ORIGINAL ARTICLE

Seasonal Variation by Race in the Male-to-Female Ratio at Birth in the United States

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ABSTRACT

Objective: *In humans, males' births exceed females' births. This ratio is conventionally referred to as M/F and is used to denote male births divided by total births. This ratio is influenced by a large number of factors and has been shown to exhibit seasonality. This study was carried out in order to ascertain whether seasonal variation in M/F exists in the United States of America and whether such variations are influenced by race.*

Materials and Methods: *Data on births by gender and race from 2003 to 2013 were obtained from Centres for Disease Control and Prevention Wonder section as four races: White, Black/African American, Asian/Pacific Islander and American Indian/Alaska Native. ANOVA and ARIMA tests were carried out.*

Results: *This study analysed 45 103 146 live births (M/F 0.51182) over 2003 to 2013. M/F was highest in Asian/Pacific Islander (*$p << 0.0001$*), followed by White (*$p = 0.002$*), American Indian/Alaska Native (*$p = 0.04$*) and Black/African American. Significant seasonality was present overall, with a peak in June, for Whites more than Black/African American.*

Conclusion: *Parental stress lowers M/F, and lower M/F found in Black/African and American Indian/Alaskan births may be stress related. The dampened seasonality noted in Black/African American births may also be due to this phenomenon. More males were born in spring, as in other species, with interesting inter-racial differences.*

Keywords: Birth rate/trends, infant, newborn, periodicity, sex ratio, United States

INTRODUCTION

In humans, males births exceed females births by approximately 3%. This ratio is conventionally referred to as M/F and is used to denote male births divided by total births, a convention which is used in this paper. The disparity between sex at birth may be influenced by a large number of factors (1, 2).

Male and female have been shown to exhibit seasonal variations in many regions, and it has been postulated that this is in accordance with the Trivers–Willard hypothesis. Briefly, this evolutionary theory proposes that individuals who are able to influence their offspring's gender ratio in accordance with their environment are likelier to procreate, dispersing these advantageous genes. In polygynous species, only the fittest males reproduce. For this reason, parental investment in a 'good quality' son may yield greater numbers of descendants than an equivalent investment in a 'good quality' daughter. It is thus advantageous for a mother to produce sons when she has good resources, and daughters when she does not. This is known as the Trivers–Willard hypothesis (3).

Initial studies had shown a low M/F in February and March and a high M/F in summer in various parts of the world (4). For the United States, early studies were inconclusive, including one that dealt with 1925 to 1934 (5), and another study for 1935 (6). However, yet another study for the period 1922 to 1936 showed an M/F rise from February to June, followed by a drop in December (7). This was confirmed by a second study for the periods 1915 to 1936 and 1942 to 1948 which showed an increase in M/F from February to June, and a drop in October (8). Such patterns support the Trivers–Willard

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hypothesis since the birth of offsprings in favourable conditions increases the chances of the said offsprings' survival. This study was carried out in order to ascertain whether seasonal variations in M/F existed in United States' live births and whether any such variations were influenced by race.

SUBJECTS AND METHODS

Births by gender and race from 2003 to 2013 were obtained from the website of the Centres for Disease Control and Prevention (CDC), in the CDC Wonder section (http://wonder.cdc.gov/natality.html). The data were available for four races: White, Black/African American, Asian/Pacific Islander and American Indian/Alaska Native.

The quadratic equations of Fleiss were used to calculate exactly 95% confidence limits (9). Chi tests and chi tests for trend were used for trend testing of male and female births using the Bio-Med-Stat Excel add-in for contingency tables (Peter Slezak, Bratislava, Slovakia) (10). Pearson correlations were carried out with SPSS (Statistical Package for the Social Sciences, International Business Machines Corporation, New York, NY, USA).

Prior to any use of statistical tools, seasonal and annual trend patterns were plotted and a number of tests were carried out on the data to check for normality, homogeneity of variance and outliers, along with visual inspection.

Seasonality was analysed using Demetra (version 1.0.4.323) and a model-based method (X12) was operated to fit an Autoregressive Integrated Moving Average (ARIMA) model to the data. A series of seasonality tests were carried out on the time series once the ARIMA model was established. These included non-parametric tests for stable seasonality using Friedman and Kruskall–Wallis tests, a test for the presence of seasonality assuming stability, evolutive seasonality test and combined seasonality test. The combined seasonality test passes if the first three tests pass at the 1% ($p < 0.01$) level and if the evolutive seasonality test fails at the 20% ($p > 0.2$) level.

Further analyses were done on the data, with the analysis of variance (ANOVA) being carried out to check for seasonality, using SPSS. The null hypothesis states that there is no statistically significant difference between the means of each month. A p value < 0.05 was taken to represent a statistically significant result.

Ethical approval was irrelevant as this analysis comprised a large and completely anonymous data set.

RESULTS

In this study, a total of 45 103 146 live births were analysed as 23 084 825 males and 22 018 321 females (M/F 0.51182, 95% CI: 0.51168, 0.51197) born over the period 2003 to 2013. The totals for each race are shown in Table 1. M/F for the four races is shown in Fig. 1, ranked from highest to lowest. There was a significant gradient between each next race when ranked highest to lowest: Asian/Pacific Islander *versus* White (chi = 126.5, $p <$ 0.0001), White *versus* American Indian/Alaska Native (chi = 9.5, $p < 0.002$) and American Indian/Alaska Native and Black/African American (chi = 4.2, $p < 0.04$).

Table 1: Totals and M/F for each race, 2003 to 2013

	All	Asian/ Pacific Islander	White	American Indian/ Alaska Native	Black/ African American
Male	23 084 825	1 398 499	17 849 540	251 363	3 585 423
Female	22 018 321	1 313 034	16 998 167	241 500	3 465 620
Total	45 103 146	2 711 533	34 847 707	492 863	7 051 043
95% UCL	0.51197	0.51635	0.51238	0.51140	0.50886
M/F	0.51182	0.51576	0.51222	0.51001	0.50850
95% LCL	0.51168	0.51516	0.51205	0.50861	0.50813

LCL = lower confidence interval, UCL = upper confidence interval.

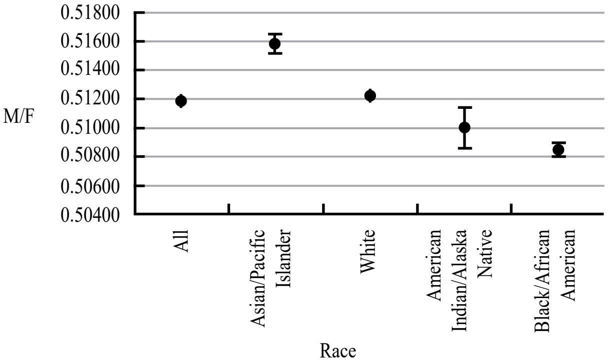

Fig. 1: Male and female by race from 2003 to 2013.

Monthly analysis showed no correlations for M/F and total live births for any of the races and for the total for all the races. A seasonal pattern was evident on the inspection of the monthly data (Fig. 2), with a rise from January to a peak in May/June, and a decline thereafter. The patterns for each race are also shown in Fig. 2.

ARIMA (0,1,1) (0,1,1) was fitted on all the data and for all the four races. Significant seasonality was present overall (Table 2). Of all the four races, White births exhibited the greatest seasonal variation, followed by Black/African American. Seasonality was absent

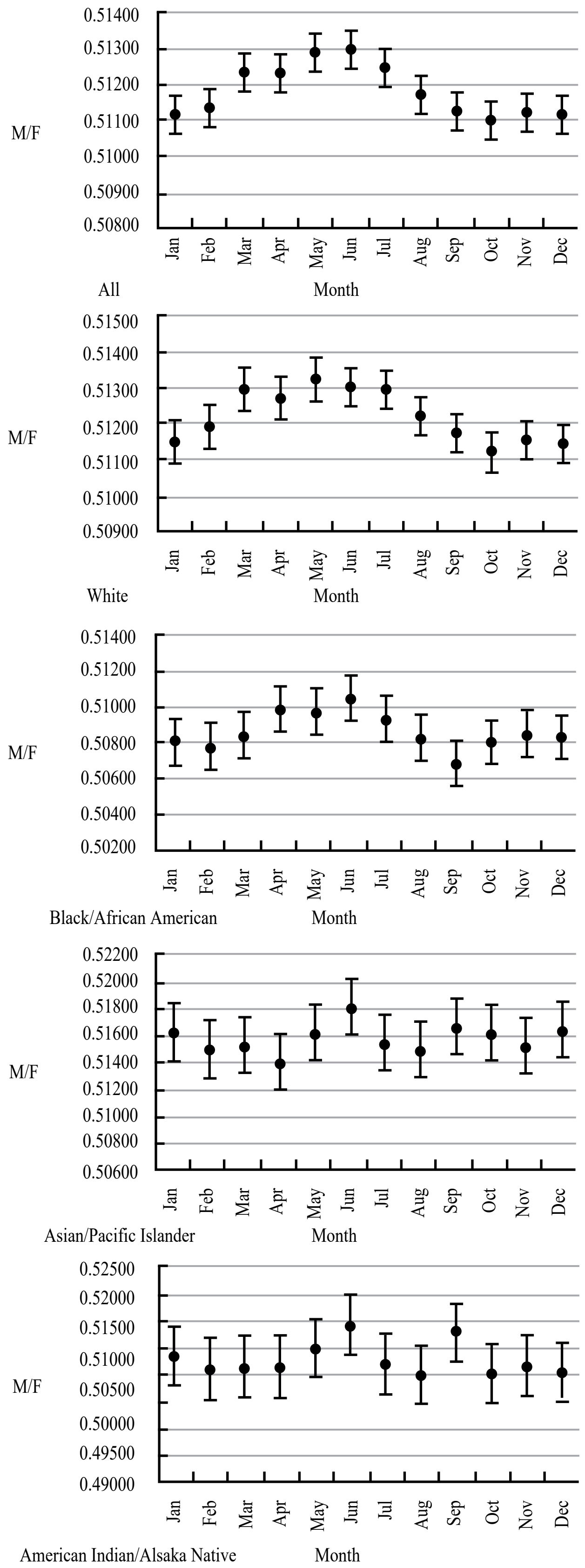

Fig. 2: Summated monthly male and female from 2003 to 2013 overall and by race.

Table 2: Male and female seasonality for all births and for each race, 2003 to 2013

	ANOVA and five seasonality tests	**Seasonality**
ALL	ANOVA	< 0.0001
	Friedman test	< 0.0001
	Kruskall–Wallis test	< 0.0001
	Test for presence of seasonality assuming	< 0.0001
	stability	0.7993
	Evolutive seasonality test	SP
	Combined seasonality test	
White	ANOVA	< 0.0001
	Friedman test	< 0.0001
	Kruskall–Wallis test	< 0.0001
	Test for presence of seasonality assuming	< 0.0001
	stability	0.4233
	Evolutive seasonality test	SP
	Combined seasonality test	
Black/ African American	ANOVA	0.005
	Friedman test	0.0005
	Kruskall–Wallis test	0.0006
	Test for presence of seasonality assuming	0.0009
	stability	0.4649
	Evolutive seasonality test	SP
	Combined seasonality test	
Asian/ Pacific Islander	ANOVA	0.6940
	Friedman test	0.6704
	Kruskall–Wallis test	0.5732
	Test for presence of seasonality assuming	0.6011
	stability	0.6668
	Evolutive seasonality test	SA
	Combined seasonality test	
American Indian/ Alaska Native	ANOVA	0.6760
	Friedman test	0.6651
	Kruskall–Wallis test	0.6546
	Test for presence of seasonality assuming	0.6013
	stability	0.7347
	Evolutive seasonality test	SA
	Combined seasonality test	

SA = seasonality absent, SP = seasonality present.

in Asian/Pacific Islander and American Indian/Alaska Native births.

DISCUSSION

Racial differences in overall M/F

Recent studies dealing with the United States have shown that M/F has declined since the 1970s (11). Moreover, M/F has been historically shown to be significantly less in Black populations when compared with Caucasian populations (12, 13), and significantly higher in Asian populations (1, 13). However, the variations between Asian and other populations must be viewed cautiously due to the patriarchal nature of such cultures that may favour males over females to the extent of carrying out selective abortions or unregistered female infanticide (14).

Racial differences persist even when races co-exist such as in South Africa and the West Indies (13), and in England and Wales (1); and it has been speculated that this may be due to innate minor physiological differences (12, 14).

However, it has been proposed that the lower M/F noted in Black/African and American Indian/Alaskan births may be stress related (15). Long-term stress in association with maternal socio-economic status influences M/F. Well-nourished mothers have higher M/F than those who are not (16). Furthermore, many studies have shown a decreasing M/F in association with surrogates of socio-economic status (17), an observation that was as far back as 1931 which showed that families with higher levels of education, economic means and higher social class had higher M/F (18).

Most experts agree that Black Americans have not completely recovered from the positional degradation of slavery that was imposed on their forefathers. Indeed, race is the most important variable found in association with unequal wealth distribution in the United States (19). These imbalances also extend to healthcare (20), and poor antenatal care increases prenatal losses, with excessive male losses that tend to lower M/F (21). The situation for American Indian/Alaskan births is very similar (22, 23). It is possible that M/F for these races is low due to chronic overall stressful conditions.

Racial differences in seasonality

Numerous studies have indicated that births vary seasonally in the United States. For example, data for 1979 to 2002 were found to be in phase with variations in fertility. Logistic regression showed that mean temperature in the month before conception correlated positively with M/F when controlled for birth order, maternal age, maternal education, plurality, gestation length, and race (24).

Seasonality in M/F has also been recently described in other countries. For example, a highly significant seasonal pattern was found in western Siberia, with a peak in the second and a trough in the fourth quarter of the year (25). This type of periodicity was also noted in Germany for the period 1946 to 1995 (26).

Ambient temperature influences on M/F may have long-term effects. It has been shown not only that M/F is influenced by ambient temperature, but also that males from cold-stressed cohorts who have experienced cold weather *in-utero* culling have, on average, longer life expectancies. This has been calculated as an average decrease in male life-span by 14 days per 1°C increase from one year to the next among those who survived to one year of age (27).

Interestingly, it has also been shown that maternal gonadotropin levels are dependent on the variations in light stimulation (28), and that the seasonal variation in M/F is synchronous with dizygotic twinning rates. It has therefore been speculated that both factors may be influenced by maternal gonadotrophin levels (2).

The findings of a dampened seasonal variation in M/F on the background of an overall lower M/F in Black/African American births when compared with White births may potentially also be related to the aforementioned socio-economic factors which might tend to dampen temperature/weather-related effects. This applies even more to American Indian/Alaska Native births. However, in the case of the latter group and in Asian/Pacific Islander births, the lower number of births may have resulted in a Type 2 error, falsely rejecting the assumption of non-seasonality due to inadequate numbers required to make such an observation.

In conclusion, it has been shown that more males are born in the spring and summer, possibly due to the fact that during this period of the year, food is more abundant (29). The findings of this study are in keeping with this contention, with interesting inter-racial differences.

AUTHORS' NOTE

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