PREFERRED WALKING SPEED IS UNDER PRECISE PHYSIOLOGICAL CONTROL

Renato Pagliara, Mark Snaterse, Max Donelan
Biomedical Physiology and Kinesiology, Simon Fraser University, Burnaby, Canada, rpa13@sfu.ca

INTRODUCTION

Preferred walking speed is becoming an increasingly important metric for predicting a range of health issues including falls, disabilities, dementia, admission to hospital, and even mortality [1-2]. This predictive ability suggests that preferred walking speed is under precise physiological control. Here, we directly tested the degree to which people control their walking speed by releasing subjects from a range of initial speeds and measuring how quickly and precisely they returned to their preferred speed.

METHODS

Seven healthy young adults (3 males, 4 females, age: 24±2) participated in our study after giving informed consent. The experiments began with each subject completing a 6-minute walk to roughly estimate their preferred speed and step frequency. They then completed a series of eight randomly ordered trials that began at four different initial speeds. These initial speeds were induced using a metronome beating at frequencies above and below their previously measured preferred step frequency (Figure 1). After 90 s, the metronome beat was replaced with six minutes of white noise. Prior to the experiments, subjects were instructed to match their cadence to the metronome beat and to walk comfortably when the metronome turns off—they were free to change their speed if they so desired. To measure walking speed we used a GPS-based speed sensor (VBOX Speed Sensor, Racelogic)—the data was logged to an SD card using an Arduino Uno microcontroller, which was also used to generate the metronome beat and white noise.

To compare the speed responses between trials and subjects, we normalized all trials to zero at steady-state speed while the metronome was playing, and one at steady-state speed after the metronome was silenced. Then, we first determined how quickly subjects converged to a new steady-state walking speed, by combining all normalized trials, for all subjects, and computing settling time (time needed to reach 95% of the final steady-state value) using system identification techniques. Secondly, we determined the degree to which speed is controlled during each steady state, by determining the root-mean-square error (RMSE) in normalized speed during the last two minutes of all trials. Finally, we determined how consistently subjects converged to the same preferred speed between the eight trials. For this we computed the average steady-state speed for each trial, and determined the standard deviation in these eight speeds for each subject separately. Here we report the average standard deviation for all subjects.

RESULTS

In response to the different metronome frequencies, subjects walked with a range of initial speeds—the average speeds at the slowest and fastest metronome frequencies were 0.96 and 1.78 m/s, respectively. But once the metronome was silenced, subjects quickly adjusted their gait towards a more moderate speed and were within 15% of their final steady-state speed after only 11 s. It took an additional 125 s to reach steady-state speed, but once there speed was precisely controlled—during the last two minutes of each trial speed varied by only 2.4% (RMSE). Despite the wide range of initial speeds, subjects consistently converged to the same preferred speed—the average variability in steady state speed between trials was only 4.7% (s.d.).

DISCUSSION & CONCLUSIONS

Our results show that preferred walking speed is indeed under precise physiological control—regardless of how fast or slow they initially walked, each subject consistently converged on one preferred walking speed.

Our finding that it takes over 100 s to reach steady-state walking speed has important implications when determining and comparing preferred speeds. Current methods used to determine preferred speed commonly involve subjects walking a fairly short distance (5-30 m) [3]. Our results suggest that longer distance tests are necessary for subjects to converge to their true preferred walking speed. However, given that subjects rapidly get within 15% of their preferred speed, short distance tests might provide a convenient method to acquire a rough estimate of preferred walking speed. But, care has to be taken when comparing preferred speed estimates resulting from tests of different lengths.

REFERENCES