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# *Current Research in Motor Control III*

## FROM THEORIES TO CLINICAL APPLICATIONS

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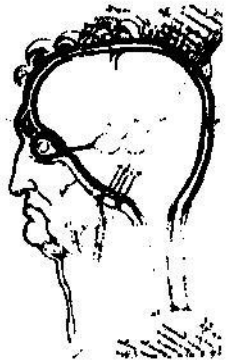

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# Concurrent measurement of lower limbs stability in balance examinations

## INTRODUCTION

In order to be in a state of balance a standing man is performing minor movements, which aim to sustain continuously shifting point of application of resultant force of center of pressure (COP) within the precincts of supporting plane. “Cop is the sum of signal of center of gravity (COG) and correction forces generated by adequate muscles” [6].

“Maintenance of balance of a man is very specific movement activity, which requires precise cooperation of all body segments in result of dynamic processes proceeding beyond consciousness” [3]. “The control of balance depends on static and dynamic compensation destabilizing forces of gravity and inertia (and also their moments) by stimulation of adequate group of muscles” [1].

A man moves his body weight from one limb to the other one. This is visible through permanent change of value with which left and right lower limb force on supporting plane. This phenomenon is called balancing [5]. Balancing can be measured by frequency and amplitude of changes of pressure forces during moving the body weight from one limb to another.

A man also changes distribution of pressure forces acting on the supporting plane. It is visible through the change of location of points of application of resultant force of base, coming from lower limbs: right (center of pressure leg right - COPLR) and left (center of pressure leg left - COPLL). It is confirmed by measurement of pressure force as well as assigned points of statokinezjograms [4].

## METHODS

Examination of such a behavior of a man gives possibility of detection of asymmetry of lower limbs load and measurement of their values. The possibility of separate examination of each limb is substantial premise enabling accurate assessment of phenomenon of balance, weight stability and symmetry of lower limbs load. Such a broadening of examinating methods in stabilography can contribute to verification of many already existing opinions in this discipline. These human behaviors, which strongly differ examinated persons, are not measurable when using one platform posturograph.

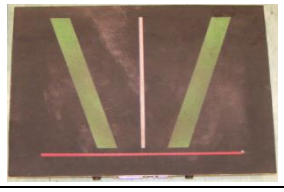
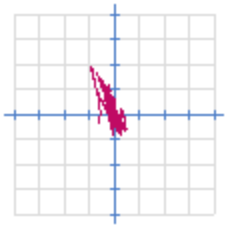
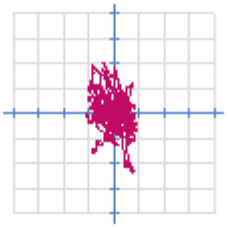
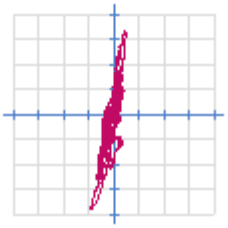
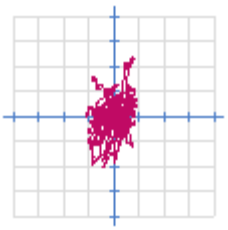
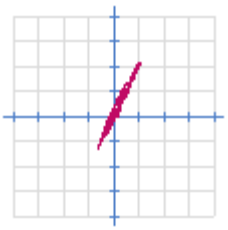
This article indicates the necessity of performing concurrent measurement of separate actions of lower limbs during examination of balance. Such a method of measurements ensures two platform stabilographic scale (picture no. 1) produced by „CQ Elektronik System” from Czernica Wrocławska (7). The owner of the company Mr. Świerc constructed this device and software, which performs tasks worked out with the coauthor of this publication Mr. Strzecha.

One platform posturograph registers signal describing relocation COP. Two platform stabilographic scale offers widen possibilities. It registers the same parameters as one platform posturograph, moreover it registers signals describing relocation of points of application of plane force coming from right ($COP_{LR}$) and left lower limb ($COP_{LL}$).


Picture. 1. Two platform stabilographical scale of „CQ Elektronik System" [7]

Below there are presented results obtained during examinations preformed on one and two platform stabilographic scales during test "standing freely" with opened eyes. In the central column (Table no.1) there are statokinezjograms, which are obtained on one platform posturograph. In the second and forth column there are statokinezjograms obtained from two platform posturograph (two platform stabilographical scale).

Table 1. The results obtained in examinations preformed on one and two platform stabilograph

| Posturograph | Right platform | One platform | Left paltform |
|---|---|---|---|
| |  |  |  |
| Examined person | $COP_{LL}$ | COP | $COP_{LR}$ |
| A |  |  |  |
| B |  |  |  |

During analysis of statokinezjograms of a person shown in the central column (Table no.1), it is difficult to distinguish differences in COP pictures. On their base it was only that the examinated persons have “similar” state of balance. But when compared statokinezjograms of left ($COP_{LL}$) and right lower limb ($COP_{LR}$) considerable differences can be seen. It can be claimed that person A has more stabile left lower limb, when person B has more stabile right lower limb.

This example show necessity of performing in stabilographic examinations of movement of COP by concurrent and independent measurement of movement of COPLL and COPLR

The most common examination of balance is “Romberg’s Test”. In order to present possibilities of two platform stabilographical scale the exemplification of results will be used.

“Romberg’s Test with point tracking” examines symmetry and stability of load of lower limbs and also influence of visual perception on these parameters. Test consists of two attempts lasting 30 s. Each attempt is preceded by 20 s. training. During the first attempt a person is standing freely with opened eyes, arms along sides. A person has to place “moving cross” in the middle of the computer screen. Later the person is instructed to close his eyes, and after another 20 lasting training the second attempt continues- this time with closed eyes.

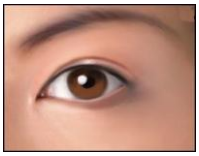
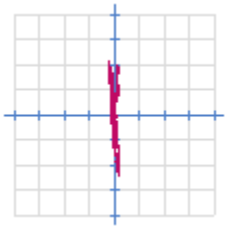
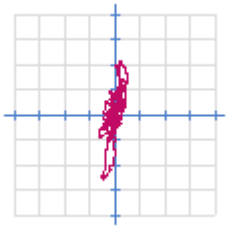
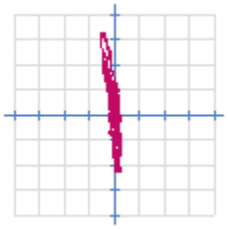
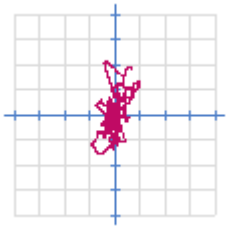
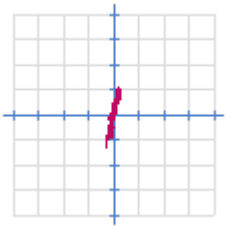
Necessity of „training” are justified by results of optimal duration time of examinations preformed on stabilographical force platforms [2]. Two meters away from an examined person, on the height of eye level there was a screen showing a picture, which dimensions were of 30x30cm.

As a result of „Romberg’s Test with point tracing” (Table no. 2) following results were obtained:

- pictures of statokinezjograms in attempts with opened and closed eyes,
- Romberg coefficient’s value (value obtained in the attempt with opened eyes to the one obtained in the attempt with closed eyes) measured for the sway area determined by relocating COP point,
- Romberg coefficient’s value (value obtained in the attempt with opened eyes to the one obtained in the attempt with closed eyes) measured for the sway area determined by relocating COPLR and COPLL points.

Before the beginning of the test there was expectation that the coefficient’s value Romberg (RQ) measured for the sway area determined by relocating $COP_{LR}$ and $COP_{LL}$ points will differ. The preformed examinations have corresponded with the assumptions. It was anticipated also that the coefficient’s value measured for the sway area determined by relocating COP will have an average value coming from right $COP_{LR}$ and left $COP_{LL}$ limb. The realized examinations has not confirmed these expectations (values in Table no. 2).

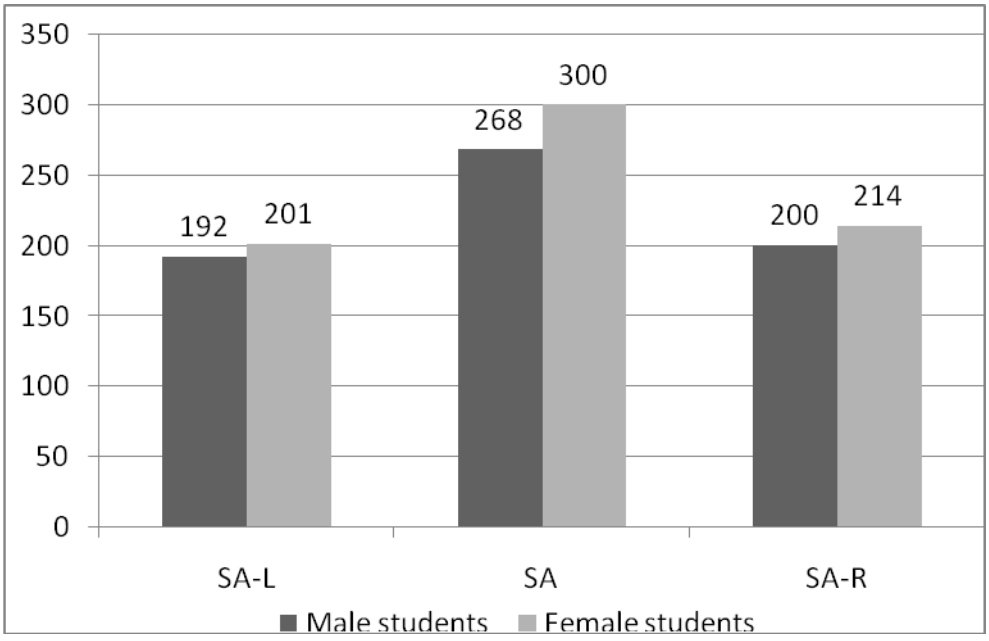
Table 2. Romberg coefficient's value of examined person (an example)

| eyes | $COP_{LL}$ | COP | $COP_{LR}$ |
|---|---|---|---|
|  opened |  |  |  |
|  closed |  |  |  |
| RQ | 1,25 | 1,56 | 0,68 |

RESULTS

Hereby are presented fragmentary results of examinations carried out on the group of 52 students (34 male and 18 female ). These results present extended possibilities of examinations enabled by usage of two platform stabilographic scale.

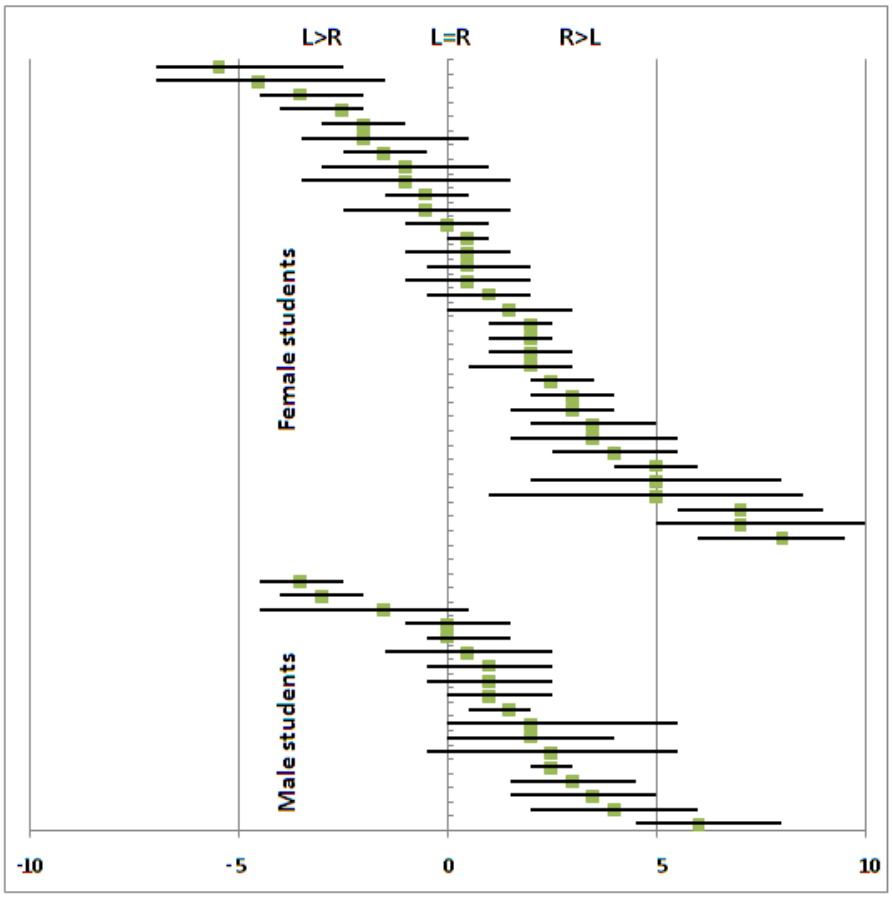
The average value of the sway area (SA) measured in standard way (Graph 1) is much bigger than the values measured separately for left (SA-L) and right (SA-R) lower limb. The difference between female and male group of students is also visible. In both groups the average value of the sway area measured by relocating $COP_{LL}$ are smaller than the one for $COP_{LR}$ indicating higher stability of left lower limb.




Graph 1. Average values SA (sway area) measured for: COP, $COP_{LR}$ and $COP_{LL}$ in groups in $mm^2$

Meaningful differences between sway area (SA) measured in the standard way and sway area measured separately for left lower limb (SA-L) and right lower limb (SA-R) reach 30% and are arising from continuous shifting body weight from one to other lower limb by persons.

The balancing phenomenon of continuous shifting the body weight from one to another lower limb shows graph 2. On the per cent scale there are placed the results of persons, represented by an interval and a point (square). The interval represents the range of the balancing for each person indicating range between minimal and maximal percentage load of lower limbs determined during the examination. The square on the interval indicates the average value of balance measurement determined during the entire examination from each sampling period (frequency 200Hz).




Graph 2. Asymmetry (in %) of the load of lower limbs in the attempt with opened eyes in “Romberg’s Test with trading point”

The majority of examined persons; female (13) as well as male (22) put much more weight on right lower limb. The balance of lower limbs was only measured in 3 cases. By this three persons the average value from the whole examinations was equal zero. The range of balancing, which is difference between minimal and maximal per cent value of load acting on lower limbs was diverse by persons. By some of them reached only 1% when by others reached as much as 7%. These facts also speak in favor of implementation of concurrent measurement of lower limbs stability

Essential innovation is also the change in the mechanical construction of the platform scale enabling reciprocal shifting of the platform's location (picture 2). Such a solution created the possibility of performing examinations in positions characteristic for sport's discipline.

Picture. 2. Possibilities of reciprocal shirting platforms

In the article were presented new cognitive possibilities connected with implementation of new measuring techniques into stabilography which can be measured with the usage of two platform stabilographic scale. The presented results indicate the necessity of concurrent and separate examination of both lower limbs with registration of former parameters describing relocation of COP.

In order to evaluate degree of symmetry of the load on lower limbs as well as influence of visual perception onto load's condition the authors developed following set of tests:

- "Romberg's Test with tracing point" testing symmetry and stability of load of lower limbs in position "standing freely",
- "Front and back deflection", testing efficiency of state of balance in arrow plane and determining safety margins and ranges of front and back stability of lower limbs,
- "Right (left) lower limb resting", testing the value of asymmetry of lower limbs load in position of freely standing right (left) lower limb;
- "72/25 right (left) lower limb" testing possibility to sustains ordered value of load on lower limb and ability of kinesthetic differentiation";
- „One foot forward, one foot backward in position as on balance beam", testing side stability of lower limbs characteristic for particular position;
- "Wrestling stand right" (left), testing proportions and stability of lower limbs in position characteristic for wrestling
- „One foot forward, one foot backward", testing proportions and stability of lower limbs in position of increased supporting plane;

The results carried out in these tests indicate necessity of separate examination of both lower limbs concurrently when checking stability.

ABSTRACT

Presented new method of measurement of balance enables measurement of weighting symmetry of lower limbs. Presented set of tests used for measurement of weighting symmetry of lower limbs and influence of visual perception on their results.

In pilot study preformed with the set of these tests following observations were made:

- meaningful differences between sway area value of statokinezjograms measured by COP and sway areas value of statokinezjograms measured concurrently and separately for both left and right lower limbs,
- much higher load placed on the right than on the left lower limb,
- meaningful disproportions in stability between left and right lower limb.

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