Correlations between severity of coronary artery disease in patients diagnosed with Acute Coronary Syndrome and changes in local earth magnetic field

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Abstract

The study was aimed to identify the relations between the severity of coronary artery disease and associated percutaneous coronary interventions with the changes in the local Earth magnetic field activity (LEMF). One-thousand-two-hundred-forty patients diagnosed with Acute coronary syndrome who underwent percutaneous coronary intervention within 2015-2016 were retrospectively included in this single centre study. The majority of acute coronary syndromes that occurred in females was associated with an increase in LEMF intensity in 3.5-32 Hz frequency ranges and were also associated with a higher number of diseased coronary arteries. Increased intensity in the same range was associated with a lower number of stented coronary arteries in males in 2015. Positive correlation coefficients were found between increased LEMF intensity in the 0-15 Hz range and the number of revascularized coronary arteries in females during the winter season in 2016. Stronger LEMF in low-medium frequency ranges is associated with acute coronary syndromes in males caused by less diffuse coronary artery disease resulting in lower number of coronary arteries segments needed for revascularisation, especially during winter. Stronger LEMF in high frequency range is associated with increased occurrence of ischaemic cardiovascular events, while stronger LEMF in low to moderate frequency ranges is associated with positive effect.

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Key Points:

- Stronger local earth magnetic field in high frequency range is associated with increased occurrence of ischaemic cardiovascular.
- Stronger local earth magnetic field in low to moderate frequency ranges are associated with positive effects.
- Similar intensity in the same frequency range may have a completely different effect on living organisms during different seasons.

Abstract

The study was aimed to identify the relations between the severity of coronary artery disease and associated percutaneous coronary interventions with the changes in the local Earth magnetic field activity (LEMF). One-thousand-two-hundred-forty patients diagnosed with Acute coronary syndrome who underwent percutaneous coronary intervention within 2015-2016 were retrospectively included in this single centre study. The majority of acute coronary syndromes that occurred in females was associated with an increase in LEMF intensity in 3.5-32 Hz frequency ranges and were also associated with a higher number of diseased coronary arteries. Increased intensity in the same range was associated with a lower number of stented coronary arteries in males in 2015. Positive correlation coefficients were found between increased LEMF intensity in the 0-15 Hz range and the number of revascularized coronary arteries in females during the winter season in 2016. Stronger LEMF in low-medium frequency ranges is associated with acute coronary syndromes in males caused by less diffuse coronary artery disease resulting in lower number of coronary arteries segments needed for revascularisation, especially during winter. Stronger LEMF in high frequency range is associated with increased occurrence of ischaemic cardiovascular events, while stronger LEMF in low to moderate frequency ranges is associated with positive effect.

Plain Language Summary

Relation between space wearther parameters and humans health has been recognized long ago. Since then, it became an issue for detailed researches worldwide. Nevertheless, there are just several laboratories all over the Globe able to analyse certain space weather parameters including local Earth Magnetic field. This is one of the first publication presenting certain interactions between deterioration of ishaemic heart disease and changes in the local Earth magnetic field. This a numerous study, analysing data of 1240 patients, who have had a myocardial infaction showing independency between myocardial infarction and magnetic field changes. Even more, it was identified which range of magnetic field spectrum is the most associated with heart disease impairment. It is the range between 32 and 65 which is described as high frequency range magnetic field. One more interesting thing was recognized, the studie showed that the increased intensity of magnetic field in the same frequency ranges during different season may cause completely different results. Summarising, it might be said that high frequency range (32-65 Hz) is associated with worser course of ischaemic heart disease, while stronger magnetic field in low frequency range especially up to 15 Hz may have benefits fur heart health.

1. Introduction

Rates of morbidity and mortality due to ischaemic heart disease (IHD) have increased over past decades in the aging population (Nowbar et al., 2019; *WHO | Disease Burden and Mortality Estimates*, n.d.) Eventually, the majority of IHD cases manifest as an acute coronary syndrome (ACS) (Deedwania, 1991); therefore, the prevalence of percutaneous coronary interventions (PCIs) as a pathogenic treatment of the disease increases globally (Jennings et al., 2014). IHD has been studied for years and the ordinary risk factors have been confirmed many times (Mulle & Vaccarino, 2013; Vaccarino et al., 2007). Smoking, obesity, and sedative lifestyle are classic risk factors in ACS patients (Čeponiene et al., 2014). The mystery is healthy living young patients with any risk factor presented with extended acute myocardial infarction. Therefore, scientists begin to investigate possible changes in our environment including weather and space weather as risk factors in humans' illnesses (Claeys et al., 2015; Messner, 2005).

Lately, researchers have produced a growing body of evidence showing correlations between certain health problems and changes in our Environment. They found that certain changes may have a great impact on a person's daily behaviour, physical and mental health. Ambient temperature has been recognized as the most significant trigger for acute myocardial infarction (AMI) development (Dimitrova et al., 2009; Ozheredov et al., 2010; Vencloviene et al., 2017; Zenchenko et al., 2013). Claeys et al. found that with a temperature decrease of 10°C, the risk of AMI may increase by eight percent (Claeys et al., 2015). Accordingly, low temperature has been described as one of the most important environmental factor potentially leading to the development of AMI for the medium latitude population and that it might be more significant than physical and emotional stress (Claeys et al., 2015). German scientists have also found that an ambient temperature reduction of 10°C increases the risk of AMI by 10 percent within 5 days (Wolf et al., 2009). Interestingly, the risk of AMI development with temperature fluctuations is strongest in the summer months (Claeys et al., 2015). The influence of changes in ambient temperature on AMI development is one of the best-studied environmental risk factors (Claeys et al., 2015; Messner, 2005) but not the only one. Moreover, correlations between geomagnetic changes and cases of ACS and acute arrhythmias have been repeatedly shown (Gurfinkel et al., 2012; Stoupel, 2006). Surprisingly, both health disorders occur under increased local time-varying earth magnetic field (LEMF) strength in different frequency ranges: ACS is more likely to be provoked by increased LEMF in high frequency ranges while arrhythmias are more associated with increased LEMF activity in low frequency ranges (Jaruševičius et al., 2018; Žiubrytė, Jaruševičius, Jurjonaitė, et al., 2018; Žiubrytė, Jaruševičius, Landauskas, et al., 2018). Interestingly, the relationship between PCIs and changes in geomagnetic climate has not been previously investigated, therefore in this study, we aimed to identify the potential relationships between PCIs and changes in LEMF activity.

2. Materials and Methods

In total, 1,240 patients (813 males, age 65,85 ± 11,01; 427 females, age 73,35 ± 8,83) diagnosed with ACS who underwent PCI in our hospital between January 1, 2015, and December 31, 2016, were retrospectively included in this study. Except that the males were almost 7.5 years younger than females ($p < 0.001$), any other differences were not found between those two groups. All patients met the following inclusion criteria: 1) performed PCI, percutaneous transluminal coronary angioplasty (PTCA) or stenting, 2) stenosis of major coronary arteries over 75 percent or stenosis of left main artery over 50 percent, 3) increased blood troponin I (TnI) or T (TnT) level more than five times above the upper limit of normal and 4) clinical symptoms of myocardial ischemia. Patients, for whom PCI was not performed or the blood troponin was normal were excluded.

Males' and females' data (age, gender, number of diseased coronary artery and treated segments) were weekly averaged and summarised, and grouped into the 4-seasons (winter – December, January, February, spring – March, April, May, summer – June, July, August, autumn – September, October, and November) for analyses. Coronary artery angiograms (CAA) were analysed according to the American Heart Association's recommended fifteen segment schemes (Song et al., 2013).

The intensity of the time-varying LEMF intensity was measured by the Global Coherence Monitoring Network magnetometer located in Lithuania. The strength of the magnetic field was measured in two directions: north-south and east-west axis, but, according to Heart Math Institute scientists, the east-west direction has been chosen for current analyses, as more significantly affecting humans (Žiubrytė, Jaruševičius, Jurjonaitė, et al., 2018; Žiubrytė, Jaruševičius, Landauskas, et al., 2018). The 24-hour magnetometer signals sampled at 130 Hz have been transferred into an open access system. The average strength of MF has been calculated at 6 frequency ranges (Hz): 0-3.5 Hz; 3.5-7.0 Hz; 7.0-15.0 Hz; 15.0-32.0 Hz; 32.0-65.0 Hz and summed 0-65.0 Hz. 0-7 Hz frequency intervals were considered as low frequency LEMF; 7-32 Hz – as intermediate frequency LEMF and 32-65 Hz was considered as high frequency LEMF range.

The statistical analysis was performed using the software package SPSS 20.0. The nonparametric Mann-Whitney U test was used for the comparison of two independent samples. Pearson correlation coefficient was calculated for the linear correlation between the two variables. The relationship between two quantitative indices was considered weak if the correlation coefficient (r) was up to 0.3, moderate between 0.3 to 0.7, and strong if 0.7 or above. The chosen level of significance $p < 0.05$.

The study was approved by the local Ethical Committee (Approval No. BEC-MF-126 20).

3. Results

3.1. Correlations between number of diseased coronary arteries and changes in the local Earth magnetic field

Single-vessel coronary artery disease (CAD) was diagnosed for the majority of the patients, 505 (41%), two-vessel CAD was diagnosed for 362 patients (29%), and 367 (30%) patients were diagnosed with three-vessel CAD.

The analysis of correlations between the number of diseased coronary arteries (CAs) and the strength of LEMF in all frequency ranges showed a tendency of positive correlation coefficients or slightly negative correlation coefficients in females during winter, spring and summer seasons in 2015 and strong negative correlation coefficient in males (Figure 1) but the results were revered during the autumn-season of 2015 (Figure 1, d). It was suggested that with increasing strength of LEMF activity in all frequency ranges, males were more likely to be admitted due to ACS caused by less diffuse CAD, meaning that a smaller number of CAs were diseased. Even more, moderate negative correlations were found in the male group in the 0-3.5 Hz, 7-15 Hz, 15-32 Hz and 32-65 Hz frequency ranges ($r < -0.478$, $p < 0.048$) during the summer season. The Autumn-season has revealed essentially different results with tendencies towards positive correlations in males and negative correlations in females. The effect of LEMF activity in the autumn season appears to be different as compared to other seasons or maybe other variables had a larger impact during this period (Figure 1).

In the analyses of the 2016 year, moderate to strong positive correlations in both groups during the winter-season were found. With increasing LEMF intensity in the 3.5-7.0 Hz, 7.0-15 Hz and 15-32 Hz ranges, the majority of ACS occurred in females and were associated with more severely diseased CAs ($r = 0.567$, $p = 0.045$; $r = 0.620$, $p = 0.031$; $r = 0.726$, $p = 0.007$, respectively). Meanwhile, only one strong significant correlation was found in the male group in a moderate frequency range ($r = 0.530$, $p = 0.036$), indicating that ACS in males could be associated with less diseased CAs under prevailing LEMF in the range of 7-15 Hz (Figure 2, a).

The Spring season revealed weak positive to weak negative correlations in both groups (Figure 2, b). Meanwhile, the tendencies of weak positive correlations in males and weak negative correlations in females were found during the summer season (Figure 2, c). Similar results were observed during the autumn season except the 32-65 Hz range, where the single negative correlation coefficient appeared in males (Figure 2, d).

3.2. Correlations between the number of stented coronary arteries and the changes in the local Earth magnetic field

In the analysis of relationship between the number of stented CAs and the LEMF strength changes showed some interesting results. It was found that a higher LEMF intensity in 3.5-7 Hz, 7-15 Hz, and 15-32 Hz frequency ranges in 2015 was associated with a lower number of stented CAs in males during the winter season ($r < -0.819$, $p < 0.024$.), while females only had weak to moderate correlations (Figure 3, a). Both groups showed weak negative to weak positive correlations during the spring, summer, and autumn seasons (Figure 3).

Significant correlations during the winter and autumn seasons were observed in the analysis of 2016. Positive correlations ($r > 0.641$, $p < 0.025$) were found between increased LEMF activity in the 0-3.5 Hz, 3.5-7.0 Hz and 7-15 Hz ranges and the number of revascularized CAs in females during winter and autumn seasons (Figure 4, a, d). Only positive correlations were observed in males and negative correlations in females during the spring-season (Figure 4, b). Slightly different trends were observed in the summer season. Weak positive correlations were found in both groups (Figure 4, c). Compared to the winter-season, where positive correlations were found in both groups, the autumn-season revealed a slightly different trend as women showed moderate to strong negative correlations in the 0-3.5 Hz, 3.5-7 Hz, 7-15 Hz and 15-32 Hz ranges ($r < -0.536$, $p < 0.013$) (Figure 4, d). A higher number of CAs was revascularized when the LEMF activity was stronger in the low frequency ranges during the winter season of 2016 (Figure 4, a). Meanwhile the same LEMF changes were associated with a lower number of CAs revascularization during the autumn season (Figure 4, d).

3.3. Correlations between number of stented coronary artery segments and changes in the local Earth magnetic field

The approximate length of diseased CAs can be estimated by evaluating the number of stented CA segments; therefore, the study was supplemented by this analysis. It was found that a lower number of segments were stented under stronger LEMF activity in the 3.5-7Hz and 7-15Hz ranges in females during the winter season of 2015 ($r < -0.639$, $p < 0.039$) (Figure 5, a). The Summer and Autumn seasons of 2015 revealed negative correlations in both groups (Figure 5, c, d). Meanwhile, weak negative correlations in females in all frequency ranges and weak positive correlations in all except the 32-65Hz range in males was found during the spring season (Figure 5, b). Summarising, it was observed that stronger LEMF activity in the low frequency ranges is associated with a smaller number of stented CA segments during 2015.

The analysis of 2016 revealed more positive correlations in females during the winter and summer seasons (Figure 6, a, c). The stronger correlations were found in the 3.5-7 Hz frequency range during the winter season in females ($r = 0.572$, $p = 0.049$) (Figure 6, a). Interestingly, in the same frequency ranges, a moderate negative correlation was observed ($r = -0.509$, $p = 0.048$) in females, while positive correlations were detected in the male group during the spring season (Figure 6, b). The weak positive or very weak negative correlations were found in both groups during the summer season (Figure 6, c). Positive correlations were found in male group in all frequency ranges except the 32-65 Hz range and negative correlations in females in all frequency ranges during the autumn season (Figure 6, d). Inconsistently, the analyses of 2016 indicated that an increased number of percutaneously treated CA segments in patients admitted due to ACS was correlated with an increased LEMF intensity in all frequency ranges, except the 32-65 Hz range. A positive correlation between LEMF intensity and the number of revascularized CA segments was found in females during the spring and autumn seasons in 2016 (Figure 6, b, c).

4. Discussion

The analysis of correlations between ACS and changes in LEMF activity in specific frequency ranges is quite innovative in the field of geomagnetic and human health research. Moreover, associations between certain characteristic of ACS patients and severity of CAD has not been previously investigated, therefore this study adds new understanding to this field.

In 2010, Zenchenko et al. described that low frequencies have an influence on ischaemic processes in the heart (Zenchenko et al., 2010). Since then, scientists have begun to believe that IHD is caused not only by ordinary risk factors but the influence of the geomagnetic field as well (Elmas, 2016). It was found that self-function of endothelium is improved by fluctuations of geomagnetic field extremely low frequencies (0.01 to 0.02 Hz), which is the same frequency of endothelial vibrations (Zenchenko et al., 2010). The overlapping of endothelial and LEMF vibrations may improve its function, resulting in a reduction of atherogenesis and improvement of blood rheological characteristics (Žiubrytė, Jaruševičius, Jurjonaitė, et al., 2018). In agreement with previous studies focused on LEMF influence on weekly hospitalizations due to unstable angina pectoris and ST elevation myocardial infarction (Jaruševičius et al., 2018; Žiubrytė, Jaruševičius, Jurjonaitė, et al., 2018; Žiubrytė, Jaruševičius, Landauskas, et al., 2018) and correlations between ACS cases per week and increased LEMF strength in high frequency range, this study also found specific correlations between more diffuse CAD and increased LEMF activity in the high frequency range. This study strongly suggests that coronary arteries have less lesions when the intensity of LEMF is increased at low frequency ranges than higher ones. Otherwise, it could be interpreted that under prevailing LEMF in low frequency ranges, patients with less diseased coronary arteries are forced to refer to hospital. Additionally, it might be that increased LEMF in low frequency ranges, which are not characteristic to our region (here, the 32-65 Hz is the dominant LEFM frequency range), cause adaptative stress to people with less diseased CAs therefore they admit to hospital with subjectively severely deteriorated condition. Meanwhile, people with more diffuse CAD might be well adapted to their chronic disease that just an extremely strong external stress may severely disbalance their condition. In agreement with previous studies, we confirmed that a higher-intensity LEMF at high frequencies (32-65 Hz) negatively affects individuals with ischaemic heart disease, especially ones with severely diseased CAs (Alabdulgade et al., 2015; *Gender Differences In Circadian And Extra-Circadian Aspects Of Heart Rate Variability (HRV) | HeartMath Institute*, n.d.; *Global Coherence | HeartMath Institute*, n.d.; Gmitrov & Gmitrova, 2004; Jaruševičius et al., 2018; Žiubrytė, Jaruševičius, Landauskas, et al., 2018). Generally, it is accepted that GMF strength changes in different frequencies ranges have different influences on the human body: an increase in the low-frequency range is considered to be positive, while the high-frequency ranges are associated with increased health problems (Hardell, 2017; Jaruševičius et al., 2018; Von Mackensen et al., 2005) Nevertheless, currently, it is hard to interpret the positive correlations between the number of revascularized coronary arteries and stronger magnetic field activity in the low frequency ranges.

The LEMF activity is constantly changing. Its annual variations are repeatedly proved. According to Jarusevicius et al., the averaged monthly magnetic field was weakest in 2016 (89.98 pT2) and the strongest in 2017 (130.16 pT2). In agreement to previous studies (Jaruševičius et al., 2018; Žiubrytė, Jaruševičius, Jurjonaitė, et al., 2018; Žiubrytė, Jaruševičius, Landauskas, et al., 2018), seasonal dependability between LEMF strength fluctuations and cases of cardiovascular events has been confirmed in this study. It was observed that increasing intensity of LEMF at the same frequency ranges can lead to completely different effects in the same-gender. In addition, similar changes in LEMF at different times of the year can affect humans differently, therefore a wide complex of analysis models are necessary. Even more, it was observed, that living organisms have better tolerance to the strengthening of the magnetic field activity in the spring season than its weakening in autumn (Huss et al., 2018).

Nevertheless, individual differences and comorbidities in addition to climate zones cannot be excluded. It was noticed that about 50% of people, mostly over 60 years old, are more sensitive to climate changes which may affect their adaptive mechanisms and risk of cardiovascular events (*Gender Differences In Circadian And Extra-Circadian Aspects Of Heart Rate Variability (HRV) | HeartMath Institute*, n.d.). Certain changes in environmental parameters lead to activation of adaptive processes and changes in physiological reactions in healthy people, while the deficiency of adaptive mechanisms may lead to severe health problems (Messner, 2005). Moreover, the effects of environmental factors can be very weak in a healthy population, but much more expressed in patients with certain comorbidities. An investigation of the association between acute atrial fibrillation (AAF) episodes and changes in local magnetic field strength revealed a stronger association in groups of arterial hypertension (AH) patients (Žiubrytė, Jaruševičius, Jurjonaitė, et al., 2018). It was also observed that geomagnetic storms pose a risk of acute myocardial infarction (AMI) and stroke development (Vencloviene et al., 2017), while occurrences of cardiopulmonary resuscitations do not reveal a relationship with environment parameters (Alves et al., 2003). This suggests that not all diseases can be linked to changes in LEMF activity, while others might be strongly dependent. Scientists in Moscow (Villoresi et al., 1995) and St. Petersburg’s (Villoresi et al., 1998) have found a relation between ambulance calls for stroke and AMI and changes in GMF activity, however, the severity of emergencies was not evaluated. Meanwhile, studies conducted in the United States did not demonstrate similar correlation coefficients (Feinleib et al., 1975; Lipa et al., 1975). It has also been shown that that geomagnetic field strength changes’ impact on human health is dependent on their location in the world.

Despite its novelty, this study has certain limitations. We did not consider the direction and size of change of LEMF, therefore following the Gmitrov et al. findings, that endothelial function is more affected by change of the LEMF than the certain value (Gmitrov & Gmitrova, 2004) further studies are necessary. Also, the differences between different locations have not been evaluated, therefore further study is being planned.

5. Conclusion

Increased LEMF activity in high frequency ranges (32-65 Hz) appears to be associated with ACS in patients with less diseased coronary arteries. Stronger LEMF in low-medium frequency ranges is associated with ACS in males caused by less diffuse CAD resulting in lower number of CA segments needed for revascularisation, especially during winter. Additionally, shorter lesions were treated under predominance of low frequency ranges of LEMF. Generally, stronger LEMF in high frequency range is associated with increased occurrence of ischaemic cardiovascular events, while stronger LEMF in low to moderate frequency ranges are associated with positive effects. Nevertheless, the similar intensity of LEMF in the same frequency range may have a completely different effect on living organisms during different seasons.

Conflict of interest

The authors declare no conflicts of interest relevant to this study.

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Figure 1. Correlations between number of diseased Coronary Arteries and changes in LEMF activity during the 2015 year. (A – Winter season, B – Spring season, C – Summer season, D – Autumn season); * - p < 0.05

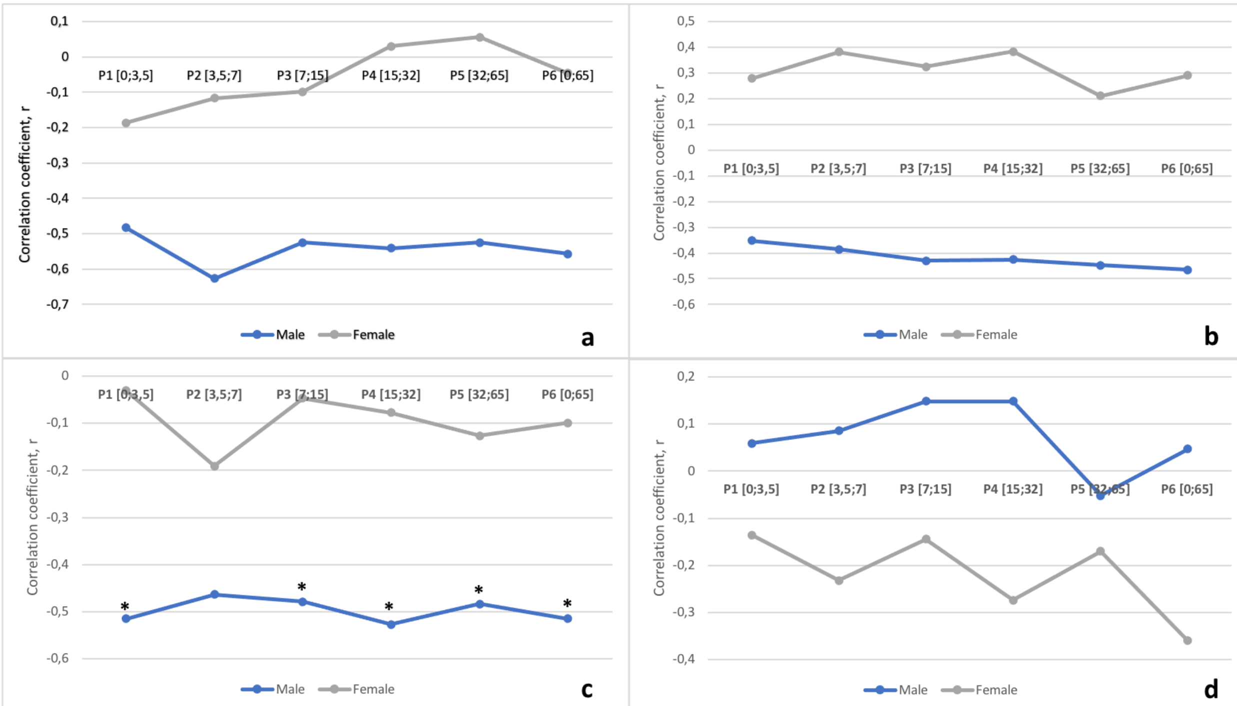

Figure 2. Correlations between number of diseased coronary arteries and changes in LEMF activity during the 2016 year. (A – Winter season, B – Spring season, C – Summer season, D – Autumn season); * - p < 0.05

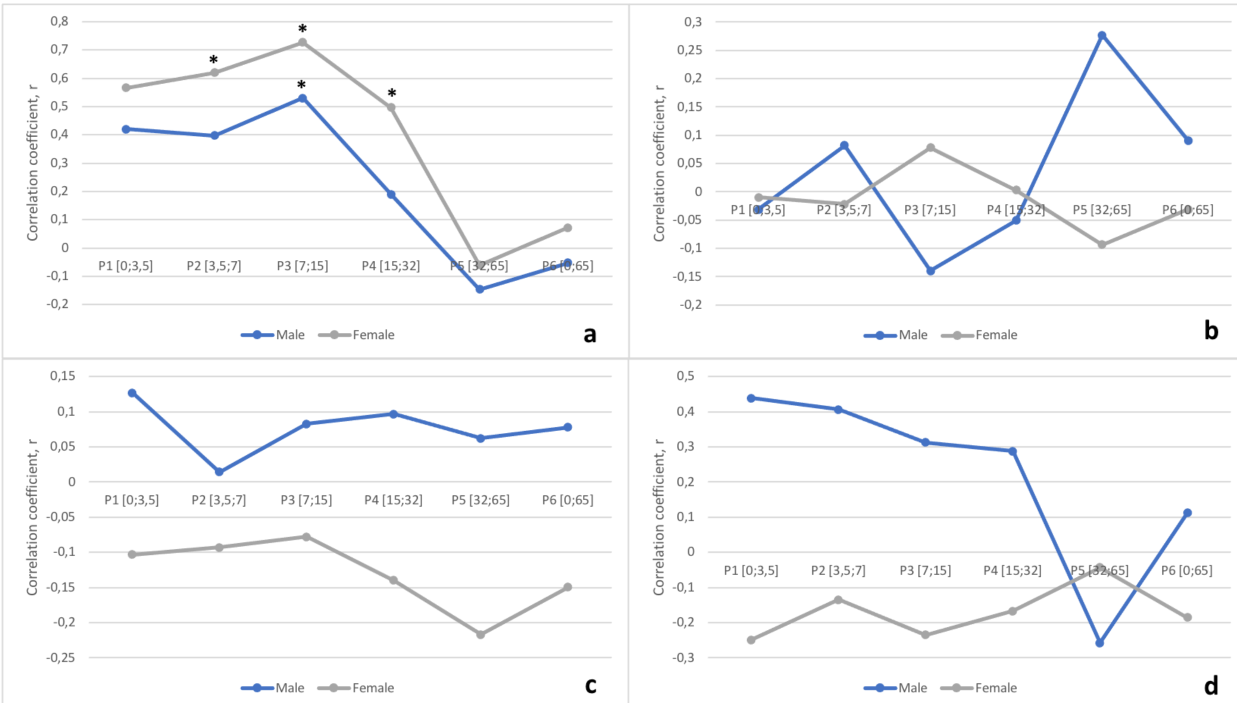

Figure 3. Correlations between number of stented Coronary arteries and changes in LEMF during the year of 2015. (A – Winter season, B – Spring season, C – Summer season, D – Autumn season); * - p < 0.05

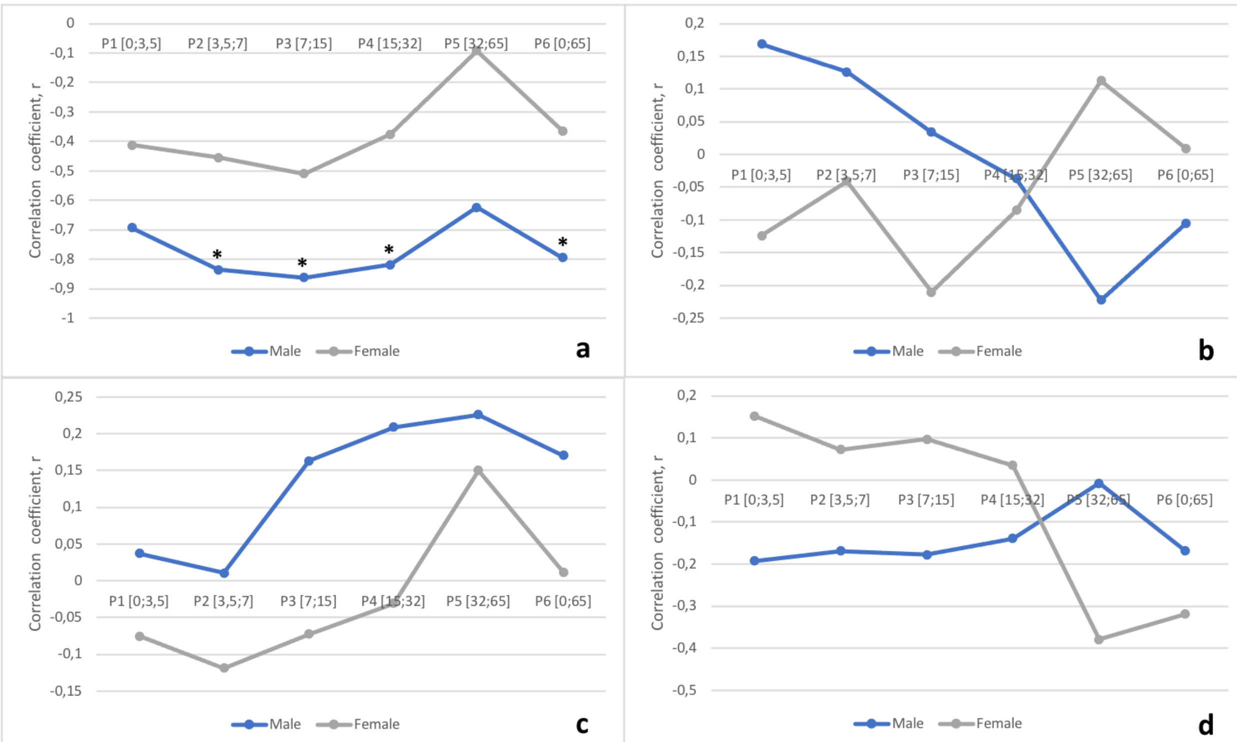

Figure 4. Correlations between number of stented Coronary arteries and changes in LEMF activity during the year of 2016. (A – Winter season, B – Spring season, C – Summer season, D – Autumn season); * - p < 0.05

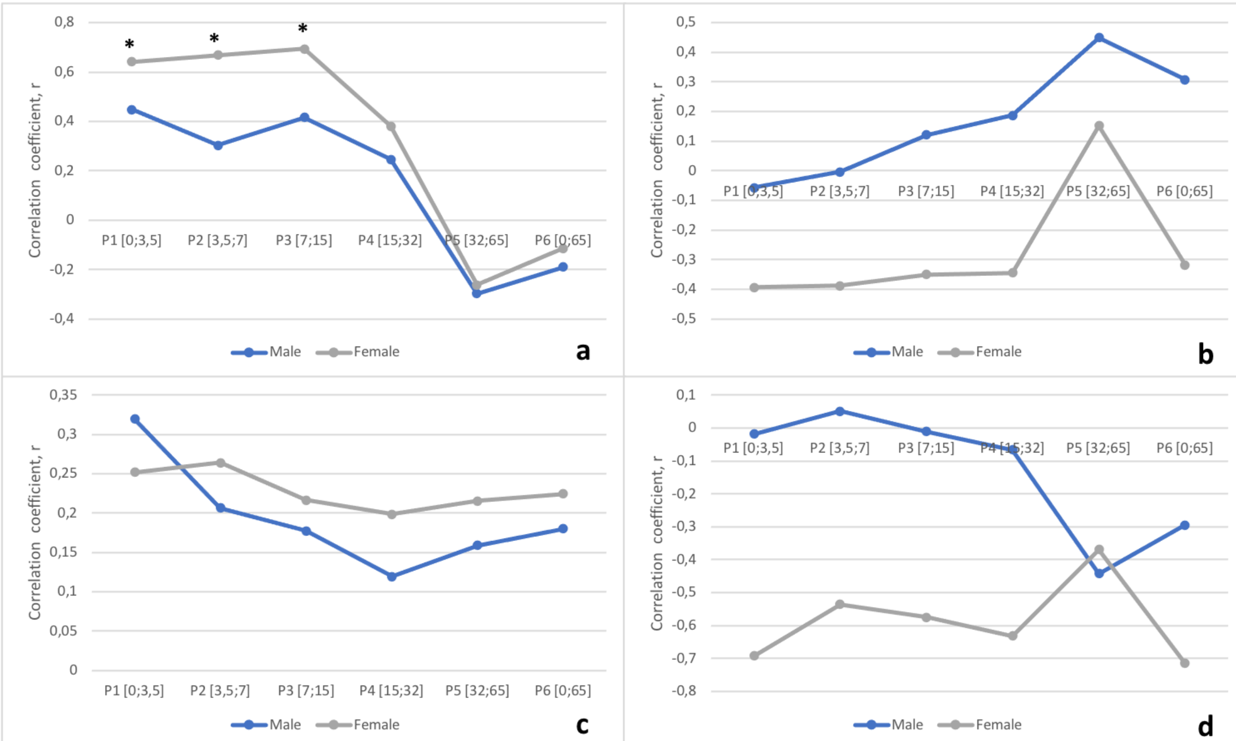

Figure 5. Correlations between number of stented segments of Coronary arteries and changes in LEMF activity during the year of 2015. (A – winter season, B – Spring season, C – Summer season, D – Autumn season); * - p < 0.05

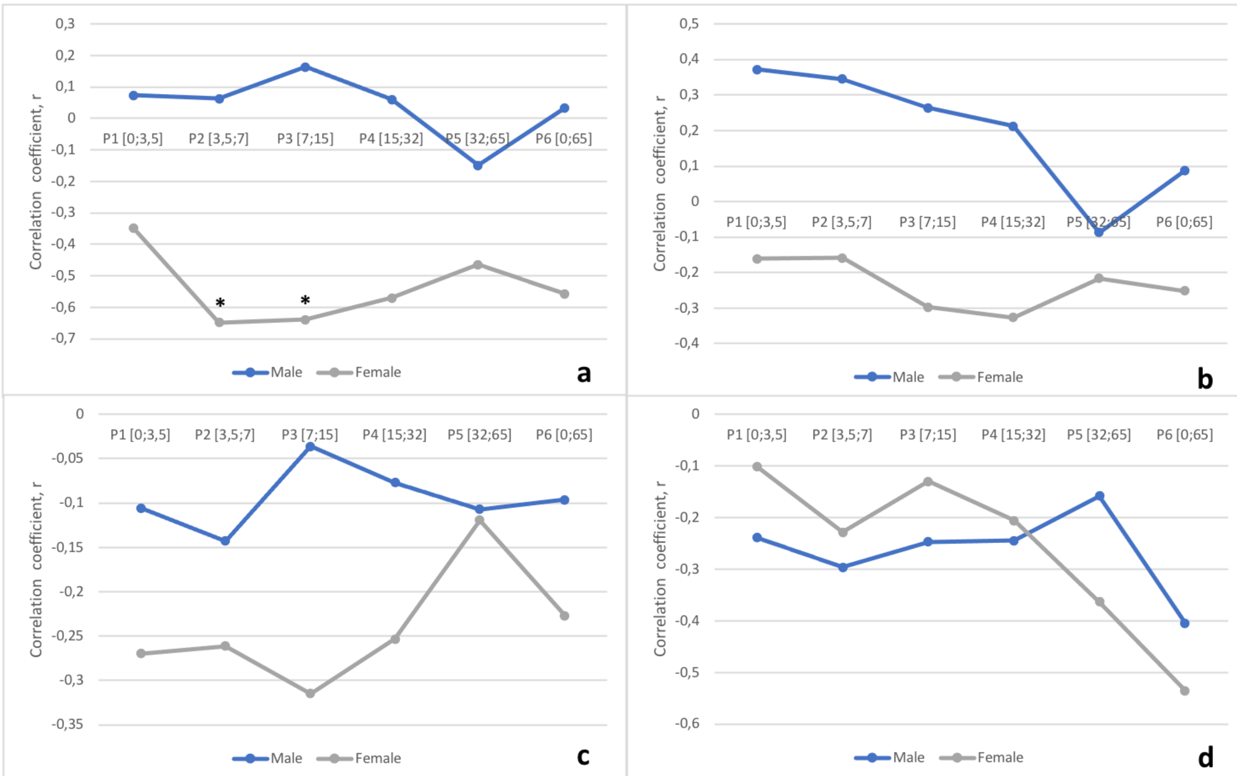

Figure 6. Correlations between number of stented segments of Coronary arteries and changes in LEMF activity during the year of 2016. (A – winter season, B – Spring season, C – Summer season, D – Autumn season); * - $p < 0.05$