Stabilometric study of the effect of heel height on postural control

Thierry FERRUS, Arnaud de TAUZIA,
Pierre-Marie GAGEY, Philippe VILLENEUVE
API 20, rue du Rendez-vous 75012 Paris

Introduction

The evidence that human body standing upright quiet pivots around its ankles to stabilize itself, deserves to be critized. Theoretically, indeed, an inverted pendulum can be stabilized by a mobilization of its center of pressure alone (COP tactics). And the degree of freedom between ground and plantar sole allows the tiny clearances of postural sway (± 0.13°) that can be produced by plantar muscles [1, 2]. Movements around ankles are not necessary for stabilizing body

Aim

Is it possible to check by an analysis of the stabilometric signal that subjects mobilize or not their centre of mass (COM tactics) from their ankles?

Method

It is enough to show that reduction of the intrinsic stiffness of the Achilles' tendon brings about an increase of the variance of the speed of COP displacements, witness of an increase in calf muscles activity [2].

The reduction of the Achilles' tendon stiffness was obtained by heightening of 3, 6 and 9 centimeters the heels of Parisian cabaret dancers, accustomed to carry these high and very high heels


Shoe with a nine centimeters heel (9) Lines indicate the other heights of heels: Ø, 3 and 6 centimeters

The variance of the speed of COP displacements was calculated from the signal collected, according to the standards of the French Association of Posturologie (AFP) [3], in eyes open situation, by a Fusyo® platform [the Fusyo® platform is a force platform for stabilometry built according to the specifications of AFP [4], moreover its surface is covered with a podometer].
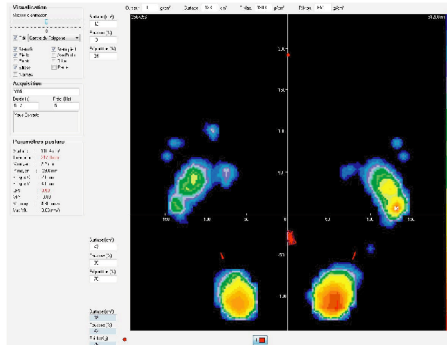

Fusyo® recording at Ø cm
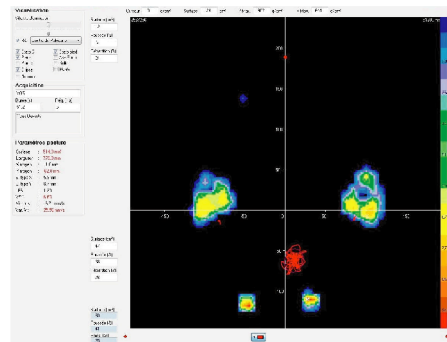
Fusyo® recording at 9 cm

Statistical analysis was concerned with the four categories of the controlled factor (height of the heels: 0, 3, 6 et 9 cm) and with seven random variables (the stabilometric parameters X-mean, Y-mean, area of the 90% confidence ellipse, speed standard deviation, ANØ2X, ANØ2Y). After checking distributions and, if necessary, normalizing them, the data were analyzed by a principal component analysis (PCA) and modeled by an ANOVA of one factor. The normality of residues was graphically checked, and their independence by the test of Durbin-Watson. Multiple comparisons tests were used.

Results
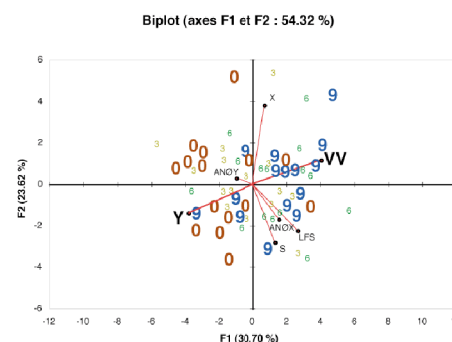
Projection on the first two axis of the PCA The zeros are on the left (no heels), the 9 on the right (heels of 9 cm), the 3 and 6 in between

Projection on the first two axes of the PCA shows a clear separation: the zeros are on the left (no heels) the 9 on the right (heels of 9 cm), the 3 and 6 in between, and this separation appears along the first axis, which is very strongly correlated with the parameter of variance of the speed (VV) [r=-0.899] and with the parameter Y-mean (Y) [r=-0.842]. The other parameters, not so much correlated with the first axis [X, r=0.159; S, r=0.298; ANØ2X, r=0.345; ANØ2Y, r=-0.218]. do not intervene in this partition, except the LFS parameter [r=0.593].

The ANOVA confirms the very strong correlation between the parameter of variance of the speed and the parameter Y-mean [r=0.779]. Only the parameters of variance of the speed and the LFS are modified by the wearing of the heels in a statistically significant way ($p < 0.01$) for the 6 and 9 centimeters heights, compared with the absence of any heel.

Discussion

These results confirm the work of Loram and Lakie [2] the Achilles' tendon stiffness insufficiency is compensated for by an activity of the calf muscles. But these results apply to the group and under these particular conditions of the experiment, we have only the right to say that, overall, these dancers, when they carry high heels, use a COM tactics from the ankles, indeed.

This result can appear ridiculous…. If one forgets to deploy its corollary: a population which presents a different correlation between the variance of the speed of the COP displacements and the variations of Achilles' tendon stiffness can legitimately be suspected not to use COM tactics

The reduction of Achilles' tendon stiffness was obtained by an opening of the angle of dorsiflexion, this opening can be obtained by other processes than by the wearing of heels, for example a reduction of the forward body bending. In fact a correlation has already been noticed between the variance of the speed and the average position of the COP along the antero-posterior axis [5].

References

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