SOME PARAMETERS OF MULTI-LOOP BIOFEEDBACK CONTROL OF POSTURE

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INTRODUCJTION

One of the most important functions of biological systems is the feedback. Special case of biofeedback processes is the maintaining of equilibrium e.g. in an upright posture, hand stand etc. The stabilizing of equilibrium requires a multi-loop biofeedback control involving the vestibular, proprioceptive and visual system functions.

The theories and practice of analysing feedback systems have been developed on very high level in engineering. The direct transformation of this technical information and results for biomechanical purposes can hit against difficulties. Although the biological reference element and input, the "summing points", the control and feedback elements as well as the " program " would be difficult to describe exactly and special problems are given in studying parameters of biological information transmission, it seems to be useful to concentrate to the functional relationship of feedback elements and to the controlled output.

In the present study the displacements of centre of pressure as well as the vertical projection of centre of mass, the time functions on anteroposterior and mediolateral directions and Fourier spectra have been recorded in traditional and/or sharpened Romberg positions, with open and closed eyes.Special track tasks with voluntary moving of centre of pressure have been solved by the subjects with audiovisual feedback. Many researchers have investigated the displacements of centre of pressure. Pemn (1989) described basic investigations that mainly interest the sport practician, concerning kinds of sports requiring high accuracy equilibrium.

Boloban (1990) measured balance on acrobats and members of selected teams with special methods. Time function diagrams have been recorded with his "star type" stabilometry device during special exercises of acrobat groups. Technical solutions of stabilometry with practical aspects have been described by Buder-Dahn (1990) Postural modulation and evoked cortical potentials have been recorded simultaneously to investigate afferent and efferent functions (Ackermann et al. 1990). A clinical approach of problematic have been introduced by Clarke, Kryok and Sherer (1990).The effect of sports on postural control has been demonstrated by Crémieux and Mesure (1990). New conceptual and theoretical frameworks have been introduced by Collins and De Luca (1993). Differential equations have been used by Stepan (1994) for modelling a balance problem. Some authors propose the integrated approaches, using a wide range of experimental situations, and keeping in mind the goals that the organisms are trying to achieve. This is probably necessary to evaluate the activity of each sensory input and motor output.

The purposes of this study was collecting data on different age-groups to lay the foundation of mass investigations in the schools as well as special equilibrium measurements in sports requiring high accuracy equilibrium.

SUBJECTS AND METHODS

40 pupils of four age-groups were included in the study: A nursery school, a primary school, a secondary school as well as an university student group took part in the

measurements. It was possible to investigate some special cases: biathlon competitors. acrobats, gymnasts.

Computerised system has been used for the investigations. The equipment includes self-constructed "Adam type" force platform, Psycho 8 differential measurement device, ADDON microcomputer and personal computer.

Two measuring programs have been used.

1.1.Electronic realisation of the traditional Romberg test.

1.2.Movement co-ordination test in connection with the voluntary displacement of centre of mass including an audio-visual biofeedback system.

2.1.Dispersion display of sampled data during the moving of body centre of mass: centre of pressure measurements on the covering plate of platform, completed with time displacement diagrams and Fourier spectra.

The battery of tests includes the following situations: **a.standing** on the platform, looking ahead with arms

a. straight out from the body,

b. as in "a" but with eyes closed,

c. as described in 1.2 using a visual bio-feedback from the computer monitor. With a task of filling in a pre-determined surface (window) on monitor. The results have been automatically evaluated.

Individual examinations:

d.standing in shooting position with biathlon rifle

e.handstand (Detailed information by **Hamza & Bretz),Rem:** measurement time: 20 s.

RESULTS

Table 1. Investigations on pupils and students of different age-groups, ΣN=40

Parameter	Mean values and standard deviations				
	Nursery school	Primary school	Secondary school before exercise	Secondary school after (warming up)	University
Age (years)	6,4 (0,51)	12,6 (0,52)	16		22,5 (1,12)
Height (m)	1,148 (0,08)	1,555 (0,072)	1,787 (0,048)		1,788 (0,076)
Mass (kg)	18,7 (2,7)	43,2 (5,1)	63,6 (10,1)		81,8 (9,05)
Sway R68 (mm) open eyes	7,4 (2,7)	4,3 (1,6)	5,6 (1,8)	6,1 (2,7)	5,2 (1,94)
Sway R68 (mm) closed eyes	8,8 (2,9)	6,5 (2,5)	7,8 (3,1)	6,8 (2,7)	6,7 (2,76)
R2/R1 %	119	151	139	111	126
Coord. perf. %	50 (8,6)	59 (9,5)	55 (7,1)	60,2 (8,5)	63,7 (7,33)
Time perf. %	88,5 (10,3)	91,6 (7,5)	95 (4,9)	97,5 (1,3)	90,8 (8,49)

Additional data are the following:

Acrobat **/20 years/** handstand 40 s. R_{68}= 13 mm

Dominant frequency of sway in mediolateral direction: 0.45 Hz and in anteroposterior direction 0.45 Hz, but in this direction higher frequencies of sway were observed.

Biathlon competitor: Romberg test, closed eyes R_{68}=3 mm; aiming and shooting, **R68=7** mm.

The barrel was parallel to the x axis of the imaginary co-ordinate system. In this direction the body sway amplitudes were significantly less and the frequencies higher then in the other **/Y/** direction.

R_{68} (mm): radius of the characterising circle, which contains 68 % of the sampled data of displacement path. **R2/R1:** relative effect of visual feedback

Coord. perf. %: the subjects try "to scribble all over" a pre-determined windows on the monitor with voluntary moving of centre of pressure, standing on the force form (efficiency factor). Time **perf.** %: percent value of the time the cursor spent in the above mentioned window (efficiency factor)

DISCUSSION

Our former body sway measurements and the present study suggest, that the proposed evaluation method is suitable for comparative investigations. Several results seem to be coherent. Comparing the pupils, we got the best results with the primary school groups **/aged** 12,6 **years/** in Romberg tests. One subject group was measured before and after exercise (secondary school).

The task was running round **.** (Diameter of circle: 3 m. Time: 15 s). After exercise we could observe a clear reduction of body sway amplitudes under eyes closed condition. After this short, so called "warming up" period, the co-ordination performance increased, notwithstanding that it was assumed, the running round loads the vestibular system.

Significant correlation has been found between the results of Romberg test (with closed eyes) and the co-ordination test described above as well as between the co-ordination **test.performance** and the reaction time

Real time visual feedback enhances motivation and helps the subject link perception to movement.

Fourier spectra reflect the nature of the sway and give objective information about amplitudes of harmonic components of body sway as well as the dominant frequencies. **/For** further investigations the methods will be completed with the auto correlation function../

In some cases we found the same results in conditions eyes open and eyes closed. We assume, that in some kinds of sports, for instance in biathlon, the information coming from the proprioceptive system, are integrated to the sensory brain structures on significantly higher level, then at the majority of untrained persons.

In conclusion the results underline the role of training. and suggest to introduce special balance exercises in the nursery and primary schools.

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