P-81 Vision based Mediolateral Centre of Mass Sway during Still-standing as Balance Indicator: Proof of Concept Study

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BACKGROUND

- **Postural instability** has become **a major public health concern**, highlighting the need for objective assessment of postural control
- **Conventional clinical balance tests** are simple to administer, but **limited by subjectivity and ceiling effects**.
- **Parameters from force plates** have additionally been used to quantify balance performance, the high cost and poor portability limit their clinical applicability.

OBJECTIVE

This study aims to explore the feasibility of using a single camera as a more accessible, alternative quantitative assessment tool for evaluating postural stability in clinical settings

METHODS

▶ **Participants :** 15 healthy adults

▶ **Experimental setting**

- For each participants, static balance was assessed under four experimental conditions, each lasting 32 seconds

1) NO: normal position with eyes open
2) NC: normal position with eyes closed
3) PO: eyes open on pillows
4) PC: eyes closed on pillows

- The center of pressure (COP) was recorded using a Tetra – ataxiometric posturography (Tetrax) and kinematic data were captured simultaneously with three iPad Pro 11 cameras. (Fig. 1)

▶ **Balance parameters**

- The COP in the mediolateral (ML) and anteroposterior(AP) directions was computed from the vertical forces of the four plates of Tetrax.
- The center of mass (COM)was estimated as a weighted average of 2D body keypoints extracted by a customized pose estimation model applied to videos recorded with three iPad Pro 11 cameras (Fig.2)
- The COP and COM time series were temporally aligned based on time-lagged cross-correlation(±0.5 s window around audio cues).
- After synchronization, the root-mean-square(RMS) sway amplitude and mean velocity(MV) were computed for both COM and COP, in the ML and AP directions, respectively.

▶ Pearson correlation coefficients were calculated between ML COP sway and ML COM sway, and between COP RMS and MV in the ML and AP directions and each of the COM RMS and MV measures under every condition.

Figure 1

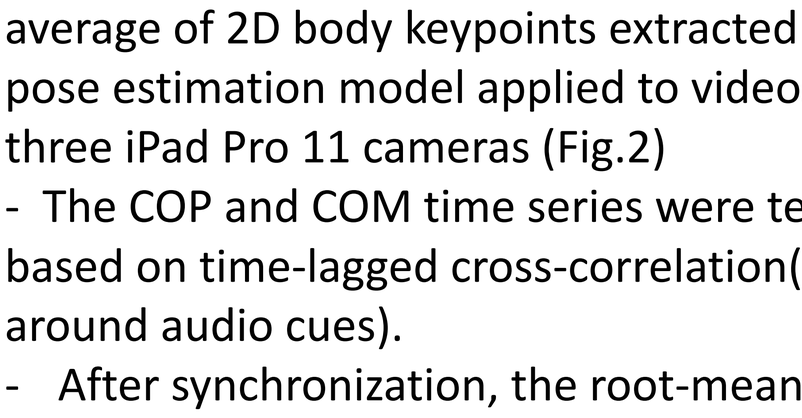

Figure 2

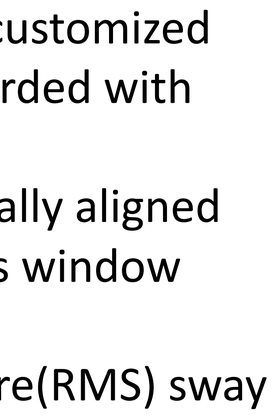

Fig 1. Experimental setting Data were simultaneously recorded using a Tetra-ataxiometric posturography system and three RGB camera of an Apple iPad Pro 11. IPad1 was placed on a stand at a height of 80 cm, 2 m directly in front of the participant, iPad2 was placed on the floor level, 2 m in front of the participant, iPad3 was held manually by an assistant to simulate a handheld device condition. In the Tetrax system, the axes were defined as X, Y, and Z, and pressures were measured on four plates separated into forefoot and heel regions, as illustrated in the figure.

Fig2. An example of 2D pose estimation. Time-series data for body keypoints are extracted from 2D images from videos recorded with three iPad cameras.

RESULTS

- The participants had a mean age of 36 ± 6 years (range 28–53), and 13 of them were male and two were female. The mean height, weight, and body mass index were 173.2 ± 7.9 cm, 75.4 ± 8.8 kg, and 35.7 ± 6.4 kg/m², respectively.

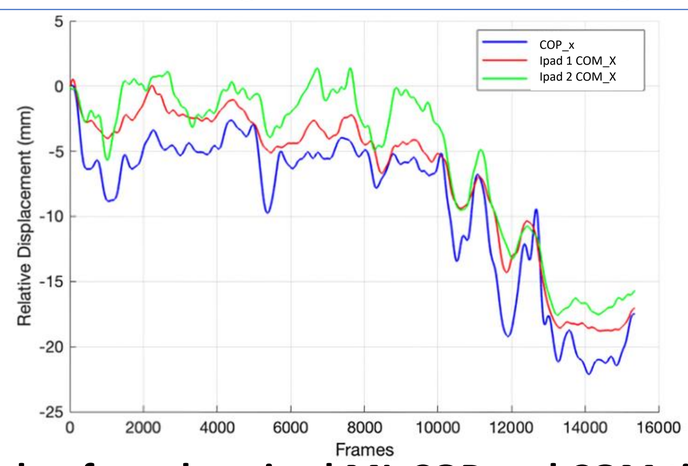

Figure 2. Example of synchronized ML COP and COM time-series
Time-series of ML COP and COM from iPads 1 and 2 are shown after temporal synchronization; iPad 3 data were excluded because excessive hand motion caused marked recording artifacts.

Table 1. Correlations between mediolateral COP sway and COM sway

(vs. ML COP)	NO	NC	PO	PC
ML COM_1	0.88±0.10 (0.64–0.98)	0.89±0.06 (0.77–0.98)	0.89±0.07 (0.74–0.98)	0.87±0.09 (0.67–0.99)
ML COM_2	0.89±0.06 (0.76–0.98)	0.88±0.06 (0.77–0.97)	0.90±0.07 (0.75–0.98)	0.88±0.06 (0.77–0.97)

Values are mean ± standard deviation (range)

Table 2. Pearson correlation between pose-estimated variables and posturography variables.

		ML CoM_1 RMS	ML CoM_1 MV	ML CoM_2 RMS	ML CoM_2 MV
NO	ML COP RMS	0.86**	0.03	0.96**	0.70*
	ML COP MV	0.17	0.14	0.42	0.32
	AP COP RMS	0.35	0.20	0.22	0.18
	AP COP MV	0.37	0.08	0.29	0.07
NC	ML COP RMS	0.70*	0.17	0.78**	0.27
	ML COP MV	0.00	0.01	0.13	-0.23
	AP COP RMS	0.30	0.22	0.39	0.05
	AP COP MV	0.03	0.09	0.14	0.13
PO	ML COP RMS	0.86**	0.24	0.91**	0.16
	ML COP MV	0.09	0.07	0.16	0.22
	AP COP RMS	0.70*	0.48	0.64*	0.10
	AP COP MV	-0.35	-0.19	-0.21	0.07
PC	ML COP RMS	0.97**	0.41	0.97**	0.43
	ML COP MV	0.44	0.29	0.45	0.52*
	AP COP RMS	0.43	0.21	0.36	0.14
	AP COP MV	-0.37	-0.18	-0.33	-0.09

Values are mean ± standard deviation (range)
p-value < 0.05 (*), p-value < 0.001 (**)
CoM_1, CoM_2 parameters derived from kinematic data from IPAD 1, 2 respectively

CONCLUSION

- **ML COM sway and RMS, from 2D pose-estimation videos** acquired by tablet devices, showed consistently **strong correlations with force-plate-derived ML COP sway and RMS** across multiple standing conditions
- **ML COM RMS** may serve as **a practical substitute for COP-based sway magnitude**, potentially enabling an accessible, camera-based evaluation of quiet-standing balance in clinical settings.

ACKNOWLEDGEMENTS

This research was supported by a grant from the Patient-Centered Clinical Research Coordinating Center (PACEN) funded by the Ministry of Health & Welfare, Republic of Korea (grant no. HC21C0064).