BASIC REGULARITY OF OSCILLATION OF CENTER OF PRESSUREБ COULD WE USE IT AT CLINICAL DECISION MAKING?

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1. Introduction

The body of an upright standing man performs oscillations around some middle position. These oscillations are well seen by investigation with stabilometric force platform. Traditionally these oscillations are regarded as function from time for coronal and frontal planes. Their 2D graph gives statokinesiogramm (sway path) – a projection of a trajectory of oscillations of the centre of pressure (CP) on horizontal plane. Analysis of the process of oscillation has great practical interest, as it reveals both physiological and pathological processes in the system of the control of body`s balance. There are different approaches to the analysis of the process of oscillations of CP in literature. The oscillations of CP in frontal and coronal planes are subjected to certain regularity, which is known as l\f noise. Subjection to this law of oscillations of CP is found at papers (Collins J.J., De Luca C.J. 1993; Maurer C., Peterka R.J. 2005).

As a matter of fact 1/f noise is known and reveals in different fields of techniques, physics and biological processes. This phenomenon represents basic pattern of behavior of any fluctuating system of biology and in techniques and at human also (Farrell S., Wagenmakers E.J., Ratcliff R.). These fluctuations characterize the dynamics of processes in physical, mechanics systems and living organisms.

General for all processes that proceed according to l\f law is that these systems have a lot of different elements. Those elements are able to accumulate energy and release it on reaching definite threshold. Standing and balanced human is that type of system. Balance condition of an upright standing human determines practically with help of reversed pendulum mechanical model (Gurfinkel V. S., Osevets M. 1972), which includes all joints, bones, chords, muscles and sinews. Besides, thorax and abdominal cavity internals, respiratory process (Bouisset S., Duchêne J.L., 1994; Hodges, P.W. et al. 2002) and heart functioning (Onell A., 2000; Pagnacco G., et all., 2001; Conforto S. et al., 2001) exert influence on balance. That is why, if there is no external or internal influence on this system, energy releases for providing balance process obey the l\f law.

However, the possibility of using that regularity of forming of oscillations of CP for clinical analysis remains unclear. This assignment is devoted to that attempt.

2. Patients and methods

2.1. Subjects

Groups of adult healthy persons and patients with deep right-side hemiparesis and frontier mental pathology took part in the investigation. Health adults – two groups with different feet placing were investigated. Feet placing with European standard (Gagey P.M., Weber B. 1995) and "feet together" position were used. The investigation for the group of patients with deep right-side hemiparesis was carried out in accordance with European standard.

Group with frontier mental pathology was investigated in "feet together" position. Full information about quantity, sex and age of the investigated groups is represented in table -1.

Table 1. Age, sex and quantity of the investigated groups.

Group	Total	Men	Women	Age
European placing	26	15	11	41 (9.5)*
Feet together	30	14	16	37.07 (1.56)
Right-side hemiparesis	54	33	21	44.0 (11.4)
Frontier mental pathology	30	14	16	37.0 (1.94)

* number inside () is standard deviation.

Healthy adults don`t have in anamnesis any injuries of lower extremities and vertebral column, consequences of neurologic illness, complicated with impellent defect or balance disorder, vision pathology that demands continual optical

correction or changing of fields of vision, consequences of middle ear illnesses and labyrinth acoustic or any craniocerebral injury were included in two first investigated groups of static stability with different feet placing. Lack of hereditary otoneurological illnesses of first-line relatives that can cause balance disorder was taken into consideration.

During the investigation of balance at standing position some investigated persons shows considerable asymmetry of position of CP, it's displacement in coronal plane or high amplitude of oscillations of CP. Those results were excluded from the investigation.

Patients with deep right-side hemiparesis at residual stage (54 persons) that had ischemia or hemorrhagic stroke as a cause of hemiparesis were included; 3 patients had craniocerebral trauma. Average time from stroke or head injury was 3 years. All the patients have circulation of the blood disturbance in the basin of the middle cerebral artery on the left. Patients have typical symptoms of the deep paresis, that is accompanied with Wernicke-Mann syndrome.

Criterions for patients with frontier mental pathology that were included into investigated group: age not more that 55 years; illness belonging to F41.1 class at ICD-10 – 12 patients (40%) with generalizational disturbed disorder and 18 patients (60%) with panic disorder F41.0 at ICD-10; lack of chronic somatic desease in the stage of acute condition, rough orthopedic and neurologic pathology, myopia of high

2.2. Task and procedure

Stabilometrical investigation of the groups was taken place directly at a day of admission to hospital before the beginning of course of treatment with help of «MBN-STABILO» posture investigation system created by MBN Company, Moscow, Russia. The Romberg's test was used. For the groups with feet placing according to european standard – hands along the trunk. Groups with "feet together" placing use complicated variant – hands are drawn out forward.

Registration of CP on the plane of support and its oscillations was taken during 51 second in each state – with eyes open (EO) eyes close (EC). European coordinate system (Gagey P.M., Weber B. 1995) was used at all investigations. Analysis of first three by size amplitudes of oscillation and their frequency at coronal and frontal planes were taken. The indication of parametres is the next: «X» и «Y» – are for oscillations in frontal and coronal planes accordingly; «f» - frequency of oscillations, «a» - amplitude of oscillations; numerals 1, 2 and 3 – numbers of oscillation`s amplitude.

2.3. Statistical analysis

Statistical analysis of results of the investigation was hold by methods of variation parametric statistics (Lackin G.F.,1990; Glanz S., 1999) with help of electronical table processor Excel using standard statistic functions.

3. Results

Analysing amplitudes and frequenses of oscillations at coronal and frontal planes for two groups of norm (at European standard of feet placing and feet together placing) by the data of analyses of main frequencies of CP in coronal and frontal plane, one fundamental regularity can be marked. The lower the frequency of oscillation, the higher it`s amplitude and accordingly, the higher frequency of oscillation, the lower it`s amplitude (see table. 2).

Table 2. Results of the analyses of amplitudes and frequences of oscillations CP of group of norm according the European feet placing standard and with "feet together" placing. *

Parameter	European standard				Feet together			
	Eyes Open		Eyes Closed		Eyes Open		Eyes Closed	
	average	m	average	m	average	m	average	m
First amplitude at coronal plane (mm)	25.60	2.457	39.68	3.491	33.93	3.253	41.03	3.273
Second amplitude at coronal plane (mm)	16.43	1.316	29.14	2.688	19.32	1.169	30.41	1.983
Third amplitude at coronal plane (mm)	11.54	0.869	21.98	1.768	15.75	1.151	23.86	1.088
First amplitude frequency at coronal plane (Hz)	0.13	0.014	0.17	0.018	0.14	0.016	0.16	0.018
Second amplitude frequency at coronal plane (Hz)	0.19	0.017	0.19	0.021	0.24	0.033	0.22	0.021
Third amplitude frequency at coronal plane (Hz)	0.27	0.026	0.28	0.030	0.29	0.021	0.28	0.026
First amplitude at frontal plane (mm)	19.25	1.787	27.59	2.377	28.42	2.450	44.08	2.481

Second amplitude at frontal plane (mm)	14.59	1.656	19.87	1.556	18.00	1.432	33.69	2.148
Third amplitude at frontal plane (mm)	10.18	0.799	16.05	1.345	14.92	1.014	25.25	1.624
First amplitude frequency at frontal plane (Hz)	0.17	0.021	0.21	0.022	0.16	0.025	0.20	0.022
Second amplitude frequency at frontal plane (Hz)	0.21	0.023	0.22	0.030	0.25	0.030	0.22	0.022
Third amplitude frequency at frontal plane (Hz)	0.30	0.028	0.25	0.031	0.39	0.046	0.29	0.031

* Average value and mistake of the average (M±m) are given.

So, we can make sure that in group of norm the regularity, marked higher, observes strictly. Oscillations that have higher frequency show smaller amplitude.

With the purpose of statistic testing of that supposition here is results of the analysis at groups of patients with right-side hemiparesis and with frontier mental pathology. Final data are introduced in tables 3.

Table 3. Results of the analyses of amplitudes and frequences of oscillations of the group of patients with deep right-side hemiparesis and with frontie mental pathology.*

Parameter	**Right-side hemiparesis**				**Frontier mental pathology**			
	Eyes Open		**Eyes Closed**		**Eyes Open**		**Eyes Closed**	
	average	**m**	**average**	**m**	**average**	**m**	**average**	**m**
First amplitude at coronal plane (mm)	34.07	2.28	42.78	2.73	35.77	2.89	51.36	3.69

Second amplitude at coronal plane (mm)	22.83	1.46	35.54	2.61	21.42	1.46	38.13	2.35
Third amplitude at coronal plane (mm)	18.97	1.18	30.83	2.24	16.45	0.91	30.61	1.86
First amplitude frequency at coronal plane (Hz)	0.18	0.02	0.23	0.02	0.14	0.01	0.19	0.01
Second amplitude frequency at coronal plane (Hz)	0.26	0.03	0.28	0.03	0.24	0.02	0.22	0.02
Third amplitude frequency at coronal plane (Hz)	0.34	0.02	0.31	0.03	0.31	0.02	0.33	0.02
First amplitude at frontal plane (mm)	36.32	3.95	50.35	4.99	30.50	1.71	57.96	3.41
Second amplitude at frontal plane (mm)	24.05	2.07	35.64	2.97	19.89	1.09	39.46	2.33
Third amplitude at frontal plane (mm)	19.96	1.83	28.52	2.29	15.34	0.57	31.24	1.56
First amplitude frequency at frontal plane (Hz)	0.14	0.02	0.22	0.02	0.17	0.02	0.21	0.02
Second amplitude frequency at frontal plane (Hz)	0.25	0.01	0.23	0.02	0.29	0.03	0.23	0.02
Third amplitude frequency at frontal plane (Hz)	0.27	0.02	0.36	0.03	0.37	0.03	0.33	0.03

* Average value and mistake of the average (M±m) are given.

The result of investigation of frequency of oscillations in coronal and frontal planes of groups of patients with right-side hemiparesis and frontier mental

pathology also confirms strict correspondence of amplitude-phase characteristics of oscillations to the regularity, mentioned above.

4. Discussion

Thus, the analysis of findings, as in groups of norm so as in groups of patients, allows to conclude: oscillations of CP in coronal and frontal plane are submitted to the basic rule – **high-amplitude oscillations are low-frequency and low-amplitude – are high-frequency.** This regularity is based on physical nature of the process of oscillation.

Concerning proper oscillations of CP at frontal and coronal planes: as a division of the oscillations into low - and high-frequency is just relative, so at practice it means that on the diagram of spectrum of frequency oscillations of higher amplitude should have less frequency than oscillations with smaller comparatively to them amplitude. In context of oscillations of CP of an upright-standing man, that regularity, as we can make sure from the investigation of groups of norm and groups of patients, is – **physiological constant of the process of balance.** If for groups of norm this character of oscillations is physiological, so for groups of patients, where balance is initially abnormal, the discovered consecution of oscillations and their frequency may occur in case of successful, physioligical compensation. This condition occurs far from always. That is why, if oscillations of CP don`t conform to regularity, described above, so we can regard this condition as a disturbance of natural compensatory process.

As an example, below presented couple diagrams of a spectrum of frequency of oscillations two patients (fig. 1).

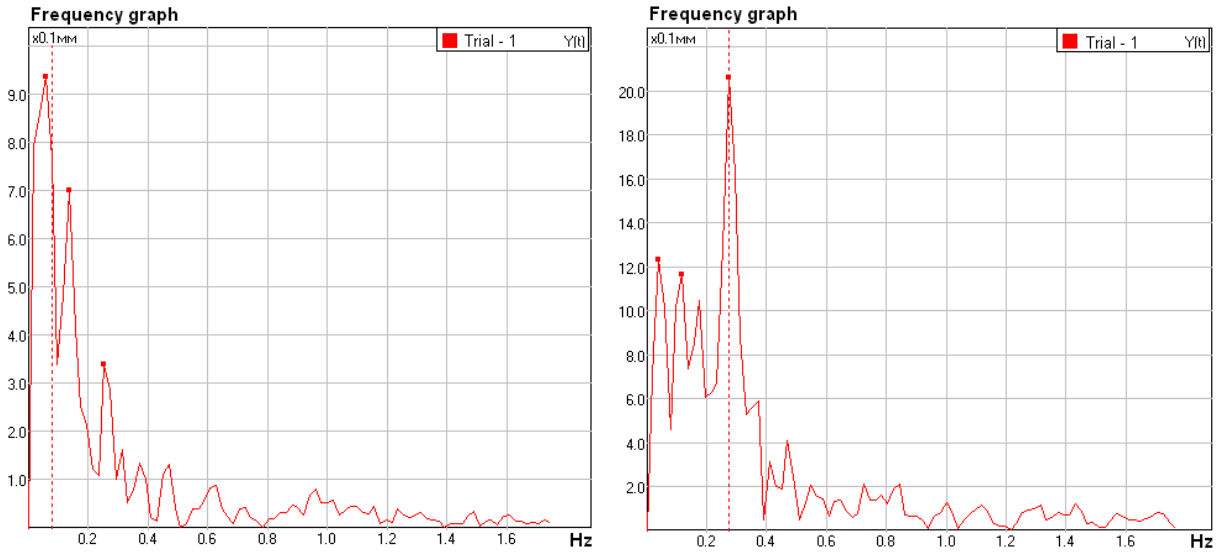

Figure 1. A diagram of frequency spectrum at coronal plane of a patient B-va G.I. (left) – consequences of hemorrhagic stroke, right side hemiparesis. Oscillation is strongly at basic rule. The patient S-ko V.J. (right) – consequences of craniocerebral injury, right-side hemiparesis, left-side pyramid deficiency, ataxy. The main amplitude is out of basic rule. Vertically – amplitude in mm, horizontally – frequency in Hz.

In the given clinical case (left diagram) we can see that common regularity of sequence of amplitudes and frequencies remains corresponding to depicted basic rule. More significant case we can see at left diagram. In that case oscillations with frequency 0.28 Hz have the biggest amplitude, since other oscillations are absent. Thus, the strict consecution of diminution of amplitudes with increasing of the frequency of oscillations is broken in that case, and we can regard that as the changing of physiological mechanics of balance oscillations forcibly with bringing in interferences in the form of oscillations with frequency 0.28Hz by means of central pathologic mechanisms.

As the disclosed regularity of correlation of amplitude and frequency of oscillations have physical and basic character, so the given circumstance can be used for analysis of data of stabilometrical research.

First of all, when analyzing spectrum of frequencies of oscillations, a submission of the spectrum to the law – quantity of amplitude is inversely to the value of frequency: “tells” that the oscillations are of free nature. In contrast to this, the changing of a given correlation of oscillations and their amplitudes may have just a forced character, for instance due to wittingly or uncontrolled muscle contraction (tremors, clonuses) or when sensitivity of a sensory field changes, or when another causes take place. At the same time free oscillations can be at both condition at norm and pathology, as we can make sure from the results of

investigation of groups of norm and patients with right-side hemiparesis and with frontier mental pathology.

5. Conclusion.

1. Oscillations of the centre of pressure at standing position, submit to basic l\f law, both for health and sick people. Clinical formula of the l\f law could be as– **high-amplitudes are low-frequency and low-amplitude – are high-frequency.**
2. Correspondence of spectrum of frequency of oscillations to that law can be considered as physiologically compensate condition and decompensate one in the absence of the same.

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References

1. Bouisset S., Duchene J.L., 1994. Is body balance more perturbed by respiration in seating than in standing posture? Neuroreport. N5.— P.957-960.
2. Collins J.J., De Luca C.J., 1995. The effects of visual input on open-loop and closed-loop postural control mechanisms, Exp. Brain Res. Vol.103, N1.— P.151-163.
3. Conforto S., et al., 2001. Hemodynamics as a possible internal mechanical disturbance to balance. Gait Posture. Vol.14, N1.— P.28-35.
4. Farrell S. et all. 2006 1/f noise in human cognition: Is it ubiquitous, and what does it mean? Psychonomic Bulletin & Review, 13:737-741.
5. Gagey P.M., Weber B., 1995. Posturologie. Regulation et dereglements de la station debout, Paris: Masson.
6. Glanz S. 1998. Primer of biostatistics, fourth edition, McGraw-Hill
7. Gurfinkel V. S., Osevets M., 1972. Dynamics of the vertical posture in man. Biophysics 17, 496–506.
8. Hodges P.W., et al., 2002. Coexistence of stability and mobility in postural control: evidence from postural compensation for respiration, Exp. Brain Res. Vol.144, N3.— P.293-302.

9. Maurer C., Peterka J., 2005. A new interpretation of spontaneous sway measures based on a simple model of human postural control J. Neurophysiol. Vol.93, N1. P.189-200.
10. Onell A., 2000. The vertical ground reaction force for analysis of balance? Gait Posture. Vol.12, N1. P.7-13.
11. Pagnacco G., et all., 2001. Muscular contractions and their effect on the vertical ground reaction force during quiet stance. Part I: Hypothesis and experimental investigation, Biomed. Sci. Instrum. Vol.37. P.227-232.