Congenital Heart Disease and Environmental Physical Activity - Kaunas data, 1995-2005

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Abstract. Recent studies described a number of fetal development sides related to the environmental physical activity. The aim of this study was to check the possible links between congenital heart disease (CHD) born in a non-selected medical network and indices of environmental physical activity. Children born with CHD in Kaunas, Lithuania, in years 1995-2005 were analyzed at the end of the first year of life (including also those died after birth from this condition). Monthly distribution of CHD (total - 371, both gender (178 boys and 193 girls), 41435 births) were compared with parameters of solar (SA), geomagnetic (GMA) and cosmic ray (CRA) activity, as well as the year, at the month of birth, 9 months before and at year of birth and one year before. CRA was represented by neutron activity on the Earth’s surface. Heliogeophysical data were obtained from space research centers in the USA, Russia and Finland. There was found a significant correlation between yearly number of births ($r = -0.9$, $p = 0.00012$). Monthly number of CHD was correlated with SA and CRA often highly at the beginning of pregnancy both in monthly and yearly ($r = -0.7$, $p = 0.025$ for SA, $r = 0.8$, $p = 0.005$ for CRA) comparison. For boys the correlation was stronger, but also it was significant for girls. GMA has not shown significant effects. It is concluded that the number of yearly and monthly CHD is connected with SA and CRA in pregnancy. Boys show high levels in these correlations. The mechanism of the cosmophysical effects on human development and temporal distribution of CHD deserve special studies.

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Introduction
The fetal development, number of newborns, their physical characteristics and congenital defects are related to physical parameters of the environment [1-6]. A recent study has been performed checking the time distribution of congenital heart disease (CHD) in two tertiary medical centers in Israel in years 1995-2005 [7]. The aim of this study was to check CHD monthly distribution at birth with concomitant environmental physical activity in the general (non-selected) medical network [hospitals] in other geographic area and with adverse tendency in reproduction [birth] numbers at the same time period (1995-2005).

Data and methods
The study was based on births in Kaunas, Lithuania’s second biggest city (355 586 inhabitants at January 1, 2008, many universitites, industry and sport facilities). In years 1995-2005 at the end of the first year of life 371 CHD/41435 births (including deaths at the first year of life) were registered in the medical network of this city. There were 178 boys and 193 girls in the studied group of CHD.

Comparing CHD and physical parameters, Pearson correlation coefficients $r$ and their probabilities $p$ were established. Probabilities of 95% and higher were accepted as significant ones meanwhile at 90% - 94% level - as a strong trend towards of significance. Lower levels were described as non-significant (N.S.).

The yearly number of births in the studied time span fluctuated from 4692 (1995) to 3207 (2003) presenting a significant inverse correlation with years of observation (correlation coefficient $r = -0.96$, and probability $p=0.00012$). The monthly distribution of births with CHD was compared with physical parameters at the month of
birth and nine months before – time of conception. Taking into account that approximately 2/3 of women were pregnant a year before giving birth, we also compared yearly CHD numbers (total and each gender in all comparisons) with yearly physical parameters at the year of birth and a year before (1994-2004). The physical indices used in this study were month, year, solar activity (SA) indices (sunspot number; smoothed sunspot number (considering sunspot grouping and used devices for observation); solar radio flux at 10.7 cm wavelength (one of Internationally used index of SA); adjusted solar radio flux).

For geomagnetic activity (GMA), indices Ap, Cp and Am were used describing integrated monthly indices measured in nanotesla (nT) units (planetary data) and measured in multiple regions [8].

CRA was represented by neutron activity (imp/min) at the Earth’s surface. Neutrons are remains of atoms crushed in the high layers of our Universe by cosmic rays of colossal energies. The Sun and geomagnetic fields are shields defending our planet from CRA annihilation. SA and GMA are inversely related to CRA, represented by neutron activity on the surface of our planet [9]. The cosmophysical data were obtained from: the National Oceanic and Atmospheric Administration’s National Geophysical Data Center and Space Weather Prediction Center, Boulder, USA; Moscow Neutron Monitor, IZMIRAN, Russian Academy of Sciences; the Neutron Monitoring Station of Oulu University, Finland [10-14].

Results

Table 1 presents the monthly comparative data of CHD and physical parameters at month of birth (delivery) and nine months before. Total patients and, separately, both gender patients’ data are presented.

Table 2 demonstrates the results for yearly CHD distribution at the year of birth and a year before, having in mind that births in the first nine months of each year are mostly a result of pregnancy conceived at previous year. Despite the small number of years (11), it's obvious that links at year of conception of most of children born in the next year show stronger connection with environmental physical parameters concomitant with the beginning of fetal development.

Despite smaller number of boys included in this study (178 against 193), physical factors studied are strongly related to the occurrence of CHD as in boys as in girls.

CRA is significantly related with CHD in both genders, while SA - more in boys (Tables 1 and 2).

In total monthly account, CRA and SA remain significantly linked to monthly number of CHD. The relatively not high number of monthly patients with CHD is rising in its relationship to physical parameters when the yearly comparison is performed, increasing the number of patients compared. It’s especially evident in the comparison with physical data a year before delivery achieving levels of strong correlation \( r = 0.7 - 0.8 \). Comparison by gender shows that CHD significantly differs by gender. In girls there was significantly \( p = 0.02 \) more ASD, TGA \( (p=0.005) \); in boys: Dextrocardia \( (p<0.0001) \) and Valvular Aortic Stenosis \( (p<0.0001) \). PDA demanding surgery was 7 in girls and 2 in boys.

Despite the relative small number of the analyzed CHD patients group we made an attempt for normalization of the data to 10 000 deliveries in relation to the discussed physical factors. There was not significant links between the yearly number of CHD and physical parameters of the year of birth. At year before delivery (when the pregnancy in most of cases undergo the initial stages) it was a 95% significant correlation \( r = 0.6 \) with CRA and a trend (90% significant) of inverse correlation with yearly smoothed sunspot number average \( r = -0.48 \).

Discussion

The presented data could be considered as an additional chapter in Clinical Cosmobiology. In previous studies newborn number (monthly), their length and weight, number of preterm births, monthly distribution of newborns with Down syndrome were discussed [1-7]. Connection of growth hormone, prolactin and corticosteroids secretion with factors of cosmophysical activity was demonstrated [15]. Also connection with the immune system [16-18] and human behavior [19] was studied.

A special interest for comparison has an analogical study made in two tertiary university centers in Israel at the same time, in 1995-2005 [7]. The specialization of these centers in pediatric cardiology and cardiovascular surgery could concentrate there an additional number of pregnant women with suspicion of fetal CHD made by repeated fetal echocardiography. The discordant trend in delivery rates \( r = 0.83, p = 0.0014 \) in the Israeli study and \( r = -0.9, p = 0.00012 \) in Kaunas, Lithuania correlation with the 11 observation years can also affect the studied links, having in mind the 11-year SA cycle (here the maximum was in year 2000). The data was obtained in newborns in the Israeli study \( n = 1739/79085 \) births) and at age of one year in Kaunas \( n = 371/41435 \) births). In this study the deliveries in hospitals not always having special affinity to pediatric cardiology and cardiosurgery facilities was given an additional year for completing the diagnostic procedures, but also not excluding the children lost at this year as a result of severe CHD. The comparative trends in these two studies are presented in Fig. 1.

The similarity of the studies is that in both monthly and yearly numbers of newborns with CHD were significantly correlated with CRA and SA. Comparison with physical activity at the beginning of pregnancy (nine months before delivery) strengthens the links with physical parameters in girls that was non-impressive when compared at the end of pregnancy. In the Israeli study separate calculation was done excluding Potent Ductus Arteriosus (PDA) that often undergoes spontaneous closure at the first months of antenatal life [20-23]. In this study the data obtained at the end of first time of life made such procedure unnecessary.

An open question is if some children are not remaining undiagnosed for CHD in this study after their first year of life.

What could be told about teratogenic mechanisms of CRA and SA? Some negative effects from exposure to CRA by high altitude flights were published [24-28]. Neutrons are used in radiotherapy [29].
TABLE 1. Pearson correlation coefficients (r) and their probabilities (p) for congenital heart disease (132 months data, Kaunas, Lithuania, 1995 - 2005) at month of delivery and nine months before delivery and related levels of cosmophysical activity

<table>
<thead>
<tr>
<th>Parameters</th>
<th>All Male</th>
<th>Female All Male</th>
<th>Female</th>
<th>All Male</th>
<th>Female</th>
<th>All Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>(at month of delivery)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(9 months before delivery)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Year</td>
<td>r</td>
<td>-0.44</td>
<td>-0.43</td>
<td>-0.22</td>
<td>-0.44</td>
<td>-0.43</td>
<td>-0.234</td>
</tr>
<tr>
<td></td>
<td>p</td>
<td>&lt; 0.0001</td>
<td>&lt; 0.0001</td>
<td>0.01</td>
<td>&lt; 0.0001</td>
<td>&lt; 0.0001</td>
<td>0.007</td>
</tr>
<tr>
<td>2 Month</td>
<td>r</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
</tr>
<tr>
<td></td>
<td>p</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
</tr>
<tr>
<td>3 Sunspot Number</td>
<td>r</td>
<td>-0.208</td>
<td>-0.24</td>
<td>N.S.</td>
<td>-0.365</td>
<td>-0.356</td>
<td>-0.19</td>
</tr>
<tr>
<td></td>
<td>p</td>
<td>0.016</td>
<td>0.0056</td>
<td>N.S.</td>
<td>&lt; 0.0001</td>
<td>&lt; 0.0001</td>
<td>0.03</td>
</tr>
<tr>
<td>4 Smoothed Sunspot Number</td>
<td>r</td>
<td>-0.226</td>
<td>-0.265</td>
<td>N.S.</td>
<td>-0.34</td>
<td>-0.36</td>
<td>-0.144</td>
</tr>
<tr>
<td></td>
<td>p</td>
<td>0.009</td>
<td>0.002</td>
<td>N.S.</td>
<td>&lt; 0.0001</td>
<td>&lt; 0.0001</td>
<td>0.1</td>
</tr>
<tr>
<td>5 Solar Radio Flux</td>
<td>r</td>
<td>-0.23</td>
<td>-0.27</td>
<td>N.S.</td>
<td>-0.358</td>
<td>-0.375</td>
<td>-0.157</td>
</tr>
<tr>
<td></td>
<td>p</td>
<td>0.0079</td>
<td>0.0018</td>
<td>N.S.</td>
<td>&lt; 0.0001</td>
<td>&lt; 0.0001</td>
<td>0.07</td>
</tr>
<tr>
<td>6 Adjusted Solar Radio Flux</td>
<td>r</td>
<td>-0.225</td>
<td>-0.273</td>
<td>N.S.</td>
<td>-0.365</td>
<td>-0.375</td>
<td>-0.168</td>
</tr>
<tr>
<td></td>
<td>p</td>
<td>0.0095</td>
<td>0.0015</td>
<td>N.S.</td>
<td>&lt; 0.0001</td>
<td>&lt; 0.0001</td>
<td>0.05</td>
</tr>
<tr>
<td>GMA indices:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Ap</td>
<td>r</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
</tr>
<tr>
<td></td>
<td>p</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
</tr>
<tr>
<td>8 Cp</td>
<td>r</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
</tr>
<tr>
<td></td>
<td>p</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
<td>N.S.</td>
</tr>
<tr>
<td>9 Am</td>
<td>r</td>
<td>-0.157</td>
<td>-0.19</td>
<td>N.S.</td>
<td>-0.31</td>
<td>-0.35</td>
<td>-0.17</td>
</tr>
<tr>
<td></td>
<td>p</td>
<td>-0.07</td>
<td>0.0288</td>
<td>N.S.</td>
<td>&lt; 0.0001</td>
<td>&lt; 0.0001</td>
<td>0.04</td>
</tr>
<tr>
<td>10 Cosmic Ray Activity (Neutrons, imp/min)</td>
<td>r</td>
<td>0.42</td>
<td>0.397</td>
<td>0.225</td>
<td>0.35</td>
<td>0.35</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>p</td>
<td>&lt; 0.0001</td>
<td>&lt; 0.0001</td>
<td>0.0094</td>
<td>&lt; 0.0001</td>
<td>&lt; 0.0001</td>
<td>0.04</td>
</tr>
<tr>
<td>11 Newborn's number</td>
<td></td>
<td>371</td>
<td>178</td>
<td>193</td>
<td>371</td>
<td>178</td>
<td>193</td>
</tr>
</tbody>
</table>

TABLE 2. Pearson correlation coefficients (r) and their probabilities (p) for congenital heart disease (371/41435 deliveries, data from Kaunas, Lithuania, 1995 - 2005) at the year of delivery and one year before delivery and related cosmophysical activity

<table>
<thead>
<tr>
<th>Parameters</th>
<th>At year of delivery</th>
<th>One year before delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Boys Girls All Boys Girls</td>
<td>All Boys Girls All Boys Girls</td>
</tr>
<tr>
<td>Smoothed Sunspot Number</td>
<td>r=-0.46 p=0.16</td>
<td>r=-0.58 p=0.06 p=-0.46 p=0.15</td>
</tr>
<tr>
<td>Cosmic Ray Activity (Neutrons, imp/min)</td>
<td>r=0.39 p=0.23</td>
<td>r=0.52 p=0.09 p=0.13 p=0.698 p=0.005 p=0.83 p=0.0017 p=0.56 p=0.07</td>
</tr>
<tr>
<td>Number of newborns</td>
<td>371 178 193</td>
<td>371 178 193</td>
</tr>
</tbody>
</table>
Pregnant women are recommended to avoid possible contacts with such radiation sources. The harmful action of neutrons is discussed in projects of their use for military purposes [30, 31]. The transformation of neutrons to protons by joining H+ radicals is a potential way to transform to a harmful agent to cells and, specifically, their nuclei [30].

SA containing wave and particle radiation has also a potential for teratogenic activity. Both sorts of radiation (CRA and SA) include sorts with high ability to damage young cells and tissues [30-36] what can be related with special effects at the early stage of pregnancy and is reflected by higher correlation in the year before delivery and significant link's in girls, that are absent by comparison made with physical parameters at the time of delivery.

Limitation of the study

Relatively small number of CHD made the statistical study less in strength and significance.

We did not have information about the amount of pregnant women undergoing fetal echocardiography check up in different institutions of the studied area.

It is not clear if a part of less symptomatic CHD not remained undiagnosed at the end of the first year of life.

Conclusions

Monthly and yearly congenital heart disease number is significantly related to solar and cosmic ray (neutron) activity. This relationship is stronger at the pregnancy first stages.

Gender differences show stronger links of CHD number with the mentioned physical parameters in male patients. The mechanism of the physical influences on the temporal distribution of CHD deserves special studies.

References


