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ABSTRACT BOOK

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P3-H-63 The path curvature of the body centre of mass during walking as an index of balance control in patients with Multiple Sclerosis

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BACKGROUND AND AIM: The path curvature of the centre of mass (CM), mechanically representative of the whole body system, may provide hints to detection of fall risk during walking. Here, an example is taken from results of an ongoing controlled study. It shows the comparison between the CM path in a healthy subject and in a fully autonomous patient with Multiple Sclerosis (MS). **METHODS:** A representative healthy subject (woman, 26 years, 1.55 m tall) and a MS patient (woman, 34 years, 1.65 m tall, with very mild left hemiparesis) are presented. Subjects walked on a force-sensorized treadmill (1) at 0.6 m/s. Data were averaged across 6 subsequent strides. The 3D displacements of the CM were computed via double integration of the ground reaction forces (Cavagna's Method). The path curvature of the CM during one stride was computed according to the Frenet-Serret formula (2). The instantaneous efficiency of the kinetic-potential, pendulum-like energy transfer of the CM was also computed (percent recovery, R: 100%=complete recovery, i.e. fully passive CM translation) (3). **RESULTS:** The left and right panels refer to the control and the MS subject, respectively. In the upper set of panels the human sketches on top of the figure help identifying the stride phases (% cycle) and give a frontal and a sagittal perspectives. The first and second rows of curves from the top give the instantaneous R and the path curvature of the CM during one stride. Each step begins with the single stance of the front leg (R=right; L=left). The horizontal bars under the curves mark the double and the single stance phases (continuous and dashed lines, respectively; grey tract=left step). The lower set of panels (closed curves) gives the planar projections of the CM path during the same stride. The space-time correspondence between the 2 sets of curves is facilitated by the shared A-D labeling of peak curvatures and the shared graphic conventions (dashed line=single stance; gray tract=left step). In both steps the curvature is peaking when R suddenly drops from 100 to 0, demonstrating that the passive pendulum-like mechanism of translation is briskly substituted by a short lasting, fully muscle-driven, propulsion. The highest peaks (A and C) are coincident with the lateral redirection during single stance. Of note, the patient's CM path is characterized by a 10-fold higher C peak (single stance, paretic-to-unaffected side redirection). This may be interpreted as a feature of "escape" limp, barely perceivable by clinical observation, when seen from the perspective of the body CM on the horizontal plane (bottom curves). **CONCLUSIONS:** Increased curvature peaks may reveal the attempt to shorten the stance on the affected side yet, placing at risk the lateral stability of the body. **REFERENCES:**[1] Tesio L, Rota V, Am J Phys Med Rehabil 2008;87:515-526 [2] Tesio L et al, J Biomech 2011;44:732-740 [3] Cavagna GA, J Appl Physiol 1975;39:174-179.

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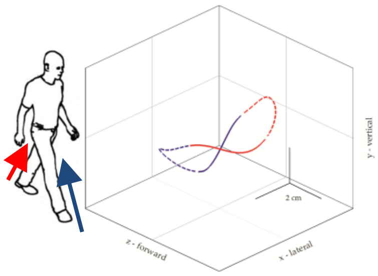


Background and Aim

Many neurologic disorders, such as Multiple Sclerosis (MS), are associated with balance impairments causing an increased risk for falls during walking. Looking at gait from the perspective of the whole-body system (represented by its centre of mass, CoM) might help to detect and interpret segmental anomalies.

The purpose of this study was to describe the curvature (1/radius; m^{-1}) of the 3D path of the CoM during walking in patients with MS reporting balance deficits.

Methods

Ten patients diagnosed with MS (34 - 55 years; 6 women), and ten healthy controls (22 - 31 years; 5 women) were enrolled. Subjects walked on a force-sensorized treadmill at 0.6 m s^{-1} (1).

The 3D displacements of the CoM were computed via double integration of the ground reaction forces.

The instantaneous efficiency of the pendulum-like energy transfer of the CoM was computed as the recovery index, R (100% = complete passive transfer) (3).

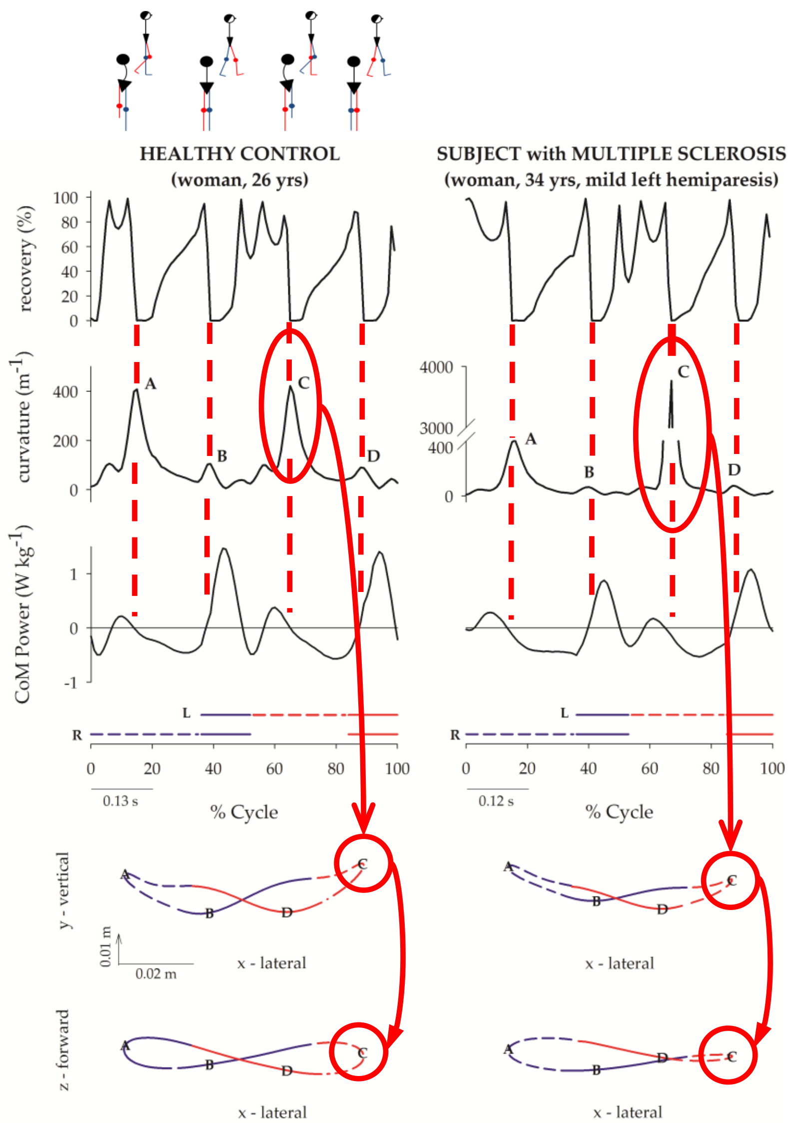
The 3D path curvature of the CoM was computed according to the Frenet-Serret formula (2).

Results

Curvature peaks occur when %R suddenly drops to 0%, indicating that the passive pendulum-like mechanism of translation of the CoM is briskly substituted for by a fully muscle-driven control.

The highest curvature peaks are coincident with a very fast (<80 ms) and sharp (radius of curvature <4 mm) lateral redirection of the CoM path.

In MS patient, the curvature is sharper (10-fold higher peak) during the single stance on the more affected side, consistent with a highly asymmetric path in the frontal plane and the need for a demanding neural control.



Representative means of 20 subsequent strides of one healthy control (left) and one MS subject (right) walking at 0.6 m s^{-1}. From top to bottom: the instantaneous %R, the path curvature of the CoM, the external power applied to the CoM, the double and the single stance phases as a function of the normalized stride period; the y-x and the z-x planar projections of the CoM path during the same mean stride.

Conclusions

Increased curvature peaks may reveal the attempt to shorten the single stance on the affected side yet, placing at risk the lateral stability of the body. The path curvature of the CoM might represent a promising index of balance control during walking in MS and other motor impairments.

References

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2. Tesio, L., Rota, V., and Perucca, L. (2011). *The 3D trajectory of the body centre of mass during adult human walking: Evidence for a speed-curvature power law*. J. Biomech. 44, 732–740.
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