

## Why we walk the way we do

Richard Baker, Professor of Clinical Gait Analysis, University of Salford

**Purpose:** This tutorial aims to present an explanation of normal gait that is both biomechanically rigorous and clinically relevant. It challenges several assumptions encountered in the literature

**Intended audience:** Anyone interested in understanding normal walking.

**Prerequisite knowledge:** The tutorial will present an approach that requires only a basic understanding of walking and biomechanics but will be of interest to those with a more advanced knowledge through its challenging of previous assumptions.

### Abstract

Gage's *pre-requisites of gait* [1] are modified (most significantly through generalising the third to *smoothing transitions between phases* [2]). The approach of Inman's team [3] in starting with a simple gait pattern based and sequentially adding features is then adopted to show how these requirements lead to the normal gait pattern.

Inman's compass gait is taken as the starting point and an example of the inverted pendulum as the fundamental mechanism that *conserves energy*. Consideration of the requirement for *clearance* introduces many of the kinematic features of swing. *Adequate step length* is achieved by the pose of the body at foot contact requiring further modification to the gait pattern. An analysis of the kinetics of the inverted pendulum introduces the requirement for a phase of double support in order to *support bodyweight*. *Smooth transitions from swing to stance* of both the centre of mass and foot require further modifications to late swing and early stance. Taken together this process explains all the major features of the kinematics of normal walking.

The principle features of the ground reaction can be explained through an understanding of the kinetics of an inverted pendulum with the modifications required for *support* and *smooth transitions from swing to stance*. Combination of these with the already established kinematic pattern lead to the key features of joint kinetics and muscle forces.

Gage related his pre-requisites to normal walking but they are applicable to any functional walking. Whilst the focus will be on describing normal gait the consequences for people walking with pathology will be considered throughout the tutorial.

**Learning objectives:** At the completion of this presentation, attendees will be able to:

- Describe five requirements for walking (based on Gage's pre-requisites)
- Explain how these lead to the major kinematic features of human walking
- Explain the features of joint kinetics and muscle activations that are required to produce these kinematics.

## **Outline**

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| • Introduction (including overview of existing literature) | 20 minutes |
| • Kinematics of human walking                              | 60 minutes |
| • Kinetics and muscle activity                             | 30 minutes |

There will be a ten minute break about half way through. Delegates are invited to bring along tablets or PCs to engage in a number of interactive learning and polling exercises.

1. Gage, J., *Gait Analysis in Cerebral Palsy*. 1991, Oxford: Mac Keith Press.
2. Winter, D.A., *Foot trajectory in human gait: a precise and multifactorial motor control task*. Phys Ther, 1992. **72**(1): p. 45-53; discussion 54-6.
3. Saunders, J.D.M., V.T. Inman, and H.D. Eberhart, *The major determinants in normal and pathological gait*. Journal of Bone and Joint Surgery, 1953. **35A**(3): p. 543-728.