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Analysis of cognitive changes based on EEG signals in third-trimester pregnant women – pilot study

Abstract *In women in the third trimester of pregnancy there are concentration disorders, which are associated with, among other things, an increase in hormones and changes in the EEG signal, especially in the 10-12Hz frequency range.*

Streszczenie *U kobiet w trzecim trymestrze ciąży występują problemy z koncentracją, które wynikają z różnych przyczyn m.in. zmian hormonalnych. Zmiany te są widoczne w sygnale EEG, zwłaszcza w przedziale 10—12Hz.* ***(Analiza zmian poznawczych na podstawie sygnałów EEG u kobiet w trzecim trymestrze ciąży - badanie pilotażowe)***

Keywords: EEG, third-trimester pregnant, signal analysis, cognitive changes

Słowa klucze: EEG, trzeci trymestr ciąży, analiza sygnałów, zmiany poznawcze
Keywords: EEG, signal analysis, third trimester pregnant

Introduction

Working memory and short-term memory determine our cognitive abilities and influence the quality of functioning and cognitive tasks. Research shows that in pregnant women cognitive processes can be reduced. Most likely, it is related to estrogen and progesterone, which has been proven by tests on mice during pregnancy[1,2,3]. Estrogen and progesterone are derivatives of steroid hormones. The amount of progesterone and estrogen increases in the subsequent months of pregnancy. In the literature, they are described as hormones affecting pregnancy and shaping secondary sexual characteristics. If pregnancy occurs, the level of progesterone in the body remains high, maintaining the lining of the uterus. If the pregnancy does not occur, the level of progesterone in the body decreases, resulting in menstruation. Progesterone binds to the progesterone receptor, which causes dissociation of heat shock proteins, receptor phosphorylation and activation of transcription through direct or indirect interaction with transcription factors. Progesterone exerts an estrogen-inhibiting action, reducing the number of estrogen receptors and increasing metabolism to inactive metabolites. Nuclear estrogen receptors have been found in the reproductive system, breast, pituitary gland, hypothalamus, liver and bones. The activated complex binds to the element of the estrogen response to DNA and activates the transcription of genes involved in the functioning of the female reproductive system and secondary sexual characteristics. The antagonistic effects of progesterone and estrogen are particularly evident in the last months of pregnancy[4,5,6].

Based on previous studies and based on literature, the association of these two hormones with cognitive changes seems most likely. Based on the obtained information from articles and research, markers of cognitive disorders related to working memory and short-term memory were created. Since the symptoms in pregnant women were the same as in the case of functional memory disorders, the developed method of markers for analysis was used. With reference to

articles suggesting the association of hormones with memory impairment in women, an EEG signal was tested to see if there are any changes in the EEG signal that confirm disorders in working memory.

Research conducted on pregnant women show the variability of the EEG signal recording depending on the stage of pregnancy. For example, NREM dreams have registered researchers to reduce delta and theta power, but increase beta-2 power from early to late pregnancy. On the other hand sex hormone fluctuations in the menstrual cycle have minimal effect on the alpha EEG response in the occipital and parietal region. In the follicular phase, small changes appear in the Alpha wave record along with the rise of the hormones etroidol and progesterone. [7-9].

Research part

A. Group in studies

For the purpose of the pilot study, a signal from three women in the third trimester in 30-35 years old and from three non-pregnant women in the 30-35 years old was pre-screened (N=6). All women from the control group (n = 3) did not report problems with concentration, did not take any drugs, without any chronic diseases. However, all pregnant women (n = 3) reported problems with concentration, difficulty of tasks, problems with remembering and reminding something.

B. Methods and Equipment

The method of measurement was the QEEG method. The signal was recorded at Fz, Cz, C3, C4 points based on the 10-20 system, which is commonly used with standard 19-channel EEG. The data was recorded in a frequency range of 1–-70 Hz. The sampling frequency was 250 Hz. The amplifier used for this study was a DigiTrack BF type digital electroencephalograph. After registering the signals, they were analysed using the modified periodogram method.

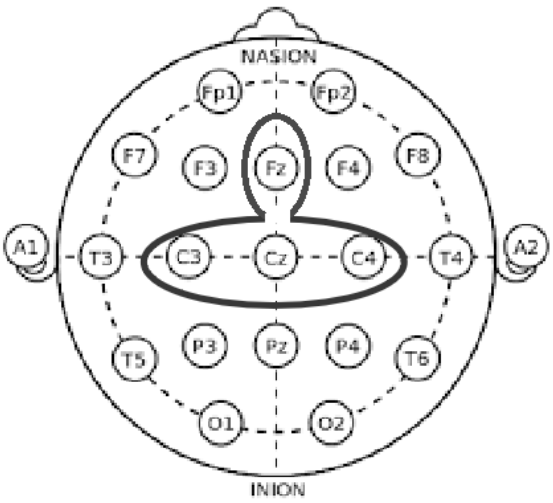

Fig. 1 10-20 system with marked measuring points.

Figure 1 shows the marked points from which the signal was measured. In the EEG signal, both as pregnant and non-pregnant women, no changes were recorded indicating problems such as with short-term memory. Only the artifacts triggered by, among others, muscle and eyes movement was recorded.

The modified periodogram of the modified periodogram, called the "Welch method", has been able to mathematically describe changes in the EEG signal in pregnant women. The mathematical description of the change characteristics was based on the coordinates of maxima and minima positions. Output is matrix: 4 lines and 7 columns. the lines are Fz, Cz, C3, C4 columns are frequencies; Delta, Theta, Alpha, SMR, Beta1, Beta2, Gamma. X and Y describe the coordinates of the periodogram. Figure 2 show example matrix. EEG signal was divided into the frequency ranges by following;

- Delta 0–4Hz
- Theta 4–8Hz
- Alpha 8–12Hz
- SMR 12–15Hz
- Beta1 15–20Hz
- Beta2 20–30Hz
- Gamma 30--40Hz

	Delta	Theta	Alpha	SMR	Beta1	Beta2	Gamma
Fz	0.1221	4.2725	10.2539	14.4043	17.9443	27.8320	34.1797
Cz	0.1221	4.3945	10.2539	14.0381	17.9443	26.9775	34.1797
C3	0.1221	4.3945	10.2539	13.6719	18.3105	26.7334	36.2549
C4	2.3193	4.2725	10.2539	14.1602	17.9443	26.9775	34.5459

Y =

	Delta	Theta	Alpha	SMR	Beta1	Beta2	Gamma
Fz	3.7147	3.3540	2.4438	-0.0284	3.1189	2.5477	1.2064
Cz	2.0254	2.8370	3.8038	-0.7568	3.2497	3.0025	0.7625
C3	2.7592	3.5266	4.2134	0.1747	1.5153	2.5887	2.1758
C4	2.7776	2.9616	3.9213	-0.4163	3.2182	2.6258	0.9812

Fig.2 An example matrix obtained for 4 measured points from PSD Welch analysis, containing coordinates maxim

Results and conclusion

In pregnant women for the Cz point and Fz, the Alpha frequency always in the analysis of the transform showed a value above 4.5 db. The so-called high Alpha in the 10-12Hz range was registered in all women surveyed. On the other hand, in non-pregnant women, even at high Alfie amplitude, more than 4.5 db were recorded. In addition, the Alpha frequency showed variability for the remaining measured points. In two people examined in 3 measured points, the Alpha was recorded below 4.5 dB in one of all measured points. Which indicates the lack of high alpha correlation with the height of the amplitudes. In women in the third trimester of pregnancy, the recorded values in Fz and Cz are characterized by a smaller divergence than in women in the control group.

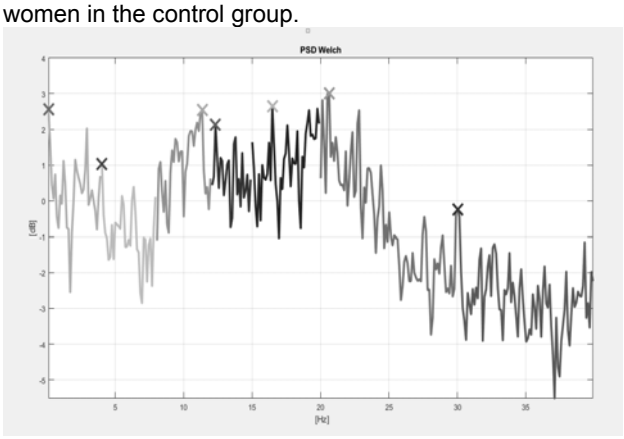

Fig. 3 Periodogram pregnant woman in third-trimester (n=1

Figures 3 -- 14 show periodograms for pregnant and non-pregnant woman and matrix. Table 1 shows the compiled parameters that show the results obtained for 10-12Hz frequency. Figure 15 shows Decision-making algorithm for indicating concentration disorders in women in the third trimester of pregnancy.

X =

3.9063	4.0283	11.3525	12.3291	19.7754	20.6299	30.0293
0.1221	4.0283	11.3525	12.3291	16.4795	20.6299	30.0293
1.2207	4.0283	11.3525	12.3291	19.0430	20.5078	39.9170
0.1221	4.0283	10.9863	12.5732	19.7754	22.7051	30.9404

Y =

2.8494	2.2692	3.5174	3.5074	2.9742	3.1377	0.7280
2.5641	1.0245	2.5439	2.1276	2.6468	3.0153	-0.2487
3.4872	1.5823	2.7977	2.8757	1.9622	2.5079	0.2448
10.7562	0.0750	1.0085	-0.3327	0.0326	0.4950	-0.1069

Fig. 4. Periodogram pregnant woman in thir-thrimester(n=1) The coordinate matrix of all measured points in a person n=1 with an Alpha frequency below 4 db marked with black square. Periodogram pregnant woman in third-trimester (n=2)

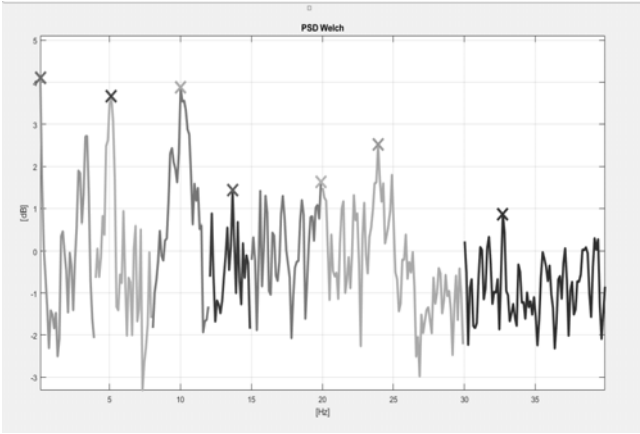

Fig. 5. Periodogram pregnant woman in third-trimester (n=2)

X =

0.1221	4.8828	10.0098	13.3057	15.6250	23.9258	32.7148
0.1221	5.1270	10.0098	13.6719	19.8975	23.9258	32.7148
2.9297	4.8828	10.6201	13.3057	17.2119	23.9258	30.1514
2.9297	4.7607	10.0098	14.7705	19.6533	24.9023	39.1846

Y =

3.5035	2.2860	4.2542	1.2522	1.4783	1.9859	0.8804
4.1126	3.6707	3.8753	1.4300	1.6275	2.5262	0.8647
2.2465	2.8360	5.0857	1.5910	1.1157	1.7276	1.7432
3.0029	1.8212	1.9232	-1.8413	1.0185	3.8470	3.2970

Fig. 6. The coordinate matrix of all measured points in a person n=1 with an Alpha frequency below 4 db marked with black square.

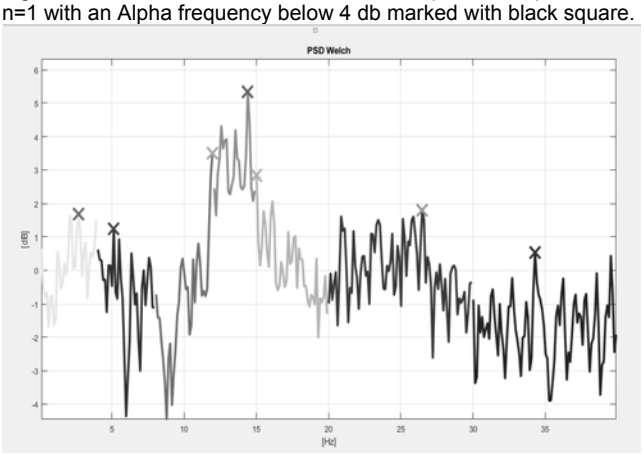

Fig. 7. Periodogram pregnant woman in third-trimester (n=3)

X =

0.1221	5.4932	11.9629	14.4043	15.0146	25.8789	38.5742
2.6855	5.1270	11.9629	14.4043	15.0146	26.4893	34.3018
0.1221	4.8828	11.9629	14.5264	19.8975	25.5127	39.9170
0.1221	7.5684	11.8408	12.8174	15.0146	24.5361	34.3018

Y =

1.8447	1.9242	3.8081	4.9047	2.5570	1.1000	0.9420
1.6893	1.2435	3.5057	5.3331	2.8377	1.8027	0.5350
11.2962	5.5451	4.8277	5.0982	3.5043	5.3300	4.4045
2.5827	1.8663	1.6487	3.3679	2.5494	1.5595	2.5309

Fig. 8. The coordinate matrix of all measured points in a person n = 3 with an Alpha frequency below 4 db marked with black square.

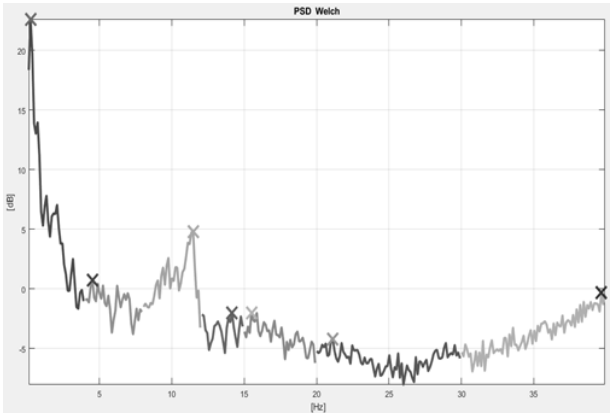

Fig. 9. . Periodogram non-pregnant woman (n=4)

X =

0.3662	6.5918	11.3525	12.0850	15.5029	22.7051	38.6963
0.2441	4.5166	11.4746	14.1602	15.5029	21.1182	39.6729
0.2441	6.7139	11.3525	12.0850	15.5029	22.5830	39.6729
2.0752	4.3945	11.4746	12.0850	15.8691	22.8271	38.9404

Y =

10.6229	0.9617	7.0297	-0.5633	-0.3879	-1.6098	-1.4019
22.6334	0.7405	4.8128	-2.0050	-1.9891	-4.2183	-0.3229
3.9223	-1.1993	11.1342	0.0761	-1.0880	-0.5465	-0.3672
4.6174	0.7604	7.6049	0.2463	0.0463	-2.2172	-0.1310

Fig. 10. Periodogram non-pregnant woman (n=4) The coordinate matrix of all measured points in a person n = 4

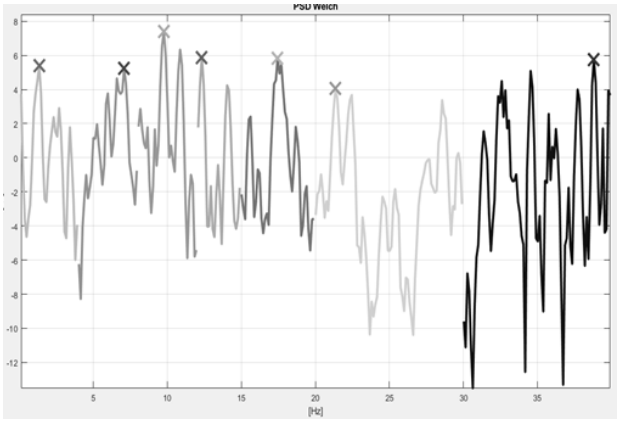

Fig. 11. Periodogram non-pregnant women (n=5)

X =

0.9766	5.1270	11.9629	12.0850	18.6768	27.7100	39.9170
1.3428	7.0801	9.7656	12.3291	17.4561	21.3623	38.8184
3.7842	6.4697	9.1553	14.4043	17.7002	23.9258	39.5508
3.6621	7.0801	10.4980	14.5264	15.1367	22.4609	38.4521

Y =

3.7450	5.1037	5.6283	6.0867	0.5914	3.2611	4.0174
5.3815	5.2395	7.4040	5.8687	5.8434	4.0630	5.7422
2.5657	5.1731	6.8238	3.2829	5.1874	5.8758	4.6601
6.4480	5.1417	2.9293	3.9161	3.3659	2.0243	2.6330

Fig. 12. The coordinate matrix of all measured points in a person (n =5)

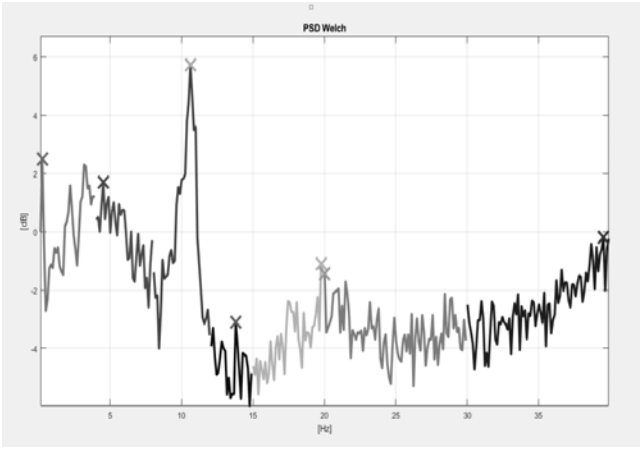

Fig. 13. Periodogram non-pregnant women (n=6)

X =

0.2441	5.1270	10.6201	12.2070	19.7754	20.0195	38.8184
0.2441	4.5166	10.6201	13.7939	19.7754	20.0195	39.5508
0.2441	5.1270	10.7422	12.2070	19.7754	21.6064	34.3018
0.2441	4.7607	10.6201	12.2070	19.8975	20.0195	39.0625

Y =

4.9956	1.3782	5.2381	-0.3990	0.6946	1.0611	-0.7918
2.4874	1.7037	5.7147	-3.0963	-1.1068	-1.4367	-0.1970
2.5765	0.3742	7.5435	-0.3505	1.6635	2.7738	1.4549
4.3133	1.2854	4.3712	-1.0624	0.3495	1.4125	-0.3338

Fig. 14. The coordinate matrix of all measured points in a person (n = 6)

Table 1. Table with the measured values for all women, channel Cz and Fz, the frequency of Alpha.

Chanel		Cz	Fz
Grope in studies		Alpha	
Pregnant women	n1	2,5439	3,5174
	n2	3,8753	4,2542
	n3	3,5057	3,8081
non-pregnant	n4	4.8128	7,0297
	n5	7,4040	5,6283
	n6	5,7147	5,2381

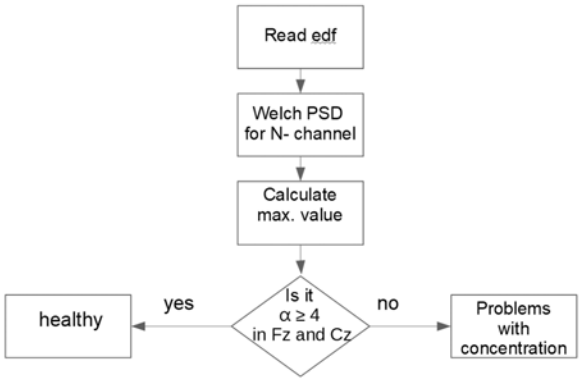

Fig.15. Decision-making algorithm for indicating concentration disorders in women in the third trimester of pregnancy

Future works

Recorded and described data indicate the regularity during pregnancy in the third trimester, describing the working memory disorders correlated with the physiological state of women. At a later stage of the work, it will be

necessary to study a larger group of women and refine the criteria, for example, the kilograms taken during pregnancy and more information about lifestyle.

The developed method and collected data are an initial part of the work to create an expert system for diagnostic purposes.

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