Why do adaptations in split belt treadmill walking take place?

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INTRODUCTION

Although the split belt paradigm has been used extensively to assess the capability of subjects to adapt the gait pattern [1], reasons as to why this adaptation occurs remain obscure. For stride length, which quickly adapts, it is clear that the adaptation is imposed by a task demand; if no adaptation would take place, subjects would not be able to keep walking on the treadmill. For step length however, this is not the case; in principle, subjects are capable of a pattern that is not adapted; they show such a pattern in the immediate phase after the transition from tied to split belts. Still, they adapt their gait pattern, and, store this adapted gait pattern, so that after-effects are visible. This leads one to believe that the adapted gait pattern is in some way “more optimal” than the unadapted gait pattern.

Potential ways in which the adapted gait pattern may be “more optimal” could be symmetry, energy consumption and stability. In the current study, we tested the latter of these, to see if gait adaptations during split belt walking are aimed at stabilizing the gait pattern. We hypothesized that (1) unadapted split belt walking (as seen in the initial phases of the adaptation period), would be less stable than normal walking and (2) that stability would improve as the gait pattern got more adapted to the split belt.

METHODS

8 healthy subjects participated in a split belt adaptation protocol. In short, they walked on a treadmill for 5 minutes with belts tied (running at 1.0 m/s), then 10 minutes with belts split (1.0 and 0.5 m/s). Kinematics of a pelvis cluster marker were recorded using a optoelectronic measurement system at 100 samples/s. Time series of the 3d velocity and angular displacement of the pelvis marker were cut into episodes of 15 strides, and of each episode, stability was estimated using the maximum Lyapunov exponent ($\lambda_c$) [2]. Differences in stability between normal walking (designated as the average over all episodes during the tied condition), initial adaptation (average value over the first 5 episodes of split belt walking) and late adaptation (average value over episodes 26-30 of split belt walking) were tested using a repeated measures ANOVA.

RESULTS

Results are shown in figure 1. In line with our hypotheses, split belt walking initially decreased stability (i.e. led to higher values of $\lambda_c$), but stability improved as the gait pattern adapted to split belt walking, so that during the late adaptation period, stability was not significantly different from normal walking.

DISCUSSION & CONCLUSIONS

The results of the present study suggest that stability issues may be responsible for the adaptations in split belt walking. Of course, other factors may also improve because of these adaptations. One highly likely candidate is energy consumption [3]. In future work, we plan on further exploring the potential reasons why humans adapt their gait pattern when walking on a split belt.

REFERENCES

Figure 1: $\lambda_s$ during Normal walking, Initial and Late adaptation phases of split belt walking. Error bars represent standard errors. Note that higher values of $\lambda_s$ indicate LESS stable gait patterns.