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Investigation of 5-Year Interconnections between Local Earth Magnetic Field Fluctuations and Acute Myocardial Infarction in Lithuania

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Abstract

The impact of the local Earth magnetic field (LEMF) on cardiovascular events has been studied recently. Data gathered during past years encouraged us to conduct this epidemiological analysis evaluating the association between changes in LEMF and hospital admissions due to AMI in Lithuania between August 2014 and September 2019. This study is unique due to its coverage of all Lithuanian patients. The frequency of morbidity of AMI was compared with the intensity of the LEMF and correlation coefficient was evaluated. The LEMF was measured by the Global Coherence Monitoring Network magnetometer located in Lithuania. LEMF was measured by pikotesla square (pT^2). The LEMF was analized in five frequency ranges [Hz], generally called between Schumann resonance, which overlap with the human brain activity waves on electroencefalogram (EEG) frequency ranges (here, they are named as SDelta (0-3.5Hz), STheta (3.5-7Hz), SAlpha (7-15Hz), SBeta (15-32Hz) and SGamma (32-65Hz) to distinguish from the EEG bands). Significant correlations between weekly admissions of AMI cases and the weekly LEMF strength in five frequency ranges and in total range was found. A clear negative correlation was observed between cases of AMI in female group and LEMF frequency ranges SDelta (0-3.5Hz), STheta (3.5-7Hz), SAlpha (7-15Hz), SBeta (15-32Hz) and in total range. In the second half of the year the number of AMI is lower, therefore negative correlations between SDelta (0-3.5Hz), STheta (3.5-7Hz), SAlpha (7-15Hz) and SBeta (15-32Hz) ranges are stronger than in the first one. This is particularly noticeable in 2016 and 2018 years.

Keywords: Acute myocardial infarction, The local earth magnetic field.

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Contents

Contribution of this paper to the literature:
This is the first ever analysis presenting one-country population's relation between incidences of acute myocardial infarction and changes in local Earth magnetic field.

1. Introduction

The aging population inevitably faces increasing morbidity and mortality associated with ischaemic heart disease [1, 2]. Despite improving therapeutic and interventional treatment methods, acute myocardial infarction (AMI) remains one of the leading causes of hospital admissions and mortality worldwide, responsible for almost 10 million deaths annually [1, 2]. The growing evidence of complexity of pathogenesis of AMI accounting more than existence of ordinary cardiovascular risk factors (stress, smoking, obesity, comorbidities, and unhealthy lifestyle) has been accumulated over past decades [3-8]. It was hypothesised that certain changes in the environment may adjust the occurrence of AMI and other cardiovascular diseases [3-8]. Ambient temperature fluctuations, humidity, and atmospheric pressure are the best-studied components, but not the only ones [3, 9-13].

Increased morbidity and mortality due to cardiovascular disease in association with fluctuation of ambient temperature alone have been proved repeatedly all over the world [13-15]. In contrary to previous opinion, that increased incidences of AMI were associated with higher ambient temperature [14-17], Claeys, et al. [18] have found that decrease of ambient temperature by 10 degrees of Celsius, increases the risk of AMI by 10 percent [18]. Similarly, German scientists have found that 10 degrees of Celsius decrease of ambient temperature may increase the risk of AMI within five days by 10 percent [15]. Even more, Claeys, et al. [18] assume that low ambient temperature is one of the essential factors for onset of AMI for medium latitude population and is more critical than physical extension or psychological stress [18]. Similarly, numerous MONICA study (*monitoring trends and determinants in cardiovascular disease*) performed between 1985 and 1994 have found that the decrease of temperature by 10 degrees of Celsius is associated with 13 percent increased morbidity and mortality due to cardiovascular diseases [19]. The importance of atmospheric pressure on cardiovascular events has been highlighted in the same study [19]. Scientists identified that a 10-bar decreased or increased pressure below or above the 1016 mbar is associated with increased incidences by 12 and 11 percent, respectively [19]. Evidence of atmospheric pressure impact on cardiovascular disease has been proved by scientists Ozheredov, et al. [4] found that increased atmospheric pressure positively correlates with arterial blood pressure [4, 11].

Surprisingly, Chinese scientists found that cold weather, in combination with air pollution, has the strongest effect on cardiovascular mortality [20]. In consistence, air and water pollution are considered as factors severely triggering the AMI in addition to strokes, cardiac arrhythmias, and pulmonary diseases [9]. It is known that inhaled ultrasmall particles cause local inflammatory processes resulting in bronchitis and pneumonia. Nevertheless, the local inflammatory chain induces systemic inflammation, which can predispose endothelial dysfunction resulting in atherosclerosis progression and vulnerable plaque ruptures manifesting as AMI [9].

Humans' interactions with the environment are obvious analysing the effect of daylight on human mental and physical health in addition to the regulation of the circadian rhythms Guillaume, et al. [9]; Abbott, et al. [21]. Wang, et al. [22] established that circadian rhythms disruption has negative effect on morbidity and mortality due to heart diseases [9, 22]. The periodicity of AMI has a significant correlation to circadian rhythms [9, 23]. Fornasari, et al. [24] have summarised that human haemostasis is strongly associated with circadian rhythms [24]. It was found that platelet aggregation and coagulant factors concentration are increased in morning hours in addition to decreased fibrinolytic activity and blood velocity increasement at that time of the day [24].

Moreover, circadian periodicity of incidences of cardiac arrhythmias and cardiovascular events has been repeatedly proved [25, 26]. Even more, Solar activity and its wind-storms forming geomagnetic storms (GS) may have similar effect on human health [5]. It was found that GS may significantly increase platelet aggregation, blood coagulation, and its viscosity in addition to decreased blood flow in small and medium vessels [24].

Additionally, the impact of the local Earth magnetic field (LEMF) on cardiovascular events has been studied during past years. It was identified that increase of LEMF in certain frequencies affects differently vulnerable patients, for example, increased LEMF activity in low-frequency ranges were associated with increased prevalence of acute cardiac arrhythmias [27-29]. In contrast, increased LEMF activity in higher frequency ranges positively correlated with ischaemic cardiac events [27-29]. Nevertheless, Liboff [30] hypothesised that ion cyclotron resonance mechanism, which effect on myocardium cell has been proved under laboratory conditions, is responsible for LEMF effect on humans' health [30, 31]. Moreover, LEMF increase negatively influence the sensitivity of baroreceptors, which are responsible for heart rhythm variability (HRV), which is essential maintaining compensatory mechanism in healthy people and increased blood pressure variability, which may lead to hypertensive crisis in certain patients [8]. Even more, it was found that for people isolated from LEMF, the diastolic blood pressure reduces at least 2 mm Hg, and the capillary blood flow increases at least 17 percent [32]. That let assume that LEMF may increase vessel wall tone, which in severe cases, may be responsible for cardiac deaths [33]. Data gathered during past years encouraged us to perform this epidemiological analysis evaluating the association between changes in LEMF and hospital admissions due to AMI in Lithuania in period from August 2014 till September 2019.

2. Methods and Procedures

In total, 31220 patients diagnosed with AMI who were treated in all Lithuanian hospitals between 1st of August 2014 and 30th of September 2019 were included into our study.

Patients' morbidity and mortality data has been taken from The Institute of Hygiene in Lithuania. The AMI accidents were compared with the LEMF intensity and correlation coefficient was evaluated.

The LEMF was measured by the Global Coherence Monitoring Network magnetometer located in Radviliskis district, near Baisogala town in Lithuania. LEMF was measured by pikotesla square (pT^2) – power of local electromagnetic field in chosen frequency range.

The LEMF was analized in five frequency ranges [Hz], generally called between Schumann resonance, which overlap with the human brain activity waves on electroencefalogram (EEG) frequency ranges (here, they are named as SDelta (0-3.5Hz), STheta (3.5-7Hz), SAlpha (7-15Hz), SBeta (15-32Hz) and SGamma (32-65Hz) to distinguish from the EEG bands).

The LEMF was measured in two (north/south and east/west) orientations. The east/west direction has been chosen for further analysis following the Heart Math Institute recommendations as this LEMF direction stronger influence the human health processes.

Seasonal and annual fluctuations of LEMF intensity are shown in Figure 1. Data are obtained from Global Coherence Monitoring Network magnetometer located in Lithuania, website https://www.heartmath.org.

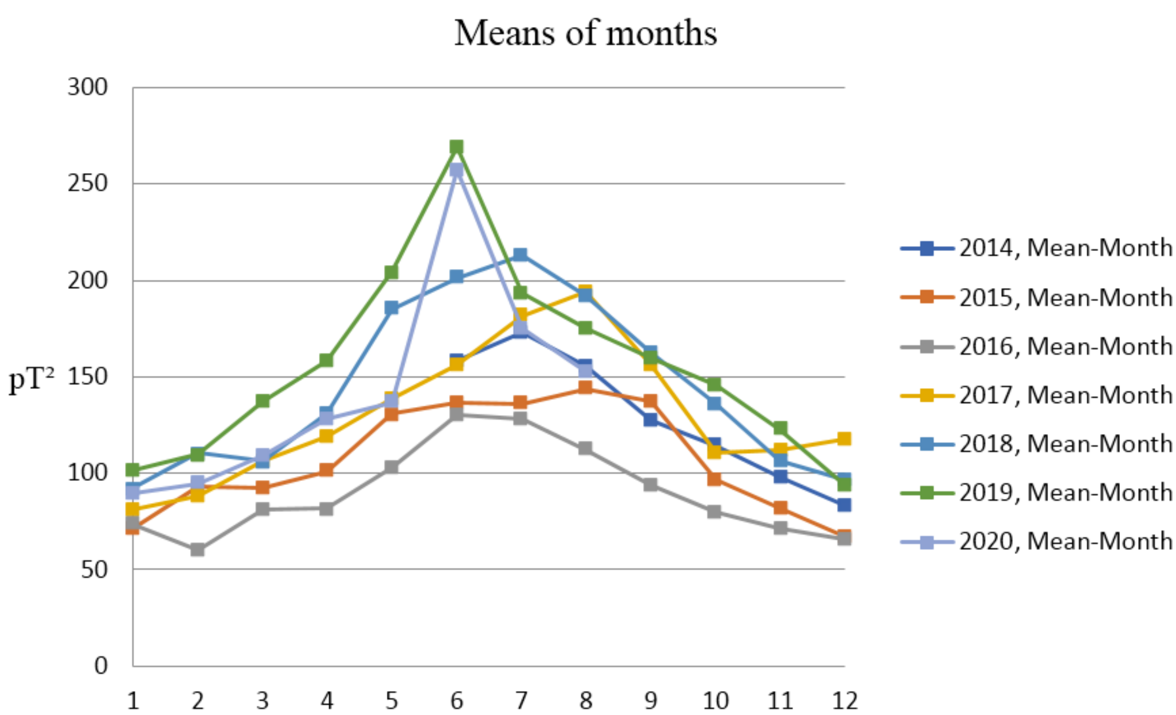

Figure 1. Average of the intensity of LEMF in all months of each year.

To determine the most reliable period of grouping and not to miss the delay effect of LEMF, all AMI cases were grouped daily, by three days, seven days and monthly. Daily grouping does not include the three-day period which is determined as the optimal delay effect period, therefore grouping by three and seven days are more reliable. Nevertheless, monthly grouping produces the highest significance, but it may be influenced by seasonal changes stronger than the weekly ones. To miss as less as possible impact of LEMF action, it was decided to group all cases weekly, therefore further analyses will be given accordingly. Seasonal fluctuations of LEMF and AMI are shown in Figure 2.

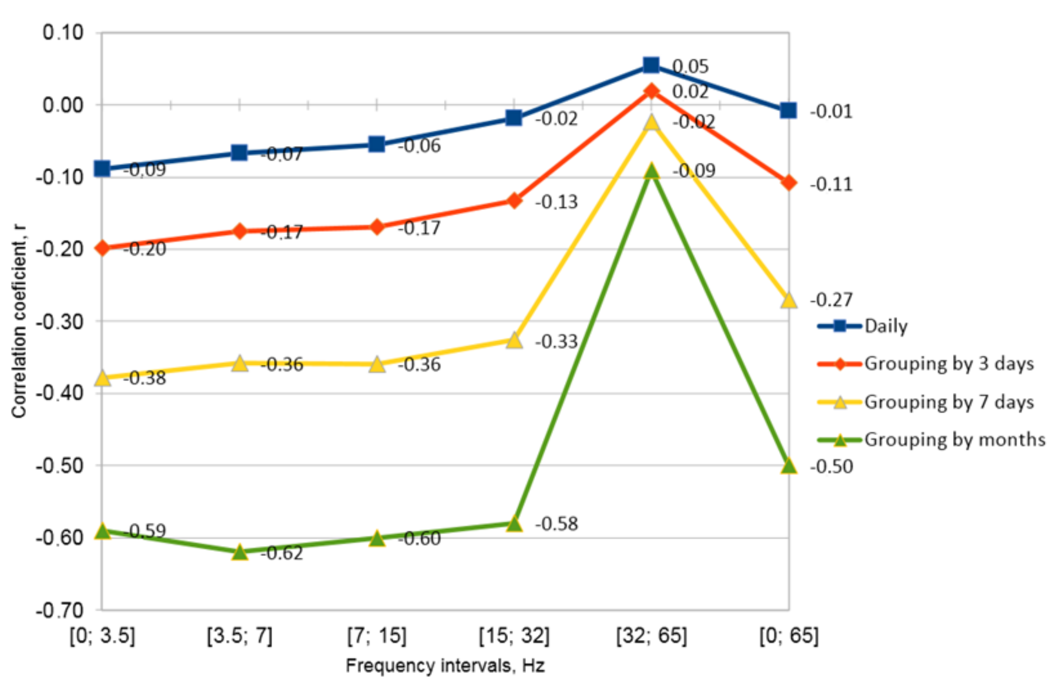

Figure 2. Correlation between EW orientation LEMF and AMI calculating in various groups of averaging.

The statistical analysis was performed using the software package SPSS 20.0. Pearson correlation coefficient for the linear correlation between two variables was calculated. The level of p < 0,05 was considered as statistically significant.

3. Results

Of all, 18379 (58.9%) patients were male and 12841 (41.1%) were female. In average 504 patients were admitted to Lithuanian hospitals due to AMI monthly.

Significant correlations between weekly admissions of AMI cases and the weekly LEMF strength in five frequency ranges and in total range was found. Further results will be given in certain frequency ranges.

3.1. 0-3,5 Hz (SDelta) Ran

A negative correlation coefficient (r = - 0.47, p = 0.017) between AMI cases in female and LEMF in 0-3.5 Hz frequency range (SDelta) was found in the first half year of 2016. Even stronger correlations remain in the second half of 2016 (r = - 0.625, p = 0.001) and in the second half year of 2018 (r = - 0.519, p = 0.006). Negative correlation was observed in male group only in the second half year of 2018 (r = - 0.388, p = 0.046). A stronger negative correlation between AMI and LEMF was observed in the total group when comparing male and female groups separately. Strong negative correlation between AMI in total group and this range was observed in the second half year of 2016 (r = - 0.692, p = 0.000) and in the second half year of 2018 (r = - 0.567, p = 0.002), they are presented in Figure 3.

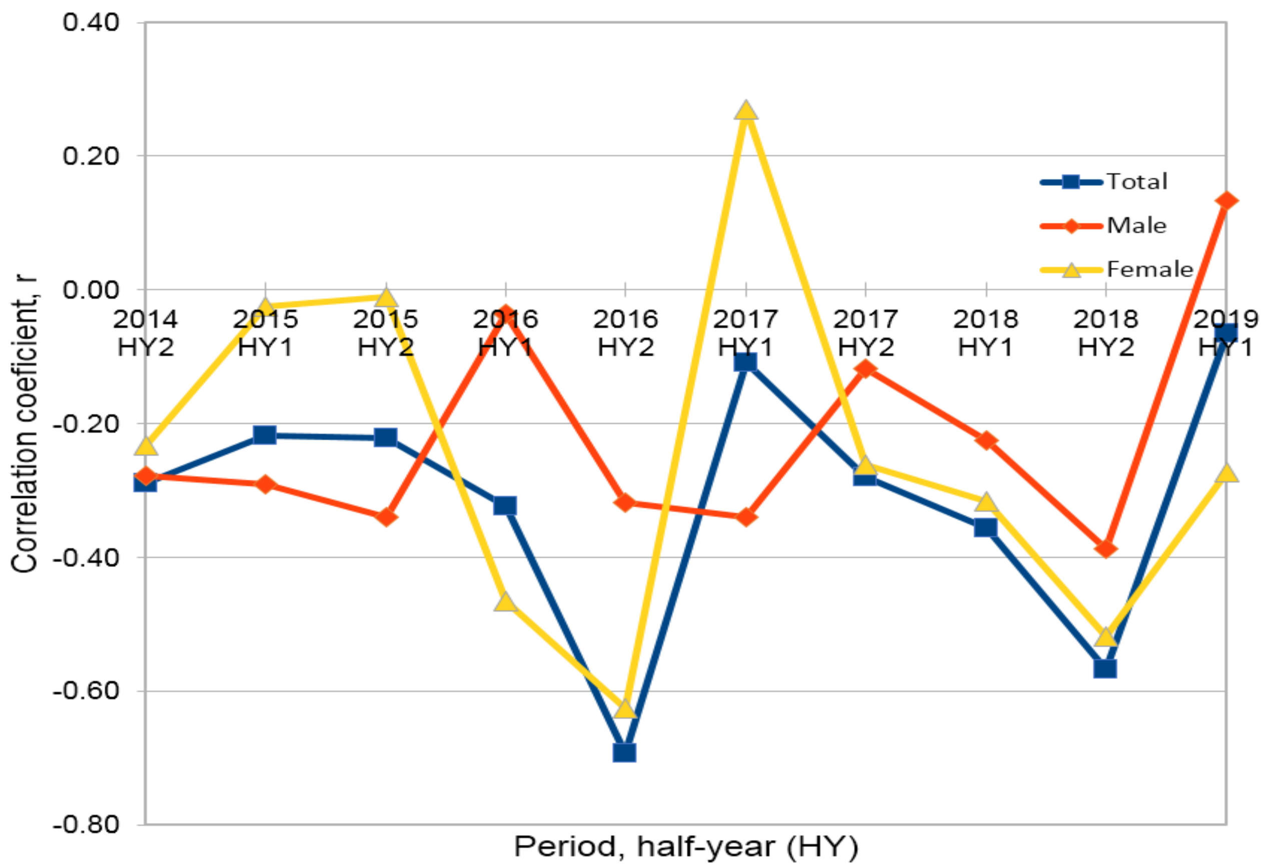

Figure 3. Fluctuations of correlation coefficient between 0-3,5 Hz (SDelta) LEMF and AMI for each gender in different periods.

Summarizing the effect of the SDelta frequency range and its prevailing negative correlations with AMI cases, might be said that stronger LEMF in 0-3.5 Hz is associated with lower number of AMI cases in both males and females. Even more, its significance were stronger form females. Therefore, this range can be accepted as having a positive effect on people with predominant ischaemic heart disease (IHD).

3.2. 3,5-7Hz (STheta) Range

A negative correlation coefficient (r = - 0.478, p = 0.013) between AMI cases in female and LEMF in 3.5-7 Hz frequency range (STheta) was found in the first half year of 2016 and remained through the second half year of 2016 (r = - 0.513, p = 0.007) and the second half year of 2018 (r = - 0.481, p = 0.011). A single negative correlation in male group was observed in the second half year of 2016 (r = - 0.449, p = 0.021). A stronger negative correlation between AMI and LEMF was observed in the whole group compared to male and female groups separately. Strong negative correlation between AMI in whole group and this range was observed in the second half year of 2016 (r = - 0.701, p < 0.000) and in the second half year of 2018 (r = - 0.505, p = 0.007).

Finally, correlation coefficients in 3.5-7 Hz (STheta) frequency range were more significant in female group and in whole study population compared to male group, especially in the second half of 2016 and 2018 year. These results suggest that STheta frequency range as well as SDelta frequency range has a positive effect on humans' with IHD and may be protecting against AMI.

3.3. 7-15 Hz (SAlpha) Range

A negative correlation coefficient (r = - 0.431, p = 0.028) between AMI cases in female and LEMF in 7-15 Hz frequency range (SAlpha) was found in the first half year of 2016 and remained through the second half year of 2016 (r = - 0.543, p = 0.004), the second half year of 2017 (r = - 0.395, p = 0.041) and the second half year of 2018 (r = - 0.507, p = 0.007). A single negative correlation in male group was observed in the second half year of 2016 (r

= - 0.461, p = 0.018). A stronger negative correlation between AMI and LEMF was observed in the whole study population compared to male and female groups separately. Strong negative correlation between AMI in whole study population and this range was observed in the second half year of 2016 (r = - 0.732, p < 0.000), second half year of 2017 (r = - 0.391, p = 0.044) and the second half year of 2018 (r = - 0.545, p = 0.003).

Summarizing, correlation coefficient in 7-15 Hz (SAlpha) frequency range was more significant for women and in general population, especially in the second half of 2016 and 2018 year. This, as well as SDelta and STheta frequency ranges, is associated with less AMI cases in Lithuanian patients.

3.4. 15-32 Hz (SBeta) Range

A negative correlation coefficient (r = - 0.436, p = 0.026) between AMI cases in female and LEMF in 15-32 Hz frequency range (SBeta) was observed in the first half year of 2016 and remained through the second half year of 2016 (r = - 0.502, p = 0.009), the second half year of 2017 (r = - 0.410, p = 0.033) and the second half year of 2018 (r = - 0.431, p = 0.025). A single negative correlation was observed in male group in the second half year of 2016 (r = - 0.481, p = 0.013). A stronger negative correlation between AMI and LEMF was observed in the whole study population compared to male and female groups separately. Strong negative correlation between AMI in total group and this range was observed in the second half year of 2016 (r = - 0.715, p = 0.000), negative correlation was observed in the second half year of 2017 (r = - 0.388, p = 0.046) and in the second half year of 2018 (r = - 0.484, p = 0.010).

In summary, correlation coefficient between AMI and LEMF in 15-32 Hz (SBeta) frequency range was more significant in women and in general study population, especially in the second half of 2016 and 2018 year.

Summarizing, all these frequency ranges might be called low frequency range as all these effect on human cardiovascular system is quite similar. Increased their intensity significantly correlates with less admission due to AMI in all Lithuanian patients.

3.5. 32-65 Hz (SGamma) Range

Slightly different trends of correlations were found in SGamma frequency range. This range is known for its positive correlation coefficients with AMI cases. The first positive correlation coefficients (r = 0.410, p = 0.038) were found through the first half year of 2016 in whole study population and through the first half year of 2018 (r = 0.417, p = 0.038) in female group. A negative correlation between AMI and LEMF was observed only in the whole study population through the second half year of 2016 (r = - 0.467, p = 0.016) which compared to general view seems rather an exception from the rule. That are shown in Figure 4.

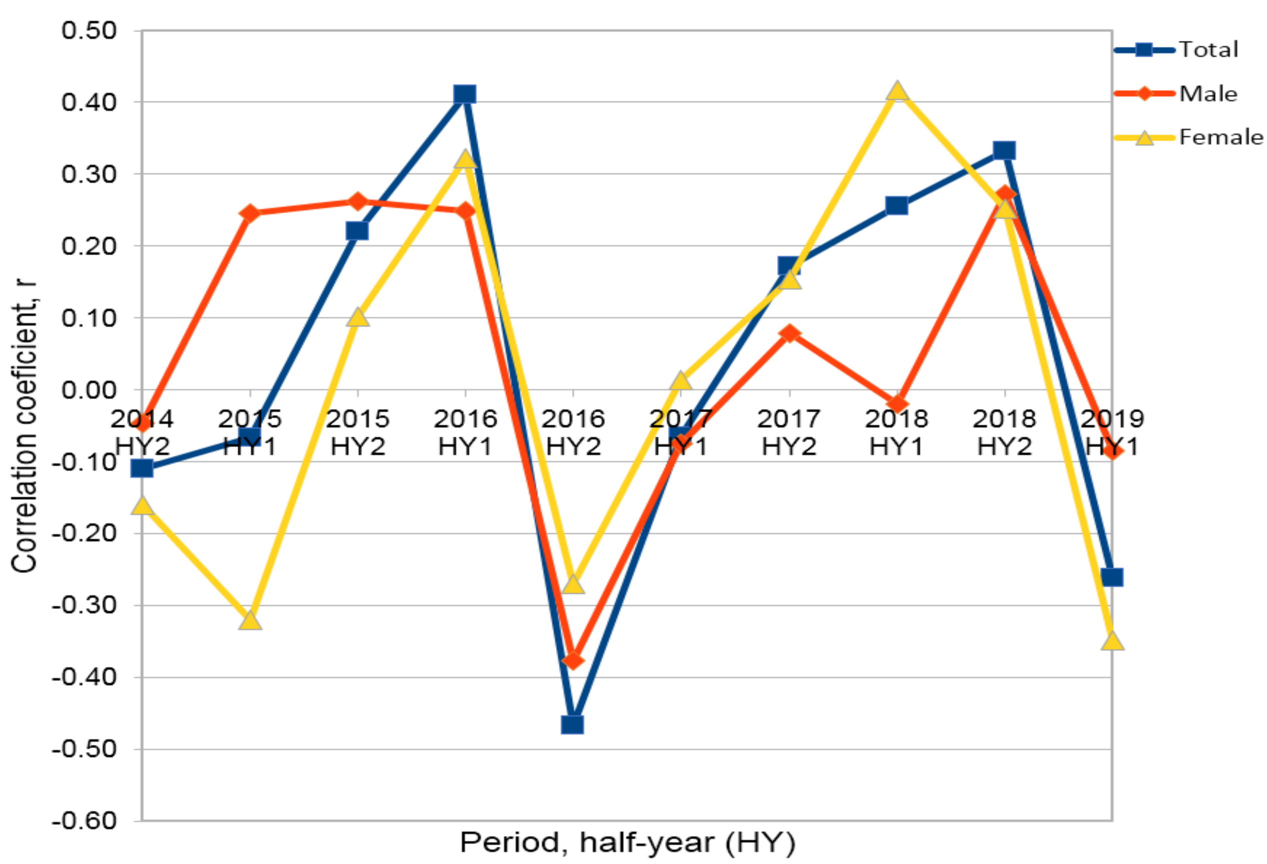

Figure 4. Fluctuations of correlation coefficient between 32-65 Hz (SGamma) LEMF and AMI for each gender in different periods.

SGamma rage is the only range were positive correlation between AMI and LEMF was identified. This let assume that this frequency range is significantly associated with negative outcomes for people with predominant IHD.

3.6. Comparison of Range's Effects in Half-Years

Correlation between the number of AMI and intensity of LEMF was different not only in various frequency ranges but it was also diverse in the first and the second half year, besides they are different in every year. In order to establish a consistent pattern of LEFM we calculated correlations separately in the first and in the second half of the year. Results are presented in Table 1.

Table 1. Correlation coefficients between each range of LEMF and AMI in first and second half year. Ratio of the half-year average correlation coefficient.

Magnetic field intensity range	Group	HY1					HY2					HY1/HY2
0-3.5 Hz	Total	-0.22	-0.32	-0.11	-0.36	-0.06	-0.29	-0.22	-0.69**	-0.28	-0.57**	1.92
	Male	-0.29	-0.04	-0.34	-0.22	0.13	-0.28	-0.34	-0.32	-0.12	-0.39*	1.90
	Female	-0.02	-0.47*	0.27	-0.32	-0.27	-0.23	-0.01	-0.63**	-0.26	-0.52**	2.04
3.5-7 Hz	Total	-0.20	-0.35	-0.12	-0.23	-0.07	-0.32	-0.22	-0.70**	-0.33	-0.51**	2.14
	Male	-0.26	-0.06	-0.39	-0.12	0.14	-0.24	-0.32	-0.45*	-0.12	-0.33	2.10
	Female	-0.03	-0.48*	0.31	-0.24	-0.29	-0.35	-0.03	-0.51**	-0.33	-0.48*	2.39
7-15 Hz	Total	-0.19	-0.26	-0.08	-0.17	-0.08	-0.26	-0.24	-0.73**	-0.39*	-0.55**	2.77
	Male	-0.34	0.01	-0.30	-0.09	0.13	-0.20	-0.31	-0.46*	-0.14	-0.36	2.50
	Female	0.06	-0.43*	0.26	-0.17	-0.29	-0.26	-0.07	-0.54**	-0.40*	-0.51**	3.09
15-32 Hz	Total	-0.17	-0.23	-0.11	-0.13	-0.14	-0.24	-0.22	-0.72**	-0.39*	-0.48*	2.63
	Male	-0.26	0.05	-0.32	-0.08	0.06	-0.16	-0.33	-0.48*	-0.12	-0.34	2.63
	Female	0.01	-0.44*	0.24	-0.12	-0.31	-0.27	-0.03	-0.50**	-0.41*	-0.43*	2.67
32-65 Hz	Total	-0.07	0.41*	-0.06	0.26	-0.26	-0.11	0.22	-0.47*	0.17	0.33	0.55
	Male	0.25	0.25	-0.07	-0.02	-0.08	-0.05	0.26	-0.38	0.08	0.27	0.60
	Female	-0.32	0.32	0.01	0.42*	-0.35	-0.16	0.10	-0.27	0.15	0.25	0.94
Year		2015	2016	2017	2018	2019	2014	2015	2016	2017	2018	

Note:
** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

In our study a clear trend was observed: in the second half-year correlation coefficients in all the ranges of 0-32 Hz are negative in total group, male and female groups. It means LEMF of 0-32 Hz has protective action for AMI. This tendency is not so clear for 32-65 Hz (SGamma) range.

Different effect of LEMF on AMI in the second half-year than in the first one. The ratio of the half-year average correlation coefficients shows correlation in the second-half year are 1.90-3.09 stronger than in the first one. This trend was not observed in SGamma range.

4. Discussions

We represent the first such numerous study focused on morbidity of AMI in Lithuanian population within the period of five years. In consistence with previous studies, our data showed that higher intensity LEMF in low frequency ranges is associated with improved cardiovascular health [34].

In the first half of the year, as in summer, the axis of the northern hemisphere of the earth is tilted to the sun more. At that time, solar wind is stronger as the main determinant of LEMF. At that time the solar wind as the main determinant of LEMF is stronger. Stronger solar wind leads to stronger LEMF in all ranges, possibly resulting in post-exposure AMI, although the action of different ranges of LEMF is different.

Jarusevicius et al. have proved that stronger magnetic field in low frequency range is associated with lower number of weekly hospital admissions due to ST elevation myocardial infarction (STEMI) [28]. Even more, similar results have been repeatedly shown in other study investigating the relation between weekly accidents of unstable angina and changes in the LEMF intensity in five frequency ranges [29].

This is the first study with such deep focus on different frequency ranges of LEMF and their associations to certain cardiovascular disease. In contrary to physics, where low frequency range is described as the range between 0 and 300 Hz, in biophysics and biomedicine the low frequency range does not extend the 15 Hz. Nevertheless, the positive effect of ultra-low-frequency-range (0-0.02 Hz) on endothelium function has been found couple years ago [35], therefore, strong negative correlations in extremely low frequency range (0-3.5Hz and 3.5-7Hz) in our study might be explained by this phenomena. It is interesting, that with increasing range of the LEMF, the correlations get a little bit weaker. Most probably, due to weaken positive effect on cardiovascular system.

In Europe, the electric power network works on average 50 Hz frequency range [32]. It is normal, that in Schumann resonance spectrum, this is the leading intensity of LEMF in our country. Nevertheless, exactly this range has been proved to be associated with negative cardiovascular events especially ischemic ones [28, 29]. Moreover, most magnetic storms are associated with the diapason of LEMF frequencies between 32 and 65 Hz [35]. Therefore, any geomagnetic storm may result in increased morbidity of AMI. Not surprisingly, the effect of magnetic storms has been repeatedly proved by various scientists globally. One of the strongest evidence has been collected in Russia's laboratories [35]. Zenchenko, et al. [35] have found that in presence of magnetic storm, the capillary blood flow significantly reduces, as well as significant reduction in arterial blood flow which might be directly correlated with occurrences of AMI and acute cerebrovascular ischaemias [35]. Moreover, certain effects of LEMF fluctuations on cell proliferation and gene expressions have been proposed in past decade Lee, et al. [34]. In Lee, et al. [34] study was found that under stronger magnetic field in 30-60Hz frequency range, the cells' normal cycles are inhibited and those small, but significant circle delays may result in increased cell proliferation but do not induce cell death what all together may result in neoplasms [34].

5. Limitations

This study has some limitations. Patients who were diagnosed with AMI and were hospitalized in Lithuanian hospitals were included in the study. Patients who were diagnosed with AMI but who were not hospitalized - were not included to the study, but some patients had AMI at home and did not receive medical attention, so the amount of AMI may not be complete.

In such cases, if a sudden death (even AMI) occurs at home and the patient is not able to be hospitalized - such patients were not included to the study.

6. Conclusions

1. A clear negative correlation was observed between cases of AMI in female group and LEMF frequency ranges: SDelta, STheta, Salpha and Sbeta.
2. Correlation coeficients between cases of AMI in female group and LEMF frequency ranges Sdelta, STheta, SAlpha, SBeta are similar. Correlation coeficients between cases of AMI in total group and LEMF frequency ranges SDelta, STheta, SAlpha, SBeta are similar.
3. A negative correlation between cases of AMI in male group and the same LEMF frequency ranges are also obvious.
4. Due to the larger number of subjects, even stronger correlations is observed in the overall sample.
5. In the second half of the year the number of AMI is lower, therefore negative correlations between SDelta, STheta, SAlpha and SBeta ranges are stronger than in the first one. This is particularly noticeable in 2016 and 2018 years.
6. Interestingly, the LEMF SGamma range had a statistically significant positive correlation between female morbidity due to AMI in the first half year of 2016, but correlation was significantly negative in the second half of that year.

It is obvious correlation between morbidity of AMI and LEMF. LEMF in frequency ranges 0-32 Hz have positive impact on human health and may act protectively. High frequency range (32-65 Hz) has significantly negative effect on IHD provoking AMI and may lead to worser outcomes.

Nomenclature:
AMI Acute myocardial infarction.
LEMF Local Earth magnetic field.
GS Geomagnetic storms.
HRV Heart rhythm variability.
EEG Electroencefalogram.
IHD Ischemic heart disease.

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