Online Supplement

A. The mechanisms of slip induced on the treadmill

During over-ground walking, the velocity of the base of support (BOS) is near stationary (its velocity ≈ 0) during a single stance phase, while the velocity of the body center of mass (COM) is in forward direction nearly at a constant level ($+v_0$). (Here the positive sign for velocity means that it is in the forward direction, Fig. S-a). The relative velocity between the COM and the BOS is $+v_0 - 0 = v_0$. In a over-ground slip, the BOS of the slipping foot moves with the moveable platform carrying a forward velocity ($+\Delta v$) while the body COM still travels with the forward velocity ($+v_0$) (Fig. S-b). (There is little change in the absolute velocity of the COM during a slip.) The relative velocity between the two is now $+v_0 - (+\Delta v)$, or $v_0 - \Delta v$. Consequently, it causes the slip disturbance of Δv.

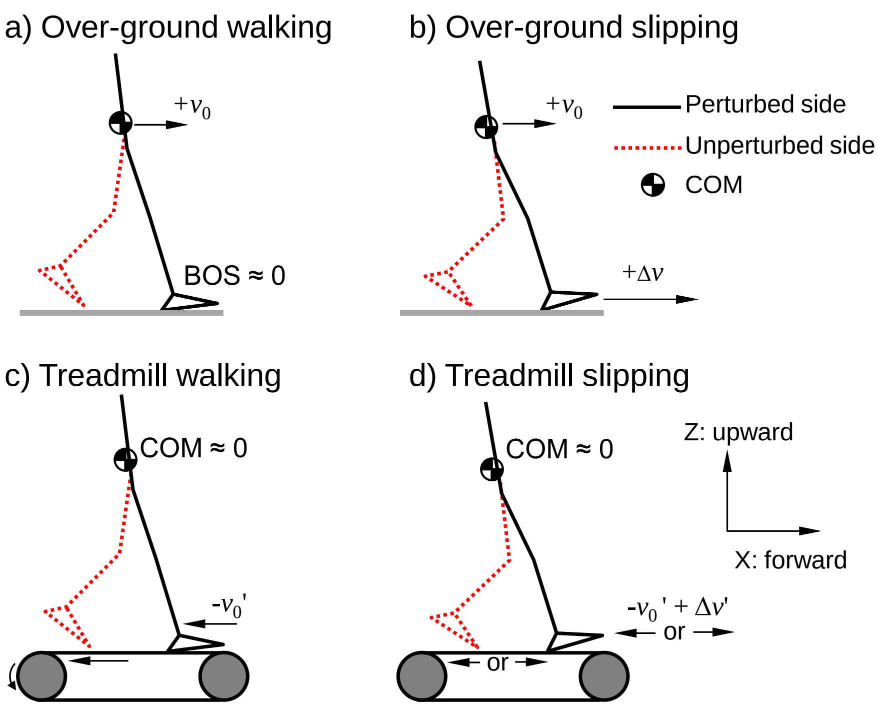

Fig. S Schematic illustrations of relative velocity of the body center of mass (COM) and base of support (BOS) during a) over-ground walking, b) over-ground slipping perturbation, c) treadmill walking, and d) treadmill slipping perturbation.

During a treadmill walking, the body COM absolute velocity is near 0 (Fig. S-c). When the treadmill belt moves in the backward direction with stance foot on top of it travelling at a constant velocity ($-v_0'$, Fig. S-c), the relative velocity between the two is $0 - (-v_0') = v_0'$ (Fig. S-c). When the moving belt suddenly gets a forward acceleration that reduces its backward velocity by the amount of $+\Delta v'$, the belt (or BOS) velocity is now ($-v_0' + \Delta v'$). We found that when this happens, the absolute COM velocity did little change; that it remains ≈ 0. The relative velocity between the two is then $0 - (-v_0' + \Delta v')$, or it is equal to $v_0' - \Delta v'$ with a slip disturbance of $\Delta v'$ (Fig. S-d). The treadmill velocity of v_0' has been set in a manner comparable to average walking velocity of v_0. The treadmill belt disturbance of $\Delta v'$ has therefore an effect comparable to the slip disturbance of Δv during over-ground walking.

B. Kinematics of slip induced on the treadmill

Each slip trial on treadmill always began with 1.5-s ramp up, followed by an approximately 4-second, steady state, moving belt speed (v_0) of -1.2 m/s (negative means moving backward, Fig. 2c). Based on the average results of the moveable-platform kinematics during a slip (Table 2), the initial slip acceleration (a) was set at 12 m/s^2 in the perturbation profile first used in the treadmill-slip training (Figs. 2c and 3, Table 2). The duration (Δt) was set at 0.2 s in this and in all profiles. From equation A, the final belt moving speed at the end of this perturbation (v_f at instant D in Fig. 2c) was then 1.2 m/s (positive means moving forward), or a *peak slip velocity equivalent* of 2.4 m/s and the slip distance (l) be 0.24 m.

$$\begin{cases} l = \frac{1}{2}\left(v_f - v_0\right)\Delta t \\ a = \frac{v_f - v_0}{\Delta t} \end{cases} \qquad \text{(A)}$$