ORIGINAL ARTICLES

SECULAR TRENDS AND LATITUDE GRADIENTS IN THE MALE-FEMALE RATIO AT BIRTH IN YUGOSLAVIA AND THE EX-YUGOSLAVIAN STATES

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Summary: Background: Latitude gradients and secular trends in Europe and North America have been found in the male-female ratio at birth (M/F: male births divided by total births) which approximates 0.515. Methods: Annual national data for Yugoslavia and the post-Yugoslavia States for male and female live births were obtained from the World Health Organisation and analysed with contingency tables. Results: This study analysed 22,020,729 live births. There was an increasing trend in M/F prior to the breakup of the former Yugoslavia (1950–1990, p = 0.002), followed by a decreasing trend after 1990 (p = 0.02). A latitude gradient was also noted, with more males being born in southern, warmer latitudes (p < 0.0001). There was an overall excess of 42,753 male births based on an anticipated M/F of 0.515. Conclusion: M/F is decreasing in this region, similar to the rest of Europe and North America. A latitude gradient is also present with more males being born in warmer (more Southern) latitudes (p < 0.0001), even in this small region and over the short time-frame studied.

Key words: Asia; Southeastern; Far East; Birth Rate/*trends; Infant; Newborn; Sex Ratio

What is already known on this subject?
- Latitude gradients have been found in the male-female ratio at birth (M/F: male births divided by total births) which is expected to be 0.515.
- M/F is declining in North America and the Europe.
- Moreover it had been shown that there is a higher incidence of male births in southern Europe than in the north, with the opposite found in North America.

What this study adds?
- The post-Yugoslavia States display an overall decreasing trend in M/F akin to the rest of Europe and North America.
- However, a male surplus in excess of 0.515 is evident, resulting in an excess of 42,753 male births for the period 1991–2004.
- A latitude gradient is also present with more males being born in warmer (more Southern) latitudes (p < 0.0001), even in this small region and over the short period studied.

Introduction

Gender is determined at conception in mammals, and male births occur slightly in excess (1). The male to female ratio of live births is expressed as the ratio of male live births divided by total live births (M/F), and for humans, this approximates 0.515 (2). The reason for this discrepancy is uncertain but a plethora of factors have been proposed (3). This ratio has recently gathered importance. Since male foetuses are spontaneously aborted more readily than female foetuses under stressful circumstances, M/F has been mooted as a potential sentinel health indicator (4).

Latitude variation in M/F

M/F varies in geographical space, with a latitude gradient that is different in Europe and North America. More males are born towards the south of Europe, in contrast with the North American continent where more males are born towards the north of that continent (5, 6).

Secular variation in M/F

Several studies have also been shown that M/F varies in temporal fashion, mostly declining in the above two continents (7).

Yugoslavia (“Land of the Slavs”)

The term “Yugoslavia” embodied the union of six South Slavic nations: Serbs, Croats, Slovenes, Bosniaks, Montenegrins and Macedonians, and was originally formed as a Kingdom in 1918. After the Second World War, this nation became the Socialist Federal Republic of Yugoslavia (SFRY), and was comprised of six socialist states: Bosnia and Herzegovina, Croatia, Macedonia, Montenegro, Serbia, and Slovenia. This second Yugoslavia ended with the dec-
laration of independence of Croatia, Slovenia and Macedo-
nia in 1991 and Bosnia and Herzegovina’s declaration of
independence in 1992. This resulted in the Yugoslav Wars
between 1991 to 1995 and 1998 to 2001 between seces-
sionist states and the central government in Belgrade. The
wars were characterised by harsh, internal ethnic conflicts
and caused enormous local economic disruption. Conflicts

This study identifies secular trends in M/F in Yugoslav-
ia and the post-Yugoslavia states from a World Health Or-
ganization (WHO) dataset that includes the past sixty years.
Trends by geographical latitude are also analysed. The null
hypothesis is that there were no significant geographical or
secular differences in M/F.

Methods

Data sources

Annual male and female live births were obtained di-
rectly from WHO. Data for Bosnia and Herzegovina was
unavailable.

Statistics

Excel was used for data entry, overall analysis and
charting. The quadratic equations of Fleiss were used for
exact calculation of 95% confidence intervals for ratios (8).
Pearson correlations were calculated in order to ascertain
the direction of trend. Chi tests and chi tests for trends for
annual male and female births were used throughout.

The latter were applied using the Bio-Med-Stat Excel
add-in for contingency tables. This add-in is based on the
original work on this subject which led to the development
of the Cochran-Armitage test (Dr. Peter Slezák, Institute
of Normal and Pathological Physiology, Slovak Academ-
icy of Sciences, personal communication).

Latitude trend testing was applied after the post-Yugosla-
vian states were ranked in the following order (from North
to South): Slovenia, Croatia, Serbia and Montenegro, and
Macedonia. A p value ≤ 0.05 was taken to represent a sta-
tistically significant result.

Results

There were 22,020,729 live births available for analysis.
Data for the former Yugoslavia was available for 1950–1990.
Data for Serbia-Montenegro and Macedonia was only avail-
able for 1991–2003 therefore 5-year tables were compiled
up to 2004 and calculations for trend were limited to 2003.

Secular trends

Five year total live births and sex ratios at births, in
5 year intervals, are shown in Table 1 for Yugoslavia and
for the post-Yugoslavian states in Table 2. There have been
increases and also decreases in M/F in different states, but
taken individually, these were not significant (Table 3).
M/F is almost always higher than the anticipated 0.515.
This resulted in an overall excess of 42753 male births for

There was an increasing trend in M/F prior to the break-
up of the former Yugoslavia (1950–1990, r = 0.4, p = 0.002
– Table 3). After this period, a decreasing trend in M/F is
manifest for several regions and overall (r = −0.5, p = 0.02
– Table 3).

Latitude gradients

Slovenia, Croatia, Serbia and Montenegro, and Mace-
donia exhibit a significant latitude gradient (for the peri-
od 1991–2003, latitudes as per Table 3, chi for trend = 28,
p < 0.0001), with more males being born to the south of
the region than to the north.

Discussion

Secular variation in M/F

Studies which have had access to M/F data from before
1950 have described increasing trends in M/F prior to this
period, followed by a decreasing trend thereafter (9). These
trends were especially noticeable in Finland, with a rise in
M/F between 1751 and 1948, as well as in Denmark (10,
11). Such data was not available for analysis from the
WHO data source.

M/F has been shown to be declining in Europe and in
North America,(7) and the results obtained in this study are
in accordance. Moreover, recent work utilising the same
WHO dataset has shown the following:

An overall decreasing secular trend in M/F was found
for Czechoslovakia and the post-Czechoslovakian (Czech
Republic and Slovakia) countries (p < 0.0001). No latitude
gradient was noted (12).

For Scandinavia, a significant decreasing trend in M/F
was noted in all countries except Norway. There was no
latitude gradient (13).

In the British Isles, an overall rise in M/F was noted up
to the late 1970s, followed by a decline thereafter. The step-
down between the periods of 1975–1979 to 1980–1984 was
highly significant for both northern and southern regions. An
overall decreasing trend in M/F was noted (p = 0.04) which
reversed the expected European latitude gradient. More
males are born in Scotland and Northern Ireland than in
England and Wales, and the Republic of Ireland (p = 0.02) (14).

For Asia, an overall increasing trend in M/F was found
(p < 0.0001) as well as a latitude gradient, with more males
being born in southern, warmer latitudes (p < 0.0001).
These results are in keeping with European data. The over-
al M/F in Asia may be rising due to improving socioeco-
nomic conditions (15).
And finally, a study dealing with the South American continent revealed a significant overall increasing trend in M/F, unlike the decline present in Europe and North America (6). A latitude gradient was also noted with more males being born in cooler (more Southern, >20° S) latitudes (p < 0.0001), a gradient that is similar to that previously reported for the North American continent and contrary to trends reported in Europe (16).

These shifts are intriguing and it was speculated as early as 1967 that inherent racial differences may influence M/F (17). Moreover, M/F declines when adverse environmental factors are present. Stressful events encourage females to spontaneously abort male foetuses at higher rates than female foetuses (18). For this reason, M/F has been proposed as a surrogate sentinel health indicator (4).

It has been shown, for example, that M/F declines after traumatic events such as after earthquakes (19), and a miscellanea of environmental disasters (20). Contracting economies have also been shown to reduce M/F but the overall trends in this paper would not seem to fit this hypothesis (21).

Studies dealing with early periods in German history, such as 1787–1802 (the period of the French Revolutionary Wars), have shown that war and its aftermath may influence M/F (22). Moreover, in Germany, two peaks in M/F have been described in temporal relation to the two World Wars (23), and these peaks were further confirmed by data from the Netherlands (11).

The wartime influence was also shown in Slovenia where it was linked to changes in sperm motility (25). However, Croatian males were shown not to have been affected in this way by the recent strife in the Balkans (25). Moreover, an analysis of the entire region likewise failed to demonstrate any influence on M/F. However, the authors speculated that a hypothetical threshold or trigger that might involve intensity and/or duration of fighting may have to be reached before M/F is affected (26).

James has proposed an M/F cycle that fluctuates over a thirty year period, a homeostatic mechanism that negatively correlates M/F with the adult sex ratio at the time of conception (1), but this is not noted in the data.

An increasing maternal age at first pregnancy has also been described in developed countries since the introduction of the oral contraceptive pill in the 1980s, but this dataset is unable to explicate any such effects (27).

### Tab. 1: 5 year total live births and sex ratios at births, in 5 year intervals, for Yugoslavia

<table>
<thead>
<tr>
<th>Year</th>
<th>M</th>
<th>F</th>
<th>Total</th>
<th>UCI</th>
<th>M/F</th>
<th>LCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950–54</td>
<td>1250519</td>
<td>1144097</td>
<td>2418637</td>
<td>0.51766</td>
<td>0.51703</td>
<td>0.51640</td>
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<td>1955–59</td>
<td>1069218</td>
<td>9070908</td>
<td>2076379</td>
<td>0.51718</td>
<td>0.51652</td>
<td>0.51586</td>
</tr>
<tr>
<td>1960–64</td>
<td>1007161</td>
<td>948630</td>
<td>1962907</td>
<td>0.51562</td>
<td>0.51494</td>
<td>0.51426</td>
</tr>
<tr>
<td>1965–69</td>
<td>970010</td>
<td>907068</td>
<td>1877078</td>
<td>0.51742</td>
<td>0.51677</td>
<td>0.51602</td>
</tr>
<tr>
<td>1970–74</td>
<td>996166</td>
<td>929062</td>
<td>1925228</td>
<td>0.51813</td>
<td>0.51743</td>
<td>0.51672</td>
</tr>
<tr>
<td>1975–79</td>
<td>973146</td>
<td>908828</td>
<td>1881974</td>
<td>0.51800</td>
<td>0.51709</td>
<td>0.51605</td>
</tr>
<tr>
<td>1980–84</td>
<td>919896</td>
<td>858359</td>
<td>1778255</td>
<td>0.51804</td>
<td>0.51730</td>
<td>0.51637</td>
</tr>
<tr>
<td>1985–89</td>
<td>919896</td>
<td>858359</td>
<td>1778255</td>
<td>0.51804</td>
<td>0.51730</td>
<td>0.51637</td>
</tr>
<tr>
<td>1990</td>
<td>919896</td>
<td>858359</td>
<td>1778255</td>
<td>0.51804</td>
<td>0.51730</td>
<td>0.51637</td>
</tr>
</tbody>
</table>

### Tab. 2: 5 year total live births and sex ratios at births, in 5 year intervals, for the post-Yugoslavian states

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>M</th>
<th>F</th>
<th>Total</th>
<th>UCI</th>
<th>M/F</th>
<th>LCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slovenia</td>
<td>1991–94</td>
<td>41859</td>
<td>39215</td>
<td>80804</td>
<td>0.51814</td>
<td>0.51469</td>
<td>0.51265</td>
</tr>
<tr>
<td></td>
<td>1995–99</td>
<td>40207</td>
<td>39215</td>
<td>80804</td>
<td>0.51814</td>
<td>0.51469</td>
<td>0.51265</td>
</tr>
<tr>
<td></td>
<td>2000–04</td>
<td>39653</td>
<td>39404</td>
<td>79057</td>
<td>0.51814</td>
<td>0.51469</td>
<td>0.51265</td>
</tr>
<tr>
<td>Croatia</td>
<td>1991–94</td>
<td>100871</td>
<td>95047</td>
<td>195918</td>
<td>0.51708</td>
<td>0.51486</td>
<td>0.51265</td>
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<tr>
<td></td>
<td>1995–99</td>
<td>102222</td>
<td>96373</td>
<td>198595</td>
<td>0.51708</td>
<td>0.51486</td>
<td>0.51265</td>
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<tr>
<td></td>
<td>2000–04</td>
<td>103573</td>
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<td>201316</td>
<td>0.51708</td>
<td>0.51486</td>
<td>0.51265</td>
</tr>
<tr>
<td>Serbia and Montenegro</td>
<td>1991–94</td>
<td>218029</td>
<td>201404</td>
<td>419433</td>
<td>0.51831</td>
<td>0.51982</td>
<td>0.51583</td>
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<tr>
<td></td>
<td>1995–99</td>
<td>221029</td>
<td>203404</td>
<td>424433</td>
<td>0.51831</td>
<td>0.51982</td>
<td>0.51583</td>
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<tr>
<td></td>
<td>2000–04</td>
<td>223029</td>
<td>205404</td>
<td>429433</td>
<td>0.51831</td>
<td>0.51982</td>
<td>0.51583</td>
</tr>
<tr>
<td>Macedonia</td>
<td>1991–94</td>
<td>69223</td>
<td>64706</td>
<td>133929</td>
<td>0.51954</td>
<td>0.51686</td>
<td>0.51418</td>
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<td></td>
<td>1995–99</td>
<td>70223</td>
<td>65706</td>
<td>135929</td>
<td>0.51954</td>
<td>0.51686</td>
<td>0.51418</td>
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<tr>
<td></td>
<td>2000–04</td>
<td>71223</td>
<td>66706</td>
<td>137929</td>
<td>0.51954</td>
<td>0.51686</td>
<td>0.51418</td>
</tr>
</tbody>
</table>

Data for Slovenia and Croatia to 2004.
Data for Serbia and Montenegro and Macedonia to 2003.
In conclusion, significant temporal and geographical M/F gradients are observed that defy easy explanation, even over this study’s short time span and in this relatively small geographical region. However, no reason for this gradient other than latitude is apparent.


Latitude variation in M/F

M/F exhibits a variable latitude gradient. It has been shown that more males are born toward the south of Europe while more males are born toward the north of the North American continent (5, 6). At face value, this dataset supports the former (European) latitude gradient at statistically significant levels, with more males born at southern and therefore warmer latitudes. But the entire region extends over just seven degrees of latitude (latitudes as per Table 3), with some degree of overlap of the states being studied, and only spans 14 years with relatively small numbers of live births. However, no reason for this gradient other than latitude is apparent.

In conclusion, significant temporal and geographical M/F gradients are observed that defy easy explanation, even over this study’s short time span and in this relatively small geographical region.

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References


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