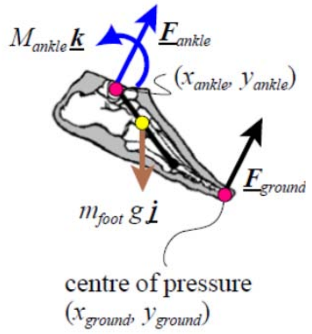
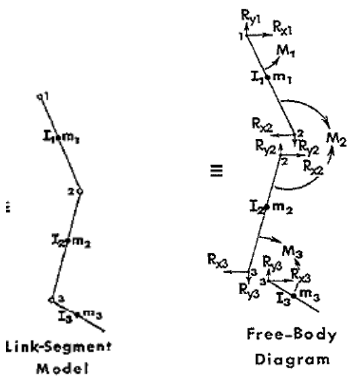
M. Cerioli **Biomechanical bases of motor control development: towards the equations of an intersegmental model?**



Forces acting on the link-segment model are gravitational, ground reaction or external, muscle and ligament forces.



(1)

Equations (1)

1a. $\Sigma F_x = ma_x$

1b. $R_{xp} - R_{xd} = ma_x$

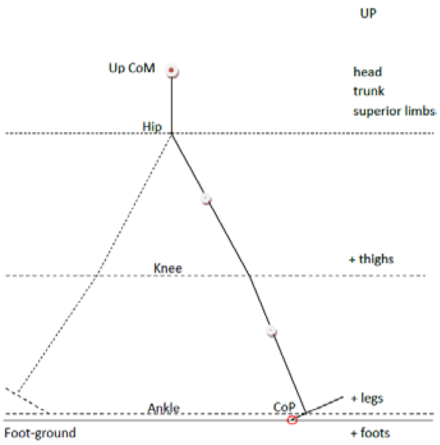
2a. $\Sigma F_y = ma_y$

2b. $R_{yp} - R_{yd} - mg = ma_y$

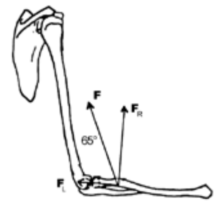
3a. About the segment CoM: $\Sigma M = I_\theta \alpha$

3b. $M_p = I_\theta\alpha - M_d - R_{xp}.(y_p - y_{CoM}) + R_{yp}.(x_{CoM} - x_p) + R_{xd}.(y_{CoM} - y_d) - R_{yd}.(x_d - x_{CoM})$

We can anecdotically describe the motor control development by relation between mobility and stability, step by step from the passive stability in supine posture to anticipatory stabilization in walking and run; but can we describe it via equations of motion?



4. $\Sigma F(hip) = \overrightarrow{ma_x}(up) + \overrightarrow{ma_y}(up) + \overrightarrow{mg}(up)$
5. $\Sigma M_z(hip) = I\alpha$: $[r_{thigh} \times F_{thigh}] - [r_{up} \times F_{up}]$
6. $\Sigma F(knee) = \overrightarrow{ma_x}(up) + \overrightarrow{ma_y}(up) + \overrightarrow{mg}(up)$
7. $\Sigma M_z(knee) = I\alpha$: $[r_{leg} \times F_{leg}] + [r_{up} \times F_{up}]$
8. $\Sigma F(ankle) = \overrightarrow{ma_x}(up) + \overrightarrow{ma_y}(up) + \overrightarrow{mg}(up)$
9. $\Sigma M_z(ankle) = I\alpha$: $[r_{foot} \times F_{foot}] + [r_{up} \times F_{up}]$
10. $\Sigma F(foot\text{-}ground) = \overrightarrow{ma_x}(up) + \overrightarrow{ma_y}(up) + \overrightarrow{mg}(up)$
11. $\Sigma M_z(foot\text{-}ground) = I\alpha$: $-[r_{up} \times F_{up}]$



(2)

It is possible to separate the muscular force in F_R, translational, and F_L, stabilizative, components and distinguish generally the Σ_F between $\overrightarrow{F\cos\theta}$ and $\overrightarrow{F\sin\theta}$.

12. $\Sigma F(hip) = \overrightarrow{ma_x}(up) + \overrightarrow{ma_y}(up) + \overrightarrow{mg}(up)$: $\overrightarrow{F\cos\theta_{hip}} + \overrightarrow{F\sin\theta_{hip}}$
13. $\Sigma M_z(hip) = I\alpha$: $[r_{thigh} \times F_{thigh}] - [r_{up} \times F_{up}]$
14. $\Sigma F(knee) = \overrightarrow{ma_x}(up) + \overrightarrow{ma_y}(up) + \overrightarrow{mg}(up)$: $\overrightarrow{F\cos\theta_{knee}} + \overrightarrow{F\sin\theta_{knee}}$
15. $\Sigma M_z(knee) = I\alpha$: $[r_{leg} \times F_{leg}] + [r_{up} \times F_{up}]$
16. $\Sigma F(ankle) = \overrightarrow{ma_x}(up) + \overrightarrow{ma_y}(up) + \overrightarrow{mg}(up)$: $\overrightarrow{F\cos\theta_{ankle}} + \overrightarrow{F\sin\theta_{ankle}}$
17. $\Sigma M_z(ankle) = I\alpha$: $[r_{foot} \times F_{foot}] + [r_{up} \times F_{up}]$
18. $\Sigma F(foot\text{-}ground) = \overrightarrow{ma_x}(up) + \overrightarrow{ma_y}(up) + \overrightarrow{mg}(up)$: $\overrightarrow{F\cos\theta_{foot\text{-}ground}} + \overrightarrow{F\sin\theta_{foot\text{-}ground}}$
19. $\Sigma M_z(foot\text{-}ground) = I\alpha$: $-[r_{up} \times F_{up}]$

1) D. Winter: Biomechanics of motor control, John Wiley & Sons, 2009
2) D. Knudson: Fundamentals of biomechanics, Springer, 2007