Introduction to the Russo-Japanese revolution in stabilometry

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Since the work of Inamura [1990] we know that the postural system is also concerned with the control of the return circulation (figure 1).

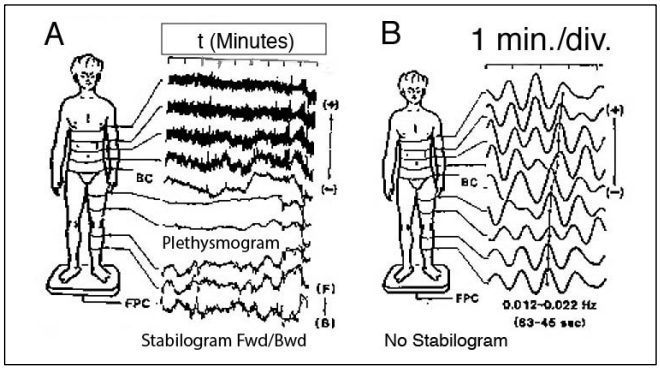

FIG. 1 - Stabilogram / Plethysmogram Comparison; The "One minute wave" of Inamura.

A: Recordings for 9 minutes. Only the Av / Ar stabilogram is shown, in phase opposition to the contours of the leg.

B: Enlargement of a part of A to show the continuity of the volumic wave between the leg and the thorax. In this subject the frequency of the wave is between 0.012 and 0.022 Hz. (Figure reworked after Inamura et al., 1990)

This discovery of Inamura did not change our approach to the stabilometry that we pursued from a purely mechanical point of view, in relation to the stability of the subject, without being able to find how to integrate this discovery into our reflections. At that time venous return was not the focus of our concerns, we were looking to calculate the position of the center of gravity from the position of the center of pressure, which mobilized a large number of teams for decades until in 2016 [Spaepen, 1977; Shimba, 1984; Levine, 1996; King, 1997; Caron, 1997; Zatsiorsky, 1998; Morasso, 1999; Barbier, 2003; Ouaknine, 2004; Gagey B, 2015; Gagey B, 2016].

Recently V. Usachev and V. Belyaev have taken over the long-term stabilometric recordings (7 minutes). They showed migrations, about every minute, of the average point around which the center of pressure stabilizes during this minute (Figure 2).

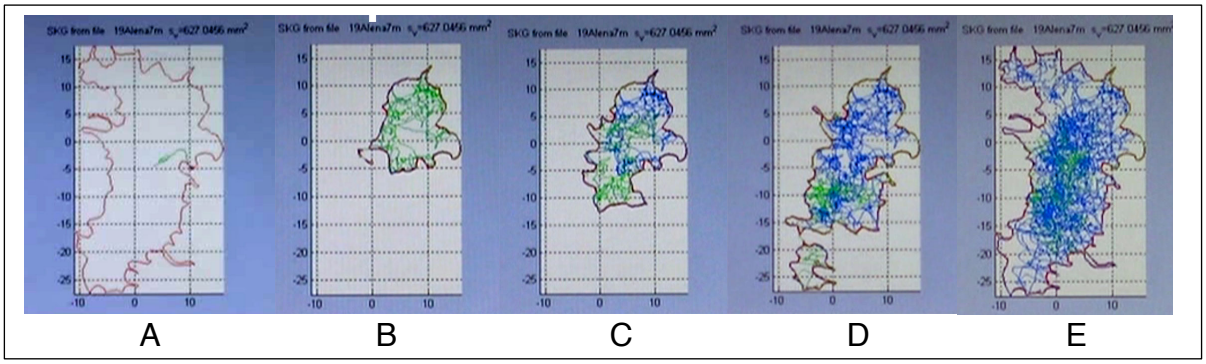

FIG.2 — Movie summary of a recording of seven minutes duration (From the film made by Victor Belyaev, 2017)

A: Contour of the surface that will be occupied by the movements of the pressure center at the end of the seven minutes of the recording. (To give a general idea of the framework of these displacements).

B: Stabilization zone of the center of pressure during the first minute (Freeze frame at the end of the first minute).

C: Zone of stabilization of the center of pressure during the second minute, contiguous to the zone of the first minute (Freeze frame at the end of the second minute).

D: Zone of stabilization of the center of pressure during the fourth minute, clearly shifted from the preceding zones (Freeze frame at the end of the fourth minute).

E: Last picture of the film.

These displacements of the zones of pressure on the plantar sole, and consequently on the venous sole of Lejars (Bourceret, 1885, Lejars, 1890) evoke phenomena related to venous

return, which remain to be confirmed. But on the other hand, the migrations, every minute, of the mean point around which the center of pressure stabilizes during this minute, have immediate consequences on our conception of the stabilometric signal analysis.

We can no longer speak of X-means and Y-means, except in the mode of approximate values, since in fact there is a series of different X-means and Y-means, and the X-mean and Y-mean that are computed on short records represent only particular elements of this series. According to the images of the film the difference would be more important between the Y-means than between the X-means, what is in accordance with the statistically known extents of the deviations of the Y-means, 48 cm, and of the X-means, 2 cm (Normes85).

We can no longer speak of measuring stability since there is no longer ONE mean position of equilibrium; remember that stability is the property of a body that automatically returns to the vicinity of ITS equilibrium position when it is removed from it.

Can we still talk about "Stabilometry"?

The Russians, with the Japanese, already propose "stabilometric" parameters that take into account the complexity of the signal coming from the force platforms, because this signal does not only account for stability phenomena, but also for hemodynamic phenomena [Usachev et al. ., in preparation for].

References

A.F.P. (1985) Normes85. Editées par l'ADAP (Association pour le Développement et l'Application de la posturologie) 20, rue du rendez-vous 75012 Paris.

Barbier F, Allard P, Guelton K, Colobert B, Godillon-Maquinghen AP (2003) Estimation of the 3-D center of mass excursion from force-plate data during standing. IEEE Trans Neural Syst Rehabil Eng. 11, 1 : 31-37.

Belyaev V. (2017) Film of a seven minutes stabilometric recording. http://ada-posturologie.fr/signal.htm [chercher le fichier - Victor Belayev Vidéo d'un enresitrement …/…(Fichier mpg, 134Mo)]

Bourceret (1885) Circulation locale. Procédé d'injection des veines. Note présentée à l'Académie des Sciences.

Caron O., Faure B., Brenière Y. (1997) Estimating the centre of gravity of the body on the basis of the centre of pressure in standing posture. J. Biomechanics, 30: 1169-71.

Gagey B, Bourdeaux O, Gagey PM (2015) From the center of pressure to the center of gravity, a new algorithm for a step forward in stabilometry. MTPRehabJournal, 13: 264-270. doi: 10.17784/mtprehab journal.2015.13.264

Gagey B (2016) Solution théorique et calcul pratique de l'équation du pendule simple inversé dite de Winter. http://ada-posturologie.fr/Programme_Bernard.pdf

Hugon et M. Ouaknine. (2004) L'équilibration posturale se réalise par relaxation entretenue de commandes automatisées. Efficience et Déficiences du Contrôle Postural. Congrès Association Posture et Equilibre. Dijon

Inamura K., Mano T., Iwaze S. (1990) One minute wave of body sway related to muscle pumping during static standing in human.In Brandt T., Paulus W., Bles W. (Eds) Disorders of posture and gait 1990. Georg Thieme (Stuttgart), 53-57.

Inamura K., Mano T., Iwaze S., Yamamoto K. (1992) Changes in functioning mechanisms of one minute wave in body fluid volume during head-up and head-down tiltings in humans. in M. Woollacott & F. Horak (Eds) Posture and gait: control mechanisms. University of Oregon Books (Portland): Vol.II, 79-82.

Inamura K., Mano T., Iwaze S. (1999) Role of Postural Sway as a compensatory Mechanism for Gravitational Stress on the Cardiovascular system. Gait and Posture, 9, suppl.1, S5.

King DlL., Zatsiorsky V.M. (1997) Extracting gravity line displacement from stabilographic recordings. Gait and Posture, 6: 27-38.
Lejars F. (1890) Les veines de la plante du pied. Archives de Physiologie, 5Ième série.
Levine O, Mizrahi J. (1996) An iterative model for the estimation of the trajectory of the center of gravity from bilateral reactive force measurements in standing sway, Gait Posture, 4: 89-99.
Morasso PG, Spada G, Capra R (1999) Computing the COM from the COP in postural sway movements Human Movement Science 18, 759-67,
Shimba T (1984) An estimation of the center of gravity from force platform data. J Biomechnaics, 17, 1: 53-60
Spaepen A.J., Vranken M., Willems E.J. (1977) Comparison of the movements of the center of gravity and of the center of pressure in stabilometric studies. Agressologie, 18, 2: 75-76.
Usachev V, Belyaev V, Kononov A, Gagey PM (en préparation) The SKG area is not an informative parameter of stability
Zatsiorsky VM, King DL. (1998) An algorithm for determining gravity line location from posturographic recordings. J Biomechanics; 31 : 161-164.