METABOLIC COST OF TRANSPORT AND THE PERSISTENCE OF STRIDE-TO-STRIDE FLUCTUATIONS DURING HUMAN WALKING

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INTRODUCTION

Healthy human gait exhibits complex stride-to-stride fluctuations [1]. These fluctuations arise from the interactions of various systems, making them a measure of the neuromuscular system's output as a whole. These fluctuations can be described by their level of statistical persistence. For example, consider the stride-to-stride time series of stride length. If a long step is likely to be followed by another long step, then the gait fluctuations can be described as having persistence. If a long step is likely to be followed by a short step, then the fluctuations can be described as anti-persistent. These observations can then be used to make inferences about neuromuscular control strategies and/or the adaptability of the system [2].

Recent findings suggest that humans have an optimal movement variability, resulting in a healthy amount of stride-to-stride fluctuations [3]. At the same time, humans tend to adopt movement strategies to minimize metabolic cost [4]. The aim of this study is to determine the relationship between the metabolic cost of transport and the persistence in the stride-to-stride fluctuations of gait.

METHODS

The participant walked on a treadmill at 5 speeds, ranging from 0.75 – 1.75 $m \cdot s^{-1}$. Each speed condition lasted 15 minutes, and the order of conditions was randomized. After the end of the final trial, preferred walking speed was determined. Kinematic data were collected using an 8-camera system (Vicon; Motek Medical; 100 Hz), and a 6-degrees-of-freedom marker-set [5]. Gait events were determined using foot velocities with respect to the pelvis [6].

For each walking speed condition, detrended fluctuation analysis (DFA) was used to calculate the scaling exponent (a measure of persistence) of two time series: 1) stride length and 2) stride time. Values close to 0.50 indicate random behavior, with increasing values denoting more persistent behavior. Left- and right-side data showed similar trends and thus only the right-side data are reported here.

Metabolic cost of transport (MCOT) was calculated from inspiration/expiration rate of O_2/CO_2. obtained from a portable gas exchange monitoring system (Kb^4, Cosmed). Resting metabolic rate was subtracted from trial data, which were then used to calculate net metabolic power ($W \cdot kg^{-1}$) [7] and divided by speed to determine metabolic cost of transport ($J \cdot kg^{-1} \cdot m^{-1}$).

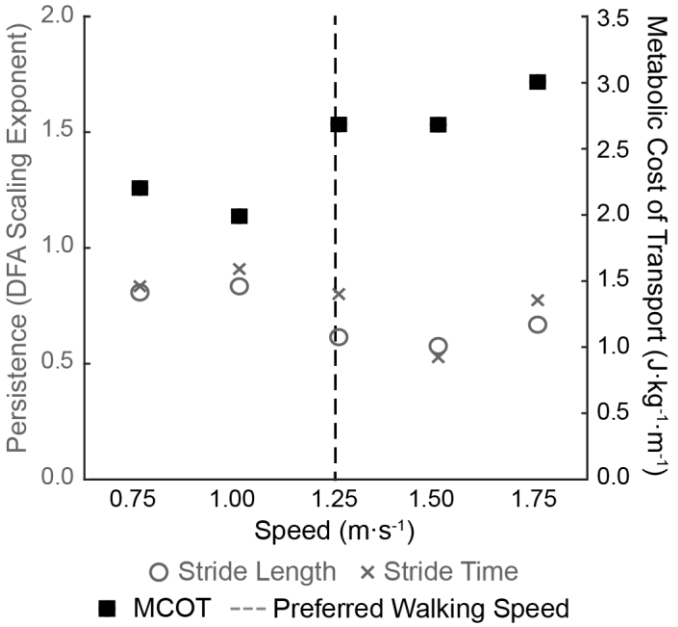

Figure 1: Metabolic cost of transport (black) and the persistence of stride length and stride time (gray) were lowest on opposing sides of the preferred walking speed (1.24 $m \cdot s^{-1}$; vertical dashed line).

RESULTS AND DISCUSSION

Metabolic cost of transport was lowest at 1.00 $m \cdot s^{-1}$ and persistence in stride length and time were lowest at 1.5 $m \cdot s^{-1}$ (Fig. 1). This preliminary, single-subject data suggests that metabolic cost and persistence of stride-to-stride fluctuations may co-vary across speeds, indicating a possible link between the two. This relationship will be further explored as we continue this study with additional participants.

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