PASSIVE DYNAMIC BIPEDAL WALKING

Design and Experimental Testing

Derek Koop
Supervisor: Dr. Christine Q. Wu
Department of Mechanical and Manufacturing Engineering
Winnipeg, Manitoba, Canada

Background

Passive dynamic bipedal walking is an unassisted gait developed by gravity. Insight gained from the study of passive dynamic bipedal walking can be used in the diagnosing and rehabilitation of human gait disorders, designing of better prosthetics, and designing of energy efficient biped robots. Passive dynamic biped walkers are difficult to develop because the are inherently unstable.

Experimental data from passive dynamic biped walkers are extremely valuable for determining the effect of parameter change and to validate mathematical models. Testing passive biped walkers on a ramp is limited by the length of the ramp. Testing on a treadmill is attractive, since it is not limited in the number of steps. However, the mechanics of gait generation and rigidity of the treadmill are quite different from the ramp.

Objective

The first objective of this project is to design and build a passive walker that can walk for many steps with a steady gait. The second objective of this project is to determine the validity of testing on a treadmill, compared to testing on a ramp.

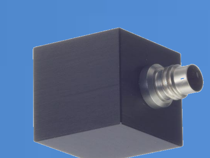
Design

Dexter Mk III is the third generation passive dynamic walker built at the U of M. The design for Dexter Mk III incorporates state of the art sensors and a leg angle limiter. The leg angle limiter, colored red, helps to produce a more steady gait, compared to the previous designs. The use of the sensors decreases the amount of time needed to process the data gathered.

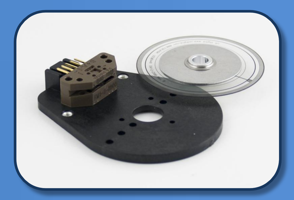
Dexter Mk III

Experimental Method

Data gathered, from testing on the ramp and treadmill, was compared to determine if the gaits produced are equivalent. The data was gathered after Dexter Mk III was fine tuned, with the correct foot shape and mass distribution. Multiple trials were completed for both the treadmill and the ramp. The acceleration of the hip and the leg angle were recorded for each trial with an accelerometer and an encoder, respectively. The gait parameters; step period, step length, and hip velocity, were calculated using the recorded data.

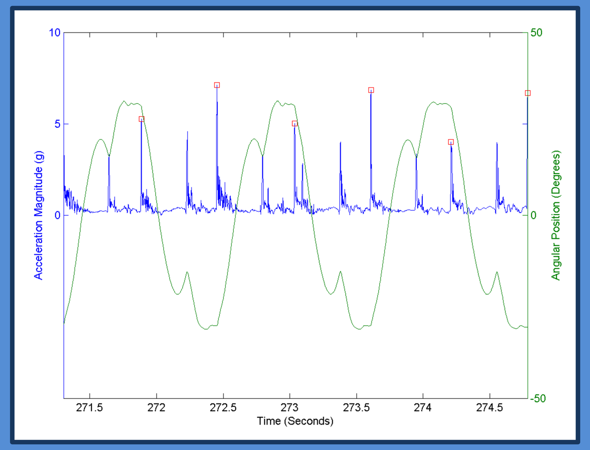


Accelerometer



Encoder

Sample Data

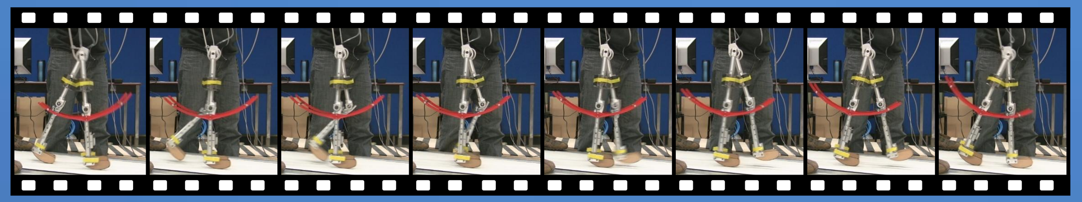


Ramp

Treadmill

Results & Discussion

The design for Dexter Mk III was found to be successful, with the walker able to exceed 100 step trials on the treadmill and able to easily walk down the ramp.



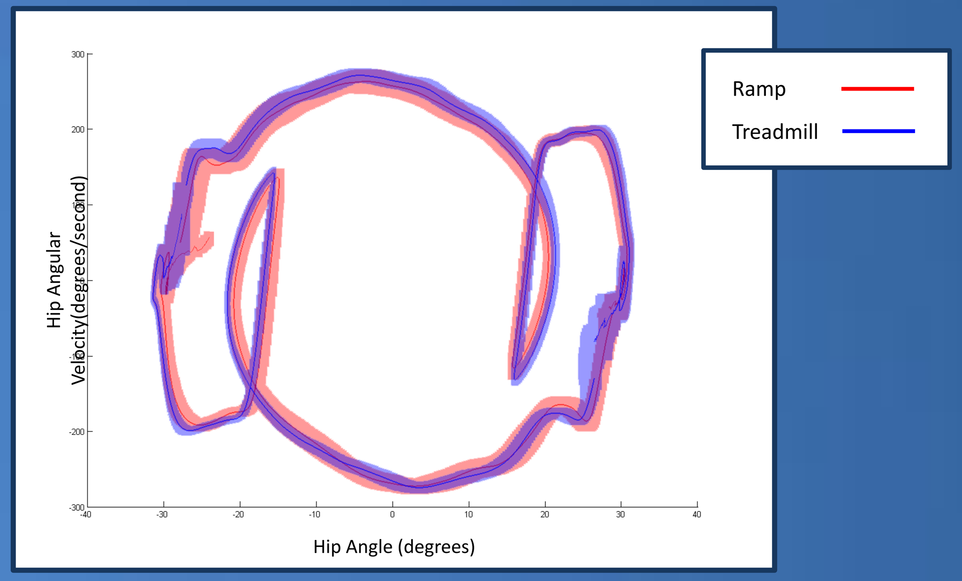
The extremely low difference between the gait parameters, measured on the ramp and treadmill, shows that the kinematics of the gait produced are quite similar.

Parameter	Ramp	Treadmill	% Difference
Step Period (sec)	0.5907	0.5966	**1.01%**
Step Length (m)	0.2286	0.2291	**0.23%**
Hip Velocity (m/sec)	0.4841	0.4788	**1.10%**
Total Number of Steps	82	176	

Results & Discussion

The phase portrait illustrates the kinematics of the gait during one step cycle. The phase portraits generated, for both the treadmill and ramp, are quite consistent and are in agreement with each other.

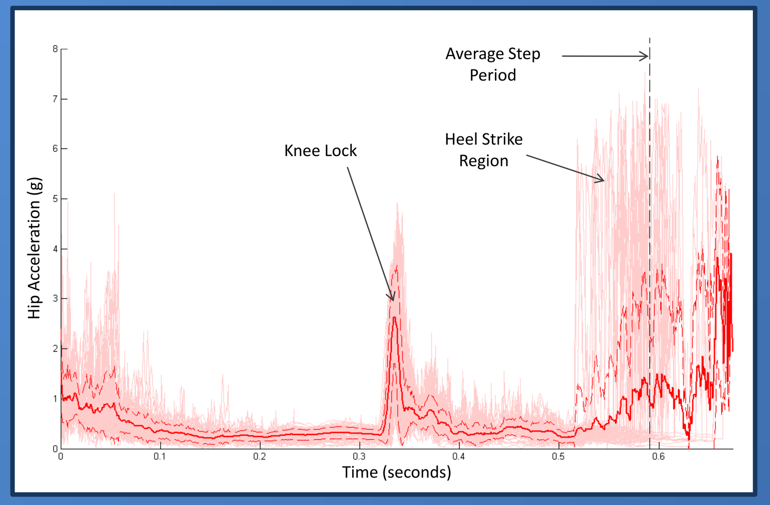
Phase Portrait



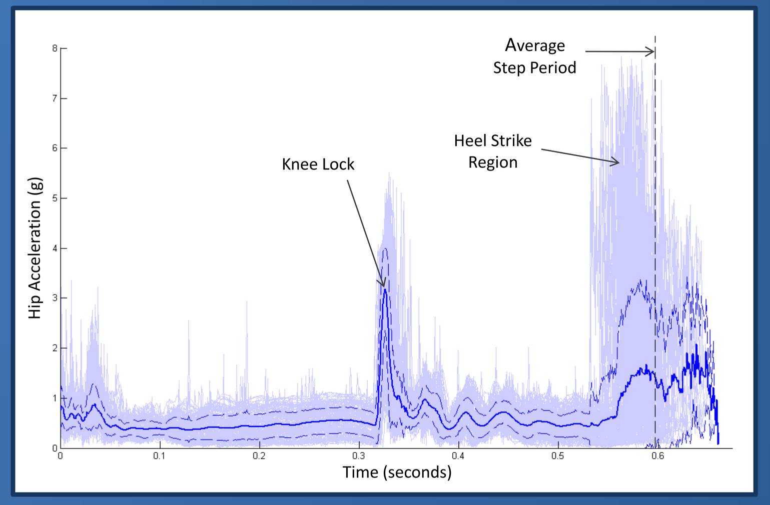
The acceleration profiles show the dynamics and partial kinematics of the gait. The kinematics shown on the acceleration profile are the knee lock and heel strike. Average acceleration profiles, for both the treadmill and ramp tests, are again synchronous and quite analogous in the magnitude of the accelerations.

Hip Acceleration Profiles

Ramp



Treadmill



Conclusions

Dexter Mk III turned out to be a huge success. The incorporation of the accelerometer and encoder into Dexter Mk III will dramatically decrease the time needed to complete future studies. The gaits produced on both, the ramp and treadmill, are concurrent within the standard deviation. Based on the exceptionally low difference between the data gathered, testing on the ramp and treadmill are equivalent. Now extensive testing can be completed on the treadmill, allowing for many steps to be recorded in one trial.