal SRB in each group of mothers, academic and non-academic, demonstrates a comparable time course (Figure 1). Peaks are detectable during the spring followed by a decrease in summer. However, the variation of SRB in academic mothers is represented by a significant drop from spring to summer ($\chi 2 = 13.106$, d.f. = 3, $P = 0.004$; spring vs. summer: $Z = -3.533$, $P = 0.001$). Each remaining pairwise calculation was statistically not significant. In comparison, non-academics showed a non significant variation of SRB during the seasons

($\chi 2 = 3.337$, d.f. = 3, P = 0.337). During the summertime it is evident that academic mothers give more life birth to daughters than non-academic mothers (Z = –1.791; P = 0.073); whereas, during the other seasons the SRB differ marginally between both groups.

Multivariate analyses considered the influences of the independent variables season, birth order of children, and mothers' age at childbirth on the SRB. The ratio, which was calculated from all mothers, was statistically significant influenced by the variable season, while the birth order of the children and the mothers' age at childbirth had no influence (Table 3). Examinations within the classes of academic and non-academic mothers showed an exclusively statistically significant influence of the seasons on the SRB for academic mothers.

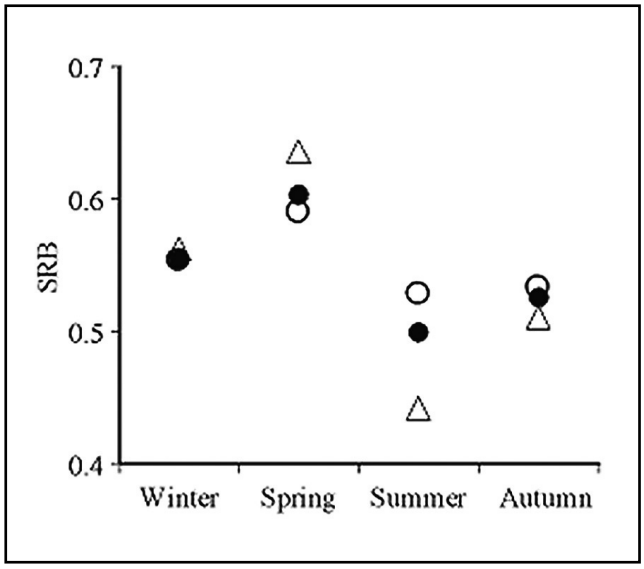

Figure 1. Variation of the sex ratio at birth (SRB) in all mothers (academics and non-academics; filled circles), as well as in academics (triangles) and non-academics (open circles) per season.

Discussion

The analysed SRB quotients correspond to the usual higher proportion of male births in different societies, in general. The SRB values in the academic and non-

Table 1. Total number of offspring by number of births

Number of births	Academic Mothers	Non-Academic Mothers
1 offspring	190	380
2 offspring	135	364
≥3 offspring	40	75

Table 2. Total number of offspring in academic and non-academic mothers per season

Birth season	Academic Mothers		Non-Academic Mothers		Total
	Male	Female	Male	Female	
Winter	68	53	176	142	439
Spring	101	58	210	146	515
Summer	68	86	189	169	512
Autumn	75	72	170	149	466
Total	312	269	745	606	1932

Table 3. Multiple logistic regression analysis for the influence of season, the birth order, and the mothers' age at childbirth on the variation of SBR

Variables	d.f.	χ^2	P Value
Academic and non-academic mothers	**9**	**17.482**	**0.042**
Birth season	3	12.163	0.007
Birth order of children	3	3.319	0.345
Mothers' age at childbirth	3	3.243	0.356
Academic mothers	9	21.098	0.012
Birth season	3	12.902	0.005
Birth order of children	3	2.829	0.419
Mothers' age at childbirth	3	5.699	0.127
Non-academic mothers	9	10.696	0.297
Birth season	3	3.318	0.345
Birth order of children	3	4.867	0.182
Mother's age at childbirth	3	3.636	0.304

academic mothers included in this study are elevated compared to the entire Austrian population [16]. These varying results are possibly due to the relatively small sample size of the study. The predictions that increased socio-economic status is corroborated with elevated total SRB values and is related to more male birth for academic mothers during springtime failed comparing to non-academics. Referring to the expected seasonal variation of SRB in both groups, only academic mothers showed a statistical significant variation. The seasonal distribution of SRB shows similarities in both groups, peaks are detectable during the springtime followed by decreases in summer.

The substantial decrease of the SRB during the summer might reflect a psychological stress effect to serve life events during periconceptional phases [17, 18] in academic mothers. Children delivered during the summer are procreated in the autumn of the preceding year. During that time period, Austrian Universities begin a new academic year and the period until Christmas is usually characterized by a high load of organizational and operational work. Because of their multiple roles (e.g., interactions with staff and students, attending meetings, writing reports and research grants etc. [19]) occupational stress in academics might be higher during this time period than it is in non-academics. Empirical studies demonstrate that academic women do notice some aspects of the academic life as detrimental to their success. A standardized survey study from academics teaching at almost 400 institutions demonstrated that women perceived time pressures and lack of personal time as the highest stressors [20]. Whether the results of different SRB distribution within the seasons are a product of the socio-economic status per se or are caused by coincident events between socio-economic and environmental factors is not clear. But the findings of this study give a subtle hint that distinctive socio-economic status expressed through different educational levels can be linked to environmental working conditions resulting in seasonal variation of the SRB.

Anyway, a selective birth rate within the seasons could be physiologically beneficial in both, academic and non-academic mothers, because the production of sons is more expensive than of daughters [21].

No association was found between the independent variable birth order of children and the SRB. This validates results gained on the Japanese population [13]. Partial regression analyses on data of the United States population revealed a significant effect of birth order, but this outcome accounted only for 10% of the SRB variation [12]. The missing effect of the mothers' age at childbirth corresponds with those of other studies [11, 12] but is in contrast to a more recently study [22] where mothers aged ≥ 45 years showed a decrease in male birth rates. One explanation for this discrepancy may be the age distribution of mothers in the present study. The proportion of younger mothers (16–20 y) was 16% and that of older mothers (40–45 y) was 1.3% to the total amount of mothers. Hence, no mothers aged less than 16 or more than 45 years were included in our study.

Taken together, the results of this study showed no influences of both variables birth order of children and the mothers' age at birth of their offspring to the SRB. Furthermore, the mothers' educational qualification did not affect the total SRB calculated from each group, academics and non-academics. However, the level of education is essential for the birth rate distribution of male and female offspring within the four seasons in the field of higher education.

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