System for Evaluation of the Static Posturography Based on Wii Balance Board

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Abstract: - The main aim of this article is to introduce the Wii Balance Board in the evaluation of static computed posturography. Posturography is a general term that covers all the techniques used to quantify postural control in upright stance in either static or dynamic conditions. This study focused on static posturography only. Static posturography is carried out by placing the patient in a standing posture on a fixed instrumented platform connected to sensitive detectors, which are able to detect the tiny oscillations of the body. Though the Wii Balance Board was originally designed as a video game controller, obtained results show that Wii Balance Board can become a device useful for assessing center of pressure displacement in medical examinations. The considerable benefits of using the Wii Balance Board are also its portability and low price.

Key-Words: - posturography, Wii Balance Board, vertigo, balance, Romberg test, medical examinations.

1 Introduction

Many medical issues can cause problems with balance. Neurological problems in the central or peripheral nervous system may impair a patient's motor control. The vestibular system for balance can be damaged, making it difficult for patients to know where they are relative to other objects and the environment. Muscle weakness may make it harder to stand, or patients can have tremors and other neurological issues that impair the ability to balance and stand safely [7].

One of the medical techniques is posturography. Posturography is a non-invasive technique used to quantify the central nervous system adaptive mechanisms involved in the control of posture and balance [7, 9].

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 study focused on static posturography only. Static posturography is carried out by placing the patient in a standing posture on a fixed instrumented platform connected to sensitive detectors, which are able to detect the tiny oscillations of the body.

This article introduces the Wii Balance Board in the evaluation of static computed posturography. Though the Wii Balance Board was originally designed as a video game controller, obtained results show that Wii Balance Board can become a device useful for assessing center of pressure displacement in medical examinations. The considerable benefits of using the Wii Balance Board are also its portability and low price.

2 Vestibular function testing

The spectrum of diseases causing vertigo is very broad, hence the first visit a doctor you have to try to provide him as much information as possible. The exact description of the symptoms helps doctors diagnose, determine the strategy of further examination and plays an important a role in treatment.

It is useful to know in particular:

- at which time the dizziness occurs
- what it causes (changes in atmospheric pressure, emotional or physical stress, premenstrual period)
- symptoms, such as (nausea, tinnitus, increase in arterial pressure, sweating, headache, tendency to fall, etc.)

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- what medicines you are taking, because dizziness can be caused by the use of certain drugs
- if you have recently suffered a head injury or neck. For example, cervical spine injury in a car accident when the head when braking or crash the car reversed rapidly forward and back

After gathering the data history and measure blood pressure the doctor performed a number of simple tests of balance function testing [1, 5, 7, 9].

2.1 Romberg test

Romberg's test or the Romberg maneuver is a test used by doctors in a neurological examination, and also as a test for drunken driving. The Romberg test is a test of the body's sense of positioning (proprioception), which requires healthy functioning of the dorsal columns of the spinal cord, see Fig. 1.

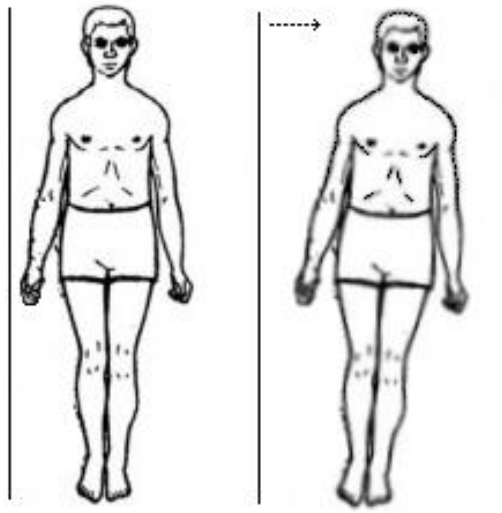

Fig.1 Romberg test [7]

The exam is based on the premise that a person requires at least two of the three following senses to maintain balanced while standing:

- Proprioception (the ability to know one's body in space)
- Vestibular function (the ability to know ones head position in space)
- Vision (which can be used to monitor changes in body position)

A patient who has a problem with proprioception can still maintain balance by using vestibular function and vision. In the Romberg test, the patient is stood up and asked to close his eyes. A loss of balance is interpreted as a positive Romberg sign [5, 7, 9].

3 Wii Balance Board

The Wii Balance Board is a balance board accessory for the Wii and Wii U video game consoles. It runs on four AA batteries as a power source, which can power the board for about 60 hours. The board uses Bluetooth technology and contains four pressure sensors that are used to measure the user's center of balance—the location of the intersection between an imaginary line drawn vertically through the center of mass and the surface of the Balance Board—and weight. Although the Japanese packaging states that it is designed to support people weighing up to 136 kilograms (300 pounds) and the "Western" Balance Board up to 150 kg (330 pounds), they are actually the same board. The packaging differs due to regulatory differences between Japan and the United States. The sensors on the board can accurately measure up to 150 kg (330 pounds). The actual physical structure of the board can withstand much greater force equivalent to around 300 kg (660 pounds) [8, 10].

Fig. 2 The top of a Wii Balance Board [8]

Though originally designed as a video game controller, the Balance Board has become a proven tool for assessing center of pressure displacement. As described Clark [2] it is proven to be both valid and reliable. Was already performed a study to prove the validity and test-retest reliability of the use of a Balance Board. The idea behind using a Balance Board instead of a force platform is the ability to “create a portable, inexpensive balance assessment system that has widespread availability.” Four standing balance tasks were used in this study including a combination of double stance, single

stance, eyes open, and eyes closed. Throughout these tests the center of pressure path length was measured and compared these data to an identical study on a laboratory-grade force platform. The study found the Wii Balance Board to be both valid and have high test-retest reliability [2, 8, 10].

4 Process of measurement

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, see Fig.3.

Conditions of measurement:

- Process of measurement: upright standing posture
- Measurement methods: with eyes open and close
- Measure period: 40 ms
- Length of measure: 20 s

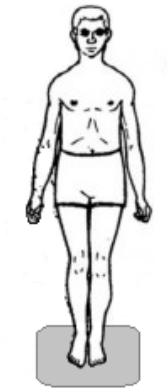

Fig.3 Process of measurement on the platform [7]

5 Measurement diagnostic values

Wii Posturografie software was special proposed for evaluation of postural stability via Wii Balance Board. This software calculates series of values which are important to determine the correct diagnosis.

Parameter "*Way*" (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 [15].

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

(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*" (cm2/s) indicates the area, which describes variation of center of gravity during the examination [2].

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

(2)

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

Where:

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

$$x_0 = \frac{1}{n} \sum_{i=1}^{n} x_i$$

$$y_0 = \frac{1}{n} \sum_{i=1}^{n} y_i$$

(3)

Parameter "*Lat*" (cm / s) expressing the resultant vector of the amplitude of the lateral center of gravity (the length of the lateral displacement of center of gravity during the measurement). As in the physical assessment of neurological attitudes, this parameter is to be seen as indicators of the peripheral vestibular lesion.

$$sum = \sum_{i=1} (x_i - x_{i-1})$$

$$Lat = sum/t$$

(4)

Where:

t	length of measure [ms]
x	center of gravity coordinates

Parameter "*Ant –Post*" (cm / s) is the anteroposterior amplitude gravity vector (length anteroposterior displacement of center of gravity during the period of measurement). As in the physical assessment of neurological attitudes, mild sagittal vector dominance at the physiological state of equilibrium is considered normal, with balance disorders is to be seen as indicators of central lesions.

$$sum = \sum_{i=1} (y_i - y_{i-1})$$
$$Ant - Post = sum/t \quad (5)$$

Where:

t	length of measure [ms]
x	center of gravity coordinates

Parameter "*AP/Lat*" is the ratio of anterior-posterior and lateral components of the examined balance, which reflects the overall dominance of directional amplitude gravity investigated.

$$\frac{AP_{open}}{Lat_{open}} = \frac{Ant - Post}{Lat}$$
$$\frac{AP_{close}}{Lat_{close}} = \frac{Ant - Post}{Lat} \quad (6)$$

Parameter "*Romb Way*" is the ratio of way with open and closed eyes. Express the ratio of a visual control of posture to maintain postural balance.

$$Way = \frac{Way_{close}}{Way_{open}} \quad (7)$$

Parameter "*Romb Area*" is the ratio of area with open and closed eyes.

$$Area = \frac{Area_{close}}{Area_{open}} \quad (8)$$

Parameter "*Side*" for the vertigo evaluation it seems to be important to express the side and harmonic center of gravity move components. 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).

$$x_b = \frac{1}{m}\sum_{i=1}^{m} x_i$$
$$y_b = \frac{1}{m}\sum_{i=1}^{m} y_i \quad (9)$$

Then the parameter (vector) S can be defined (10).

$$\vec{S} = \overrightarrow{x_b x_0} \quad (10)$$

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

6 Measurement results

The example shows part of the practical examination results. To be specific: patient with open eyes were monitored for 20 seconds and then the same patient with close eyes were again monitored for 20 seconds.

The Wii Posturography software created for calculation series of parameters which are used as a support for diagnosis of patients.

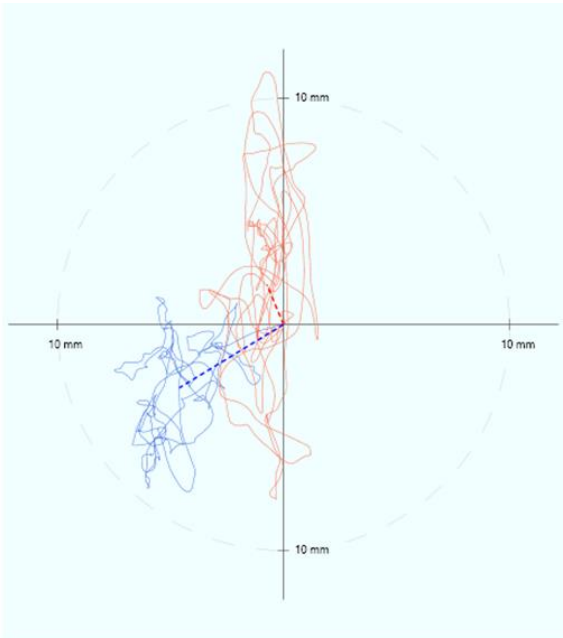

Fig.5 Image shows the patient´s body motion during measurement with open and closed eyes

Figure 5 shows center of gravity trajectories (patient´s body motion) and direction of motion vector. The chart shows patient´s body motion with eyes open (blue line) and with eyes close (red line).

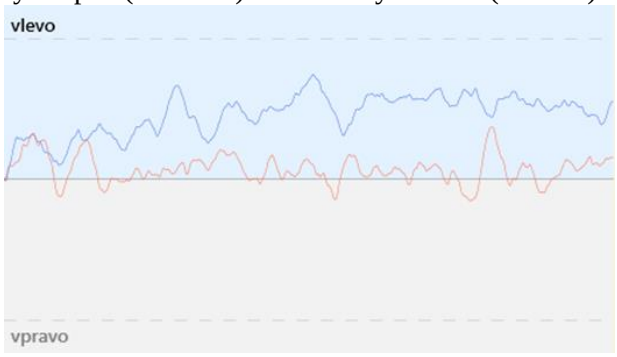

Fig. 6 Shows the X-coordinates in the closed and opened eyes

Figure 6 shows that the patient is tilted to the left side with open eyes (blue line) and with eyes closed (red line) is tilted only slightly to the left side.

Fig. 7 Shows the Y-coordinates in the closed and opened eyes

Figure 7 shows that the patient is tilted to the backward with open eyes (blue line) and with eyes closed (red line) is tilted greatly to the forward.

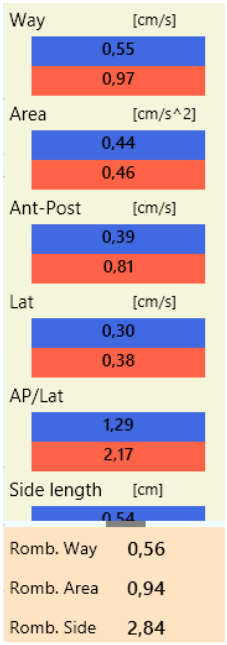

Fig. 8 Measurement results of the patient

Figure 8 shows the measured values, which are used for the diagnosis of balance disorders. From the diagnostic values and supporting graphical views show that the patient may have a central fault.

7 Evaluation of the measured values via proposed expert system

For evaluation of the measured data was created the software utilizing already a proposed expert system. An expert system was developed based on the measured data of patients on the posturography platform. The obtained data were including diagnosis suggested by a doctor. This makes it possible to use fuzzy logic to create an evaluation system that serves as a support for assessment of diagnosis.

Figure 8 shows measurement results as Way, Area, Ant-Post and Lat with opened and closed eyes. This data are copied to the evaluation system, which suggests the diagnosis.

In case the doctor does not agree with the proposed diagnosis has the option to choose a diagnosis and then save it. This makes it possible the expert system repeatedly learns and improves.

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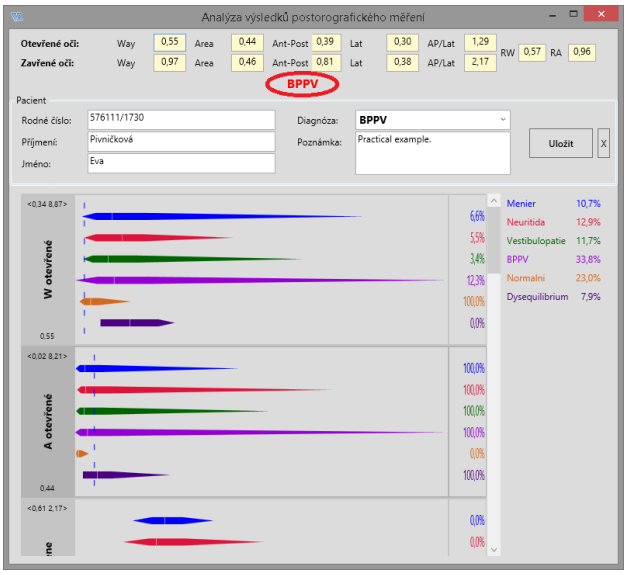

Fig.9 Software "Analysis of the results of posturography measurement" displaying the proposed diagnosis (in the red frame)

8 Conclusion

This article focused on introducing the Wii Balance Board in the evaluation of static computed posturography. For the purposes of measurement was created software "Wii Posturography" that calculates basic numerical values such as the Way, Area, Ant-Post, Lat, but also the "Side" parameter for dominance tilt. The program also displays the measurement results into graphs. Each measurement can be saved for later analysis. This makes it possible to compare individual measurements and track the health status of patients. For determine of diagnosis was created the software Analysis of the results of posturography measurement. The software suggests the diagnosis but the doctor must agree with the proposed result. The Balance Board has become a proven tool for assessing center of pressure displacement. The main advantage using a Wii Balance Board instead of a force platform in evaluation of static posturography is the ability to create a portable, inexpensive balance assessment system that has widespread availability. This would allow the device the Wii Balance Board including created "Wii Posturography" software introduced in GP surgeries. The further research should focus on another measurement of patients and analysis of the obtained data.

9 Acknowledgments

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