Toward a cyclic model of human gait

Yaron Y. Glazer
Counterspiral
San Francisco, CA
yaron@counterspiral.com

Abstract— The inverted pendulum model of bipedal gait is perfectly efficient in theory, but human gait is far less efficient in practice. The main cause of the discrepancy has been linked to the need to redirect the body's mass from leg to leg between steps, which requires a significant amount of work during the transfer. New research lays the conceptual groundwork for a more biomechanically efficient model of human gait predicated on the wheel, with forward motion produced via the application of lateral force by the feet. The costly vertical components of pendular gait and the transfer of mass between legs are both avoided as the legs cycle symmetrically beneath the vertically and mediolaterally static center of mass. To access this cyclic model of gait, the feet must be fully developed into dynamic, three-dimensional spiral structures that rotate around a central axis when they do work. A targeted exercise is proposed to help transition feet developed under the standard model of biomechanics to the spiral model.

Keywords—gait, biomechanics, efficiency, foot development

I. INTRODUCTION

To align the inverted pendulum with empirical observation, standard gait models typically add a double support phase between steps. This adjustment introduces inefficiencies, as the falling center of mass (“CoM”) must be redirected upwards at a cost that grows geometrically with step length, and the CoM must be transferred laterally between legs at a cost that grows geometrically with step width.

II. CYCLIC GAIT MODEL – CONCEPTUAL FRAMEWORK

Humans are capable of producing an alternative gait with the efficiency of a wheel. Under this model, the ankles function like a modified propeller, with the swing heel abducting in the horizontal plane while the stance foot rolls medially (Fig. 1).

These coordinated actions create a couple moment around the ankle hub, which is translated via the shaft, knee hub, and axle mechanism to the pelvis, where it drives the swing hip in an arc around the midline to position the swing foot for the next step. The feet function like a tire under this conceptual model. During each step, the swing foot clenches and inverts to position the toenails for contact with the ground. While the swing leg abducts, the stance foot rolls medially across the extended midline over its inverted toenails. As gait becomes cyclic, each foot reproduces the ground reaction forces of one hemisphere of a torus, together producing a continuous roll.

In pendular gait models, the feet act as levers, pushing down and back into the ground to propel the body forward. This new model reconceives the feet as dynamic, three-dimensional spirals that rotate around a central axis with every step. The bones of each foot form a single twist of a logarithmic 3D spiral (Fig. 2). The twist begins underfoot at the Lateral process. It tracks the lateral edge of the foot and crosses the horizontal plane at the Vertical pivot between the toenails of the third and fourth toes, traversing the transverse arch to make contact where the inside tip of the big toe meets the extended midline.

Feet initially developed under the standard model can be transitioned to the spiral model using a simple but novel training exercise called Counterspiral. The feet are rotated against each other at the midline, and then a kneeling position is assumed on a pliant surface like a mattress. The feet are clenched, inverted, and abducted in turn, with controlled application of the body’s weight after each cycle. This exercise activates a symmetry-based development engine that realigns the bones of the feet into their spiral structures and then stretches muscle and connective tissue over the resulting framework, effectively “winding” the lower body.

Fig. 2. When fully developed, the bones of the feet form a dynamic, three-dimensional spiral structure that rotates around the foot’s longitudinal axis.