STRATEGIES FOR WALKING ON A LATERALLY OSCILLATING TREADMILL

Brian T. Peters[1], Rachel A. Brady[1], Jacob J. Bloomberg[2]

[1]Wyle's Life Sciences Group, Houston, TX, USA, brian.peters-1@nasa.gov
[2]Neuroscience Laboratory, NASA Johnson Space Center, Houston, TX, USA

INTRODUCTION

Most people use a variety of gait patterns each day. These changes can come about by voluntary actions, such as a decision to walk faster when running late. They can also be a result of both conscious and subconscious changes made to account for variation in the environmental conditions. Many factors can play a role in determining the optimal gait patterns, but the relative importance of each could vary between subjects. A goal of this study was to investigate whether subjects used consistent gait strategies when walking on an unstable support surface.

METHODS AND PROCEDURES

We used a treadmill mounted on a six degree-of-freedom motion base (Moog, East Aurora, New York) to provide support surface motion to walking subjects. After two minutes of normal treadmill walking at 1.1 m/s, subjects continued to walk for another twenty minutes while the treadmill oscillated laterally. Data from nineteen subjects is reported here. The amplitude of the sinusoidal motions was 25.4 cm for all subjects, but eleven were exposed to oscillations at 0.2 Hz and the remaining were tested using 0.3 Hz. Data from both groups are combined here because no differences were found in the variables of interest. Video-based motion analysis was used to record movement of the trunk, feet and treadmill. These were analyzed using custom software (Matlab, The Mathworks, Inc., Natick, MA). A frequency domain data analysis was conducted on the lateral trunk position and subjects' step width was also determined. Data reported here represent the final ten minutes of the data trial when all subjects had achieved a stable walking pattern.

RESULTS

After subtracting the treadmill position from a body midline marker positioned near T12, the resulting waveforms varied between subjects. For some, the predominant feature of the signal was the oscillatory pattern associated with the natural lateral motion that occurs with each stride. For others, this stride-related signal was superimposed on a sinusoid that had the same frequency as the lateral treadmill motions. This was an indication that some subjects were remaining more fixed in space (FIS) while others were more fixed to the base (FTB). A ratio was calculated for each subject comparing the amplitude of the torso signal to the amplitude of the support surface motion at the base motion frequency. These data are shown in Figure 1. We classified those subjects with ratios on a continuum between 0.05 and 0.3 as FTB and the four subjects with ratios above 0.4 as FIS.

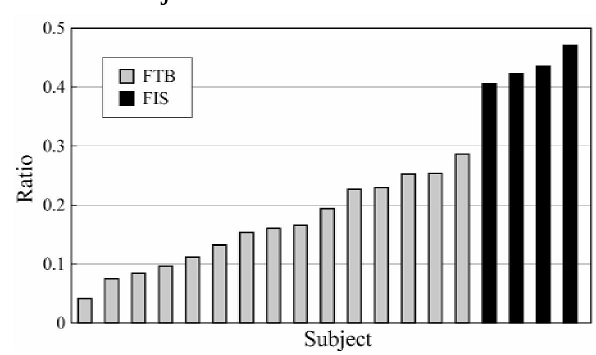

Figure 1. Ratio of lateral torso amplitude to lateral base amplitude at the base frequency.

Step width was originally calculated to confirm an assumption that it would be wider while the support surface was being manipulated. A more striking result was the increase in variability of the step width throughout the trial. The data were further analyzed to account for the movement of the support surface. In Figure 2, the step width data for one subject is shown on a polar plot. The angular coordinate for each point is determined by the lateral position and velocity of the support surface during its oscillation. The distance from the center of the plot to each point is the normalized right-foot-to-left-foot step width.

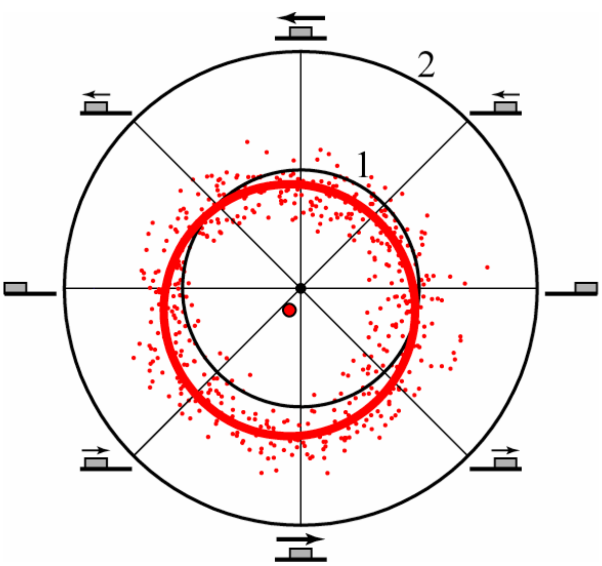

Figure 2. Polar plot showing right-foot-to-left-foot step width data for one FIS subject. Graph "labels" depict treadmill position and velocity. The unity circle defines mean step width during normal walking period of test.

A shift in the center of a best-geometric-fit circle is an indication that the subject is adjusting their step width according to the treadmill movements. Interestingly, this shift is predominantly downward for FIS subjects and upward for FTB subjects. The downward shift indicates that as the support surface is moving to the right, the FIS subjects take a wider step when transferring support from the right leg to the left. They take a narrower right-to-left step when the treadmill is moving to the left. The opposite is true for the other FTB subjects. In either case, modulation of the step width, according to the movement of the base, accounts for some of the increased step width variability that was observed.

DISCUSSION

Two strategies can be observed when subjects' are exposed to lateral oscillations of the support surface during treadmill walking. Some subjects maintain their position with respect to the support surface and move with it. Others are more fixed relative to space and allow the treadmill to travel beneath them. Warren et al. (1996) found similar differences between subjects during an investigation in which it was the visual scene that was manipulated instead of the support surface. Further investigation is required, but it is assumed that these strategies emerge based on individual differences in the relative weighting that is place on the sensorimotor inputs used during the gait optimization process. An ability to rapidly re-weight these inputs could be beneficial for maintaining stable gait.

A goal of our laboratory is to develop a training program that facilitates the rapid adaptation of gait when astronauts are exposed to novel environmental conditions. A better understanding of subjects' natural tendencies will allow us to tailor our training paradigms to each individual.

REFERENCES

Warren et al. (1996). *J Exp Psychol Hum Percept Perform* 22:818-838

ACKNOWLEDGEMENTS

This work is supported through the National Space Biomedical Research Institute through NASA NCC 9-58.