# MIMU BASED POSTUROGRAPHY: COMPARISON OF METHODS

**Annamaria Guiotto (1), Elena Pegolo (1), Zimi Sawacha (1,2)**

*1. Dept of Information Engineering, University of Padua, Italy; 2. Dept of Medicine, University of Padua, Italy*

## Introduction

The application of Inertial Measurement Units (IMU) and Magneto IMU (MIMU) use is increasing in posturography, both in healthy and in pathological subjects, as demonstrated by the high number of papers focusing on this topic [1-2].

Posturography is considered the gold standard objective measure of standing postural control. The main measures of assessing balance are generally derived from the center of pressure (COP) (i.e. time-domain measures, frequency-domain measures), through force/balance plates [3-4] (COP approach, A-COP). Recently some attention has been paid to the possibility of extracting similar measures from the center of mass (COM) [4] or through MIMU [1], directly from the acceleration measured by sensors positioned close to the COM [2] (acceleration approach, A-ACC) or from the reconstructed position of the center of gravity (COG - projection of COM on the base of support, COG approach, A-COG) [5-6]. The aim of this study was to compare the posturographic parameters calculated with the above mentioned approaches: 1. from the COM trajectory measured through the trajectory of a marker positioned on the 5th lumbar vertebra [4] (A-L5), 2. A-ACC [2], 3. A-COG [5], 4. A-COP.

## Methods

Instrumented posturography data were acquired on 13 healthy subjects (4M-9M, mean age 27.5±4.3 years, mean BMI 22.5±1.8 kg/m2, 41.4±1.8 shoe size), through a MIMU sensor (Muse, 221e srl, Italy, 100 Hz) positioned in correspondence of the 5$^{th}$ lumbar vertebra, fixed through an elastic band (A-ACC and A-COG), and simultaneously through a force plate (Bertec corp, FP6040, 200 Hz) as gold standard (A-COP) [3-4] and a stereophotogrammetric system (SMART-D, Bts srl, 200 Hz) (for A-L5). Subjects stood for 60 seconds with their eyes open and closed, in upright position with their arms along the body and their feet 30° apart (assured through a cardboard triangle), looking at a target, at eye level, 5 meters away. After a calibration refinement, MIMU data were processed as in [2] for A-ACC and by applying a Kalman extended filter for A-COG [5-6], and posturographic parameters extracted. A-COP and A-L5 parameters were calculated as in [2-3]. The measures obtained in A-L5 and A-COG were compared by computing the root mean square error (RMSE). Pearson's correlation analysis was performed among the different posturographic measures.

## Results

Results of the comparison between A-L5 and A-COG showed a RMSE of 22.1±2.1 and of 26.1±10.7 mm (mean±sd among all the subjects' data) in the medial-lateral and anterior-posterior direction respectively. Results of the Pearson's correlations coefficients showed excellent to good correlation in the ellipse area and sway area between A-COP/A-L5/A-COG, very good correlation in sway path between A-L5/A-COG, moderate correlation in the ellipse area between A-COP/A-L5/A-ACC (see Table 1).

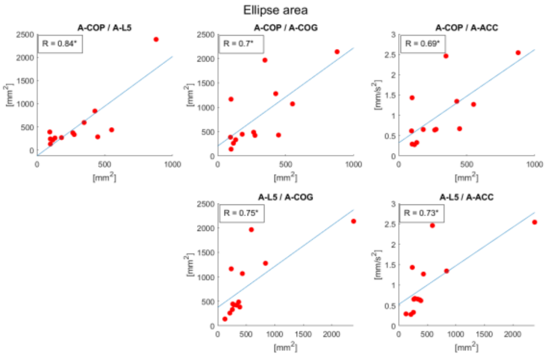


*Figure 1. Scatterplot with regression line and Person's correlation coefficient (R). * Statistically significant correlation.*

## Conclusions

Several methods to perform posturography were compared. Not all the parameters based on MIMU correlate significantly or well with the parameters from A-COP. A-ACC and A-COG showed encouraging results for future applications of balance assessment in daily living environments.

## References

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*Table 1: Results of the Pearson's correlation in some parameters as example. Bold numbers indicate a statistically significant correlation.*

| | A-COP / A-L5 | A-COP / A-COG | A-L5 / A-COG | A-COP / A-ACC | A-L5 / A-ACC |
|---|---|---|---|---|---|
| Ellipse area | **0.84** | **0.71** | **0.75** | **0.69** | **0.73** |
| Sway area | **0.90** | **0.83** | **0.95** | 0.33 | 0.46 |
| Sway path | 0.35 | 0.48 | **0.83** | -0.45 | 0.06 |
| AP median frequency | 0.13 | -0.03 | 0.19 | -0.05 | 0.00 |