Algorithms in the examination of the postural stability

PIVNICKOVA L., VASEK V., DOLINAY V.
Faculty of Applied Informatics
Tomas Bata University in Zlin
nam. T.G.Masaryka 5555, 760 01 Zlin
CZECH REPUBLIC
pivnickova@fai.utb.cz, vasek@fai.utb.cz, vdolinay@fai.utb.cz   http://fai.utb.cz

Abstract: - This paper deals with algorithms used in evaluation of static posturography. Posturography is a non-invasive medical technique used to evaluate vertigo. Traditional static posturography has several results, such as charts describing speed, direction, harmony of patient's tilts, but for the medical studies and formation of norms are more sufficient numerical outputs, which we are going to deal with in this paper. If we consider possibilities and available data outputs from the posturography platform, we have many variation of view of it. Severance evaluations have in the past been defined, but still some significant signs remain hidden in charts or worse, in raw data. This paper show traditional numeric approaches and try to point the new one, focused on lateral deviation and refining current options. The proposed algorithms need to be verified by the practical experience now and found the rate of its usability.

Key-Words: - area, posturography, Romberg, tilt, vertigo, way

1 Introduction

Posturography is a non-invasive technique used to quantify the central nervous system adaptive mechanisms involved in the control of posture and balance. Another term linked with posturography is vertigo. Vertigo is very common feeling, known more or less to everyone. Vertigo is not a disease, vertigo is symptom. Extensive studies on 30 000 people of all age groups in Germany confirmed that about 20% men and up to 40% of adult women from time to time have feeling of motion when one is stationary. Vertigo may occur in all age groups, although with increasing age, the incidence increases [1].

Posturography as an examination method is measuring of postural balance in static or dynamic conditions. Static methods are mostly judging standing balance, dynamic in general focused to walk. This paper entirely deals with static posturography and its numerical evaluations.

2 Process of examination

Static posturography is carried out by placing the patient in a standing posture on a fixed instrumented platform connected to sensitive detectors (force and movement transducers), which are able to detect the tiny oscillations of the body [2]. See Fig. 1.

The parameters of measurement:
(based on common options for STP-03 platform)

- Measure period: 40 ms
- Length of measure: 20 s
- Area for calculating weighted area: 5°
- Angle step for display vectors: 15°
- Number of samples for harmonic analysis: 250

Fig. 1 Static posturography [3]

Traditional static posturography is based on Romberg test, which means that two exams are executed - with eyes open and then with eyes closed. The mutual relations between results are track. A normal person is upright, but the patient suffering from vertigo deviates from the vertical position as he (she) tries to compensate for a sense of movement that feels. The patient usually tilts to the side, which has affected labyrinth.

3 Measurement results

Posturograph STP-03 software (widely use in Czech Republic) calculates the value of the way *(1)* and area *(2)* of the patient center of gravity circumscribed over the posturographic platform. Evaluates the ratio between these values for the examination with open and closed eyes are important parts of vertigo assessment.

Parameter Way, *W (cm/s)* describes the path of moving center of gravity, but because the examination time given a constant number, Way is characterized as the speed of center of gravity. Parameter Way for open eyes is marked with postfix *f; (Wf)* - visual fixation. Way for the closed eyes is marked with postfix *s; (Ws)* – visual suppression.

$$M_i = \sqrt{(x_{i+1} - x_i)^2 + (y_{i+1} - y_i)^2} \qquad (1)$$

$$W = \frac{T^{-1}}{n} \sum_{i=1}^{n} M_i \ [mm/s]$$

where:

M_i	particular element of way calculation
T	measure period [s]
x,y	center of gravity coordinates
n	number of measured samples

Parameter Area, *A* (cm^2/s) indicates the area, which describes variation of center of gravity during the examination. Like the parameter Way, Area for the visual fixation is marked *(Af)* and for visual suppression *(As)*. [4]

$$N_i = \frac{\left| \begin{matrix} (y_{i+1} - y_0) * (x_i - x_0) \\ -(y_i - y_0) * (x_{i+1} - x_0) \end{matrix} \right|}{2} \qquad (2)$$

$$A = \frac{1}{t} \sum_{i=1}^{n-1} N_i \ [mm^2/s]$$

where:

N_i	particular element of area calculation
t	length of measure [s]
x_0, y_0	average values of center of gravity coordinates *(3)*

$$x_0 = \frac{1}{n} \sum_{i=1}^{n} x_i \qquad y_0 = \frac{1}{n} \sum_{i=1}^{n} y_i \qquad (3)$$

3.1 Visual presentation of results

As mentioned earlier, the posturograph examination has also visual outputs. This paper is not dealing with those results directly so outputs will be describe shortly, but information covering by them are much more wider than used numerical results.

Fig. 2 shows center of gravity trajectories (patient body motion) focus and direction of motion vector evaluation. The above charts are for open eyes, bottom for closed eyes. On the left is the trajectory of motion, in the middle motion vectors in a bar-shaped view. On the right is shown the envelope vectors.

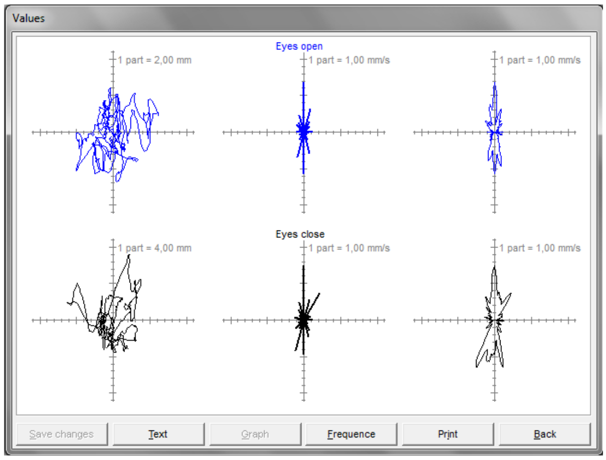

Fig. 2 Results in charts

Fig. 3 shows harmonic analysis of the patient's movements. The above charts are for open eyes bottom for closed eyes. On the left is the lateral component of movement, in the middle anteriopostural component of movement. On the right is the frequency analysis of the above mentioned components is showed. The area for the simulation analysis is highlighted by red line segments.

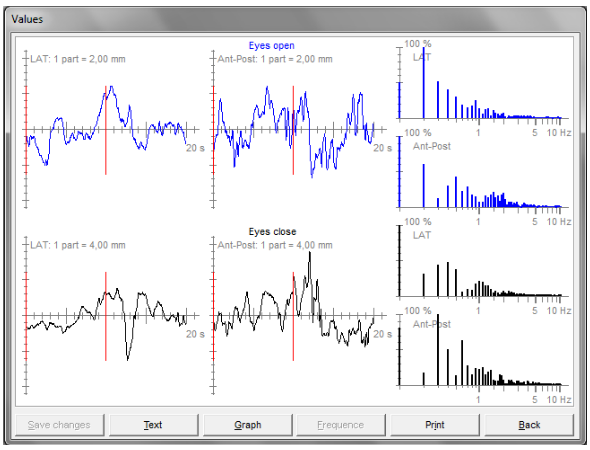

Fig. 3 Frequency analysis in charts

3.2 Addition of side parameters

For the vertigo evaluation it seems to be important to express the side and harmonic center of gravity move components. There is no direct numerical expression of these motion components, only visual presentation is partly covering it. We try to present simple procedure based on current data and nature of vertigo. Let's suppose, patients who have visual fixation, they have relatively good results but when loosing this fixation, the disturbance become wider. The same presumption can be applied to beginning of the examination and late course.

Modify the equation *(3)*, replacing *n* with *m* where *m* is the number of measured samples in the first second of the examination and retrieve new, average values of center of gravity coordinates x_b and y_b *(4)*.

$$x_b = \frac{1}{m}\sum_{i=1}^{m} x_i \qquad y_b = \frac{1}{m}\sum_{i=1}^{m} y_i \qquad (4)$$

Then the parameter (vector) *S* can be defined *(5)*.

$$S = \overrightarrow{x_b x_0} \qquad (5)$$

For the evaluation of dominant tilts is necessary to calculate orientation and vector size. These values expand current numerical results and improve diagnostics accuracy.

4 Conclusion

This paper describes current methods of posturography evaluation. Shows basic numerical and visual outputs and provides new on in the form of vector *S* (side).

The proposed evaluation needs to be however verified by the practical experience now and found the rate of its practical usability.

The further research also needs regarding the harmonicity of motion and its easy numerical presentation for standards formulation.

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