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Standardization in Platform Stabilometry being a Part of Posturography

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Posturography is not a clearly defined subject. Numerous investigators are working in this field being active in technical laboratories, research institutes and medical departments. Dependent on the intention and the focus of interest the problem statement is formulated and the approach is chosen. So rather different types of equipment are used to measure and study postural stability and body movements either spontaneous or with application of stimuli. One aspect of posturography is the recording of body movements of subjects in standing position. In this restricted sense of the word we will speak about stabilometry. A number of quite different methods are practized for the stabilometric measurements. Without any claim or suggestion about completeness some sticking proves of inventivity will be mentioned. Supposing certain rigidity in the body a number of authors studied the movements of the head using accelerometers *(Tokita, Watanabe* and *Fukuda,* 1972), light beams *(Boman* and *Jalavisto,* 1953; *Jarrige,* 1968; *Kapteyn, 1972; Tokumasu* and *Kawano,* 1976), strings *(Fearing, 1924)* and mechanical structures *(Vierordt,* 1864; *Tokita, Miyata et al.,* 1976) fixed to the head. Other authors measured the movement of the trunk, also using quite different methods as accelerometers *(Thomas* and *Whitney,* 1959) Light *(Hirasawa,* 1973), sound sources *(Guegen* and *Leroux,* 1973); *Amblard* and *Cremieux,* 1976), strings" *(Kuhnke,* 1950; *Smith,* 1957; *Neshner;* 1971; *Gantchev, Draganova* and *Dune v,* 1972), magnetic coils or video systems *iKepteyn,* 1973; *Spaepen, Peeraer* and *Willems,* 1979). A less direct method tor studying the body stability is the recording of the movement of the body's point of pressure to the foot support using a force measuring platform.· The displacement of the point of pressure" is not only caused by a possible shift of the body's point of gravity, but also by the acceleration and deceleration forces related to the movements of the inertial mass of the body *(Smith,* 1957; *Scott* and *Dzendolet,* 1972; *Gurfinkel,* 1973; *Hlavacka* and *Litvinenkova,* 1973; *Kapteyn,* 1973; *Geursen, Aliena et al.,* 1976; *Spaepen, Vranken* and *Willems,* 1978; *Massen* and *Kodde,* 1979; *Kodde, Caberg* and *Mol, 1982).*
The contribution of this dynamic part is at least as large as that of the static part being the effect of the shift of the point of the body's point of gravity. Besides that such a shift can be caused by a movement of the standing subject as such it also can be caused by a change in configuration of the parts of the body in which case the measured shift is not representative for the subjects stability *(Corti,* 1959). In some platforms the static and dynamic components are separated. *(Thomas* and *Whitney,* "1959; *Spaepen, Fortuin* and *Willems, 1979).* Some platform are sensitive for horizontal shearing forces as· well *(Begbie,* 1967; *Dichgans, Mauritz et al.,* 1976; *Spaepen, Vranken* and *Willems," 1978).*

Ask for Standardization

The studies using these different methods and instrumentations deliver data and conclusions while the comparison is extra hampered by non-uniformity in presentation. At the fifth International Symposium on Posturography in Amsterdam (1979) this subject has been discussed. The general feeling was that posturography only will grow to a generally accepted clinical tool when posturographic investigations in patients suffering from corresponding diseases deliver corresponding results in the various clinical departments. In relation to this a need was felt for general agreements about methods and pre- sensation of results. The meeting decided to appoint a commit- tee for preparing a report on standardization in platform stabilometry to be presented in 1981 at the sixth International Symposium on Posturography on Kyoto. This report, introduced "to the members of the symposium, has been subject of a plenary discussion in the business meeting of the society on Posturography in Kyoto 1981. In this discussion special attention has been given to the result of a questionnaire distributed among 200 ENT physicians of leading hospitals in Japan which nation wide survey delivered 115 responses out of different departments. In this publication the report will be presented step by step, as it was discussed at the meeting with the brief considerations of ·the committee and the summary of the comment of the meeting.

Propositions on Standardization 1. DEFINITION.

Platform stabilometry measures body movements of subjects in standing position by means of a stabilometer, the assumption being that the stabilometer is a force-measuring platform.

CONSIDERATION: in the extended field of posturography a restricted part has to be fenced off to be called Platform Stabilometry.

COMMENT: none.

2. INDICATIONS OF DIRECTIONS.

Designations used to indicate the direction of body movements during platform-stabilometric measurements should be:
Anterior (A), Posterior (P) Left (L) and Right (R), always defined from the subject's point of view.

CONSIDERATION: Although either Latin or English words can be preferred here has been chosen for a connection to the common use in Neurology, EEG etc.

COMMENT: The recommended terms are preferred above forward backward.

3. THE STABILOGRAM.

The body movements in standing position in one direction (either AP or LR) can be presented as a function of time; this presentation is to be called Stabilogram (symbol Stg). In this presentation the time scale is to be taken horizontally, and the body movements in anterior and right direction, respectively, should be written on the positive vertical axis, i.e. by an upward excursion in the recording.

CONSIDERATION: *Gurfinkel* c.s. use this notation and since it has grown to common use *(Gurfinkel, Kotz* and *de Chick,* 1965 ; *Helfand, Gurfinkel et al.,* 1964).

COMMENT: none.

4. THE STATOKINESIGRAM.

Body movements during standing can be presented as ex- cursions of the body in the horizontal plane; for example as excursions of the body"s point of pressure on the supporting platform. This type of presentation should be called Statokinesigram (symbol Skg). In this presentation the UR movements should be written on the horizontal x-axis, writing R in positive direction, i.e. as a deflection to the right in the recording; the AIP movements should be written on the vertical y-axis, writing A in positive direction, i.e. as an upward deflec- tion in the recording.

CONSIDERA TION: *Baron* c.s. use this notation. Since it has grown to common use *(Baron, Bobot* and *Bessineton, 1956; Baron,* 1964).

COMMENT: none.

5. TIME OF RECORDING.

The recording of postural movements should preferably start 10 seconds before the time of analysis (i.e. the effective time interval over which the signal is to be analysed), in order to eliminate transient phenomeris. The time of analysis should preferably be 50 seconds.

CONSIDERA TION: For a valid analysis the recording should be long enough to eliminate a first part disturbed by possible transient phenomena and to keep th an a period usable for a valid analysis *(Fearing,* 1924; *Kuhnke,* 1950; *Smith, 1953; Corti,* 1959; *Cantrell,* 1963; *Begbie,* 1966, *Jarrige, 1968; Sugano* and *Takeya,* 1970; *Soames, Atha* and *Harding,* 1976).

COMMENT: The feeling is that up to now there is no evi- dence for an optimum length of the period of analysis. In Japanese centres various periods are used for example 20 sec (23 0/0), 30 sec (37 0/0), 50 sec (7 0/0) and 60 sec (30 0/0). The meeting wishes results of studies before making a decision in this.

6. THE MENTIONING OF SCALE UNITS.

In the presentation of Stabilograms, scale units should be defined in Newton-metre-second units. Dependent on the stabilometer used the vertical axis should represent the dimen- sion of force (Newton), moment of force (Newton-metre) or dis- placement (metre). The presentation should indicate the deflec- tion in the Stabilogram due to a steady moment of force of 1.0 Newton-metre.

CONSIDERA TION: Measuring platforms can measure quite different physical units (force, moment of force, displacement). For a good understanding of the presented data the scale units have to be mentionedin a uniform system of reference.

COMMENT: none.

7. THE LOCALIZATION OF THE STATOKINESIGRAM.

In the presentation of the Statokinesigram, the centre of the figure (Le. the intersection of the two axes) should be defined by the situation in which no moment is exerted on the stabilometer. The dimensions should again be expressed on the axes in Newton-metre-second units. The presentation of a Statokinesigram should state the coordinates of the mean value of the deflections in both directions.

CONSIDERA TION: Dependent of the test situation or subject the center of a satokinesiqrarn can be situated outside the calibration point being the place of the recording element when no moment is exerted on the platform. This localisation has to be shown as an essential source of information and should be mentioned expressed in units of the chosen system of refer- ence *(Baron,* 1963 ; *Litvinenkova* and *Baron, 1968)).*

COMMENT: none.

8. RECOMMENDATIONS ABOUT THE TEST CIR- CUMST ANCES.

Since the measurement of the subject"s stability can be influ- enced by the circumstances under which it takes place, the following recommendations are made:

, a) The subject should remove his shoes and stand on the stabilometer platform with the heels together, at an angle of 30 degrees between the medial sides of the feet.

b) No fixed sound sources should deliver information for spa- tial orientation in the room used for posturography; the noise level in the room should preferably be below ISO 40 dB(A).

c) The room should be large enouqh to prevent acoustic spa- tial orientation, the mimimum area being preferably 3 x 4 metres. The stabilometer should be placed at least 1 metre from any wall. "

d) During registrations with the eyes open, the subject shoulo focus on a circular area with a diameter of 5 cm, at a distance of 3 metres straight ahead.

e) For recordings of visual postural stabilization the peripheral field of vision should provide information on the verti- cal, and the room should have normal (diffuse) illumination of at least 40 lux (lumen per square metre).

f) During registrations with the eyes closed, some low-level dim light (about 20 lux) should be. presented In the room in order to put the subject at ease and enable the investigator to observe him (her).

CONSIDERA TION: Besides the instrumentation and the de- fined test position the measuring results may be influenced by secondary factors concerning the test circumstances *(Thomas* and *Whitney,* 1959; *Cantrell,* 1963; *Begbie,* 1967; *Spaepen, Fortuin* and *Willems, 1979).*

ad. a) the position of the feet and the possible support of shoes will influence the result of the measurement *(Fearing,* 1924 a; *Begbie,* 1967; *,Owen Black, O"Leary* and *Wall, 1976; Soames* and *Atha,* 1978; *Okubo, Watanabe et al., 1979; Brauer* and *Seidel, 1980).*

ad. b) a fixed sound source can be a point for orientation and reduce the measure of instability *(Edwards,* 1946; *Takeya, Sugano* and *Ohno,* 1976; *Marne-Karelse* and *Bles,* 1977).

ad. c) reflection of sound against a wall can deliver spatial orientation as used intensively by blind people *(Edwards, 1942 1946 Takeya, Sugano* and *Ohno,* 1976; *Marme-Karelse* and *Bles, 1977).*

ad. d) the value of a test situation "eyes open" in relation to "eyes closed" depends completely on the usability of the total potential of the visual system. A fixation point must be situated within 5 meters distance from the subjects head *(Bles* c.s.) *(Edwards,* 1946; *Guegen, Leroux et al.,* 1976; *Bles, Brandt et al., 1978).*

ad. e) The peripheral eye field must be saturated with infor- mation about the vertical illuminated at a sufficient level *(Ed- wards,* 1942, 1946; *Wapner* and *Witkin,* 1950; *Fukuda, 1952" Begbie,* 1966 *Litvinenkova* and *Baron,* 1968; *Hlavacka* and *Lit- vinenkova,* 1973; *Bles* and *de Wit,* 1976; *Lee* and *Lishman, 1976; Amblard* and *Carblanc,* 1978; *Kapteyn, Bles et al., 1979"*

Okubo, Watanabe et al., 1979; *Seidel* and *Brauer,* 1979; *Bles, Kapteyn et al.,* 1980).

ad. f) subjects feelings of unsteasiness as weil as a possible peeping through eyelids have to be prevented *(Edwards, 1946; Begbie,* 1967).

COMMENT: The foot position and the wearing of shoes has been discussed profoundly. As the basic question has been formulated "What instruction is given to the patient about his way of standing". A situation of relaxed standing is incompatible with a obliged foot position or a put off of the shoes. Especially in "some cultures the last event can be experienced as unpleasant and making the subject uneasy. In the case that the subject is investigated in a special body attitude for exampie the military attitude the situation can be defined as complete as whished.

Concerning the sound in the testroom, usage of headphones or earplugs has been discussed and rejected. The feeling was that a level of diffuse noise of 40 dB (A) might be tolerable but no spatial orientation might be possible by means of a fixed sound source or reflections of sound against fixed objects.

In Conclusion: The recommendations about the visual aspects got general agreement. The meeting asked for results of studies about the effects of the instruction to the subject about the way of standing on the results of the investigations *(Fearing,* 1925; *Kuhnke* 1950; *Wapner* and *Witkin, 1950; Smith,* 1953; *Corti, 1959).*

9. THE STANDARD TEST CONDITION.

The standard stabilographic measurement condition (SC) is defined by the recommendations 8a, b, c, d and e.

CONSIDERATION: "The results of the stabilometric measurements in healthy subjects show a large interindividual difference. So no sharp normal values can be defined and the large standard deviations exclude a sharp criterium *(Fearing,* 1924 a, b, *Kuhnke,* 1950; *wepner* and *Witkin,* 1950; *Cantrell, 1963; Begbie,* 1967; *Litvinenkova* and *Baron,* 1968; *Sugano* and *Takeya,* 1970; *Bessineton, Bizzo et al.,* 1976; *Njiokiktjien* and *van Parys, 1976).*

COMMENT: none.

10. THE WEIGHT OF THE VISUAL CUES.

The influence of visual information can be expressed in the so called *Romberg* quotient of the measure of stability obtained in the situation defined by 8a, b, c, f and the corresponding measure of stability obtained in the standard condition (SC) *(Njiokiktjien* and *de Rijke,* 1972; *Njiokiktjien* and *van Parys, 1976; van Parys* and *Njiokiktjien,* 1976; *Owen Black, O"Leary* and *Wall, 1977).*

CONSIDERATION: The weight factor of the visual information in stability is unequal for the different subjects. So it is reasonable to define a relative factor.

COMMENT: none.

11. THE WEIGHT OF SPECIFIC TASKS.

The influence of factors or circumstances on the subject's stability can be related to the standard condition (SC) in a way similar to that described for the *Romberg* quotient.

CONSIDERATION: Just as the influence of visual information the effect of other tasks will be dependent on the situation and personal factors, so its reasonable to define relative measures.

COMMENT: none.

12. INDIVIDUAL DIMENSIONS.

The subject's body weight and height influence the posturographic data, but no distinct correlation has so far been established which could justify a uniform method of correlation. The subject's height and weight should therefore be specified in the presentation, which should also mention the correction used in the analysis in view of these factors.

CONSIDERATION: In literature no general accepted calculation methods are presented concerning corrections for interindividual differences in weight and height reducing the standard deviation of the platform stabilometric data in a population of healthy subjects. Therefore in case of presentation individual stabilometric data the individual weight, height and age should be reported *(Fearing,* 1925 *Hellebrandt, Tepper et al., 1937; Wapner* and *Witkin,* 1950; *Thomas* and *Whitney,* 1959; *Sugano* and *Takeya,* 1970; *Bessineton Bizzo et al.,* 1976; *Kapteyn, 1978; Hlavacka* and *Saling, 1979).*

COMMENT: none.

13. SAMPLING OF THE SIGNAL.

When the posturographic signal is sampled for analysis, the components in the higher frequencies should be eliminated by means of a low-pass filter. The sample rate to be used should be 20 per second, i.e. 1024 samples in 50 seconds and 512 samples in 25 seconds, if it can be managed.

CONSIDERATION: The results of calculations can be influenced by the sample rate with which the signais is digitized: so an agreement is wanted. In making a decision one has to consider the facilities of current instruments and the frequency considered as being the highest valuable component in the stabilometric signal. Taking 10Hz as being the highest valuable component the minimum sample rate is 20 samples per second. For elimination a possible disturbing effect of higher components should be filtered out before the sampling.

COMMENT: The recommended sample-rate has been experienced as being minimal. The cut-off frequency and the steepness of the filter should preferably be mentioned in a publication. The effect of various sample procedures has been mentioned as a subject for study and further discussion at the next symposium

14. MEASURES OF STABILITY.

A measure of stability can be calculated in several ways. Two possibilities are suggested:

a) The line integral per second (L) is the sum of the absolute values of the line segments between two successive samples of the Statokinesigram (Skg), divided by the time of analysis (T). This gives the equation:

$$L = \frac{1}{T}\sum_{i=1}^{N}\sqrt{\left(x_i - x_{i-1}\right)^2} + \left(y_i - y_{i-1}\right)^2$$

b) The root mean square (RMS) is the root of the quotient of the sum of the squares of the distances of the samples of the Skg to the mean value of these samples and the number of samples.

This gives the equation

$$S = \sqrt{\frac{\sum_{i=1}^{N}\left[\left(x_i - \overline{x}\right)^2 + \left(y_i - \overline{y}\right)^2\right]}{N}}$$

CONSIDERATION: Two possible measures for stability are presented as being examples *(Agajan,* 1967; *Sugano* and *Takeya,* 1970; *Njiokiktjien* and *de Rijke,* 1972; *Kapteyn* and *Bles,* 1976; *van Parys* and *Njiokiktjien,* 1976; *Kodde, Caberg* and *Mol,* 1982).

COMMENT: none.

15. FREOUENCY ANALYSIS.

When a frequency analysis is made, for example according to *Fourier,* the presentation of results should show the frequencies plotted on the horizontal axis in a logarithmic scale between 0.02 Hz and 10Hz; the amplitude of the spectrum should be presented vertically in a linear scale, with dimensions and units indicated.

CONSIDERATION: The recommended presentation is a consolidation of what has been grown as common use *(Agajan, 1967; Sugano* and *Takeyda,* 1970; *Aggashyan,* 1972; *Scott* and *Dzendolet,* 1972; *de Wit,* 1972; *Gueguen* and *Leroux, 1973; Leifer* and *Meyer,* 1-975; *Owen Black, O"Leary* and *Wall, 1976; Matsuoka* 1977; *Taguchi,* 1978; *Brauer* and *Seidel, 1979; Watanabe, Okubo* and *Ishida, 1980).*

COMMENT: none.

16. FREQUENCY BANDS.

The frequency content of an analysis can be presented by an integration of the amplitudes within frequency bands, the limits of these bands being 0.02 Hz, 0.2 Hz, 2 Hz and 10 Hz.,

CONSIDERATION: The selectivity of a frequency-analysis depends of a number of factors and the sharpness of a peak is not necessarily indicative for a diagnostic event. In connection to this it may be useful to integrate the spectrurn within frequency bands related to physiological movements or specific diagnoses.

COMMENT: Before a possible decision about frequency bands, more basic studies have to be made about sample rate, time of analysis and methods of frequency analysis. A profound discussion should be prepared to be held, at the seventh symposlurn in Houston. *(Wapnerand Witkin,* 1950; *Thomas* and *Whitney,* 1959; *Helfand, Gurfinkel et al.,* 1964; *Begbie, 1967; Gentchev, Draganova* and *Dune v,* 1972; *Leroux, Baron et al., 1973; Dichgans, Mauritz et al.,* 1976; *Njiokiktjien* and *van Parys,* 1976; *van Parys* and *Njiokiktjien,* 1976; *Soames, Atha* and *Harding,* 1976; *Tokite, Miyata et al.,* 1976; *Seidel, Brauer et al., 1978).*

17. MENTIONING OF THE RECOMMENDATIONS ABOUT STANDARDIZATION.

A presentation of a stabilometric study should state whether the above mentioned recommendations were or were not followed. If not, then the experimental conditions should be described in detail.

CONSIDERATION: The use and mention of the recommendations will promote the standardlzation.

COMMENT: The meeting agrees the intention for growing to standardization in stabilornetry and recommends studies about subjects mentioned before for having a useful and good prepared discussion at the Houston Symposium in 1983.

THE COMMITTEE FOR STANDARDIZATION OF STABILOMETRIC METHODS AND PRESENTATIONS,

T .S. Kapteyn {et President ISP)
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