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Assessment and validation of a simple automated method for the detection of gait events and intervals

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Abstract

A simple and rapid automatic method for detection of gait events at the foot could speed up and possibly increase the repeatability of gait analysis and evaluations of treatments for pathological gaits. The aim of this study was to compare and validate a kinematic-based algorithm used in the detection of four gait events, heel contact, heel rise, toe contact and toe off. Force platform data is often used to obtain start and end of contact phases, but not usually heel rise and toe contact events. For this purpose synchronised kinematic, kinetic and video data were captured from 12 healthy adult subjects walking both barefoot and shod at slow and normal self-selected speeds. The data were used to determine the gait events using three methods: force, visual inspection and algorithm methods. Ninety percent of all timings given by the algorithm were within one frame (16.7 ms) when compared to visual inspection. There were no statistically significant differences between the visual and algorithm timings. For both heel and toe contact the differences between the three methods were within 1.5 frames, whereas for heel rise and toe off the differences between the force on one side and the visual and algorithm on the other were higher and more varied (up to 175 ms). In addition, the algorithm method provided the duration of three intervals, heel contact to toe contact, toe contact to heel rise and heel rise to toe off, which are not readily available from force platform data. The ability to automatically and reliably detect the timings of these four gait events and three intervals using kinematic data alone is an asset to clinical gait analysis.

Keywords: Kinematic gait event detection; Temporal gait parameters; Heel contact; Toe off; Heel toe intervals

1. Introduction

Gait event detection is a tool for measuring definable events/phases to aid the analysis of gait, the evaluation of treatments for pathological gait and also the development of gait assist devices and sensors. This tool could be used to assess different sensors used in functional electrical stimulation orthoses for foot drop [1] and to automate the gait analysis evaluation of this treatment for children with CP [2].

The determination of gait event timings is usually done using force platform data and/or foot switch recordings. The former method, though very reliable, has the limitation of only determining the start and end of contact phases between the foot and the platform. In normal gait these will be heel contact and toe off. The timings are used with varying degrees of importance in different applications, the most obvious of which is the determination of swing and stance durations. However, the timings of heel off and toe contact can be of equal importance in some other circumstances like the characterisation of temporal parameters of footfall. Another example is the evaluation of pathological gait such as cerebral palsy. The timings of the different gait events and the durations of gait intervals, such as the heel–toe interval, can be used to assess the degree of deviation from normal gait. The use of footswitches or other methods to determine the timings of such events might seem a good solution. However, some limitations, either due to the technology or the encumbrance to normal gait, hinder their use. Their inclusion will necessitate an additional evaluation in the gait laboratory.

One source of data readily available in a gait lab is the marker detection system. Three-dimensional (3D) co-ordinates of foot markers can be used to provide the timings of the four gait events and to infer the durations of different gait phases. A literature search revealed few studies that utilised kinematic data to determine gait temporal parameters [3–8]. Some limitations of these methods

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