Gait Analysis Based on Linear Acceleration

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Abstract:

We were investigating the relationship between different physiological features and the gait of different subjects. Data about gender, eye color, weight, leg length, and age were compared to the three-dimensional linear acceleration of the subjects, from which the three dimensional velocities and distances were derived. Correlations about back-and-forth movement with respect to gender, the average sideways linear accelerations compared to the number of steps, and the maximum forward linear acceleration to leg lengths were determined. Males had a higher average forward linear acceleration than females, with males at about 6 m/s^2 and females at about 5 m/s^2, the r^2 value of the maximum horizontal linear acceleration with respect to the stride length was 0.438, and the r^2 value for the maximum forward linear acceleration with respect to leg length was 0.577.

Introduction:

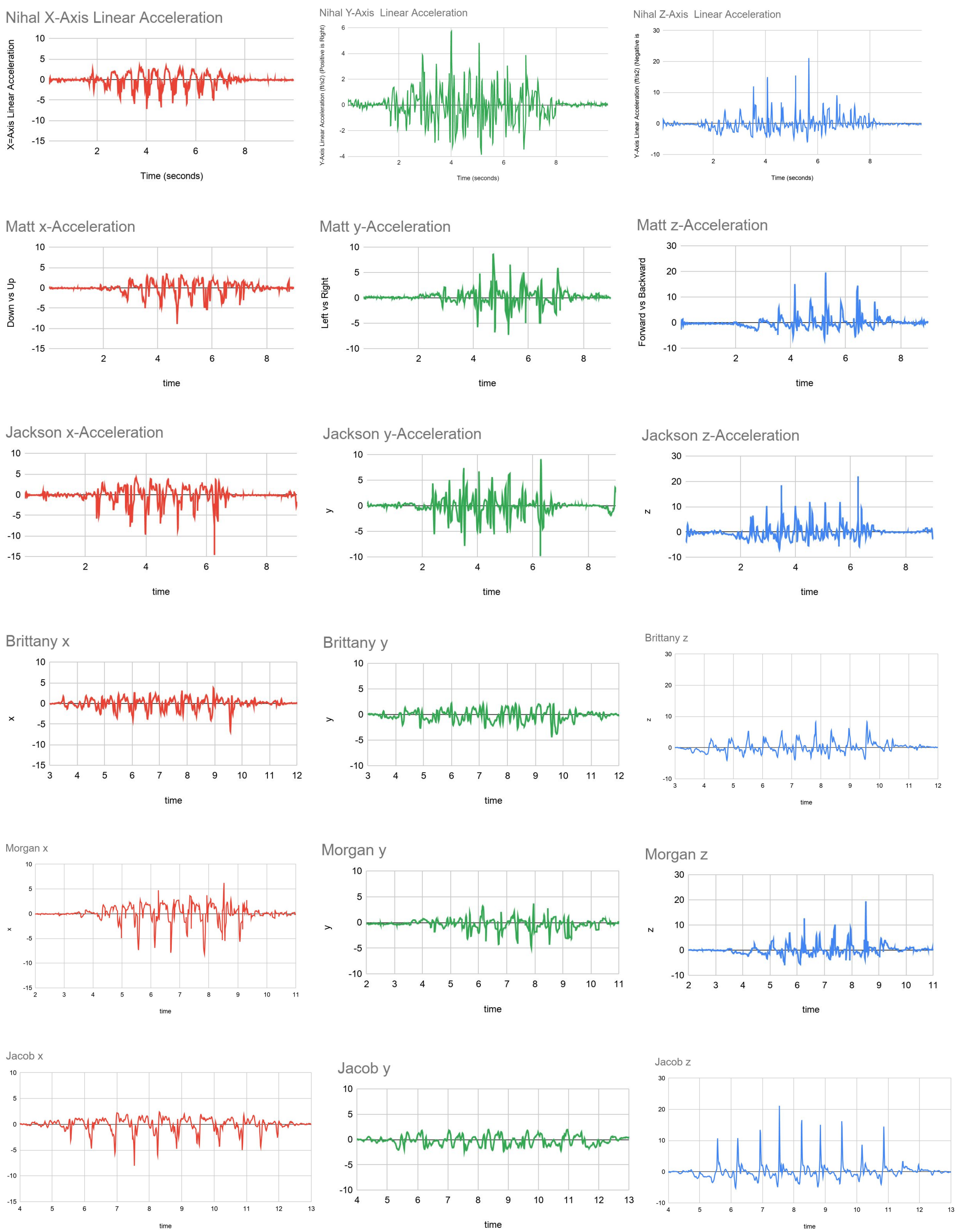
This project served as an introduction to data analysis and data collection as well as designing and conducting original experiments. The basis of this research surrounds the concept of humans walking in a semi-repetitive fashion as they walk, known as gait. The concept was to gather data on how people walk and find what, and if, correlations exist between the traits of a person and their walking gait. If the testing is successful, this concept will be shown to be true in some fashion.

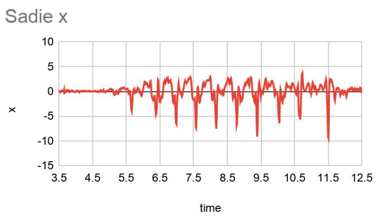
Method:

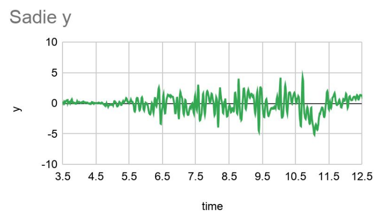
We began by measuring different data on each test subject. We measured each subject's height and leg length (from the floor to the hip joint) in inches. We then surveyed them about their weight (in pounds), gender, and age, as well as their eye color and preference between dogs and cats. Next, we set up the linear accelerometer on a Motorola G4 Plus using the "Physics Toolbox Accelerometer" by Vieyra Software. Then, we taped the phone horizontally (with the camera and speaker on the right) to the subject's lower back, and recorded acceleration along each axis during a 6 meter walk. We then uploaded the data to Google Sheets, where we converted the .csv files to tables, then graphs.

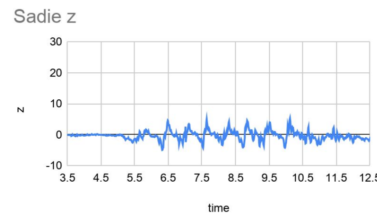
Results:

Below are the graphs of the x, y, and z accelerations of each subject when x is up(-) and down(+), y is left(-) and right(+), and z is forward(-) and backward(+). There were seven total test subjects. Each graph displays a nine second time interval.



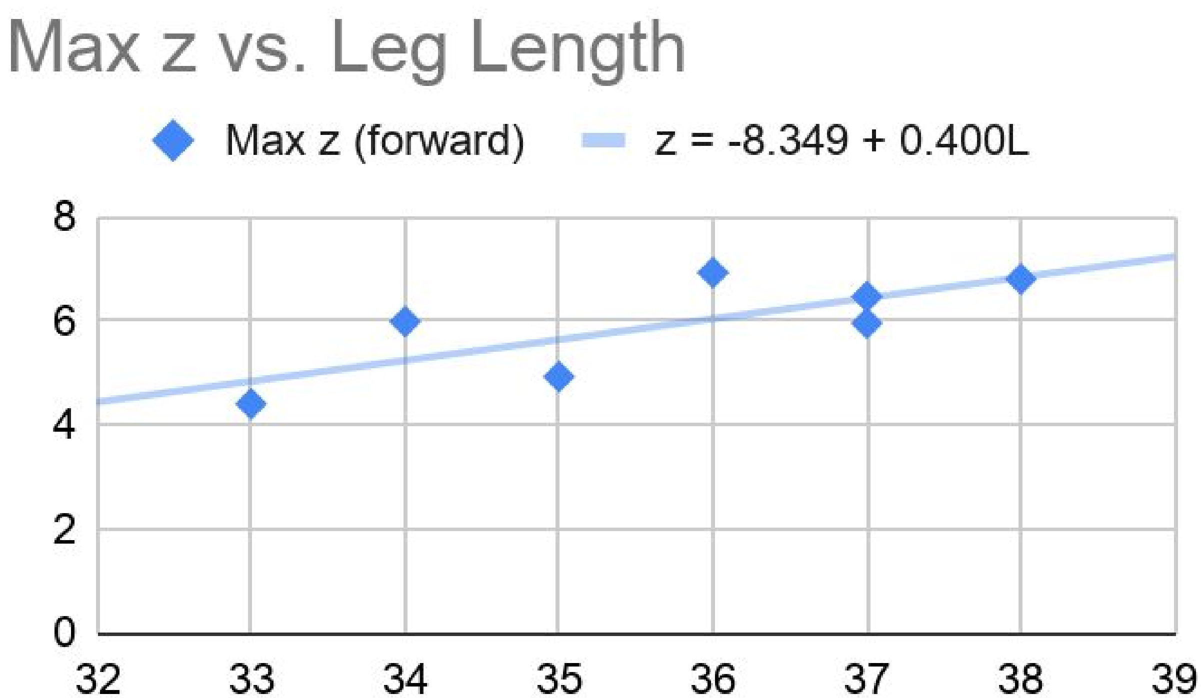






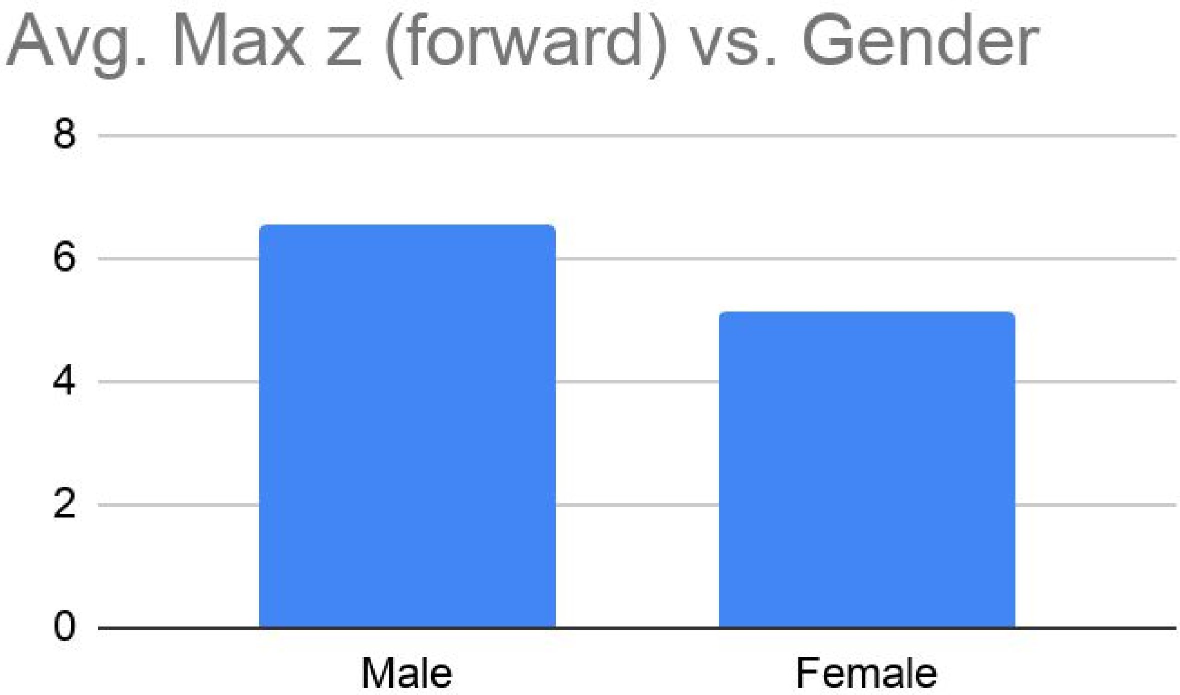
Discussion:

In analyzing the results, we found four significant correlations. The first correlation we found is between the leg length of a subject and their maximum forward acceleration.



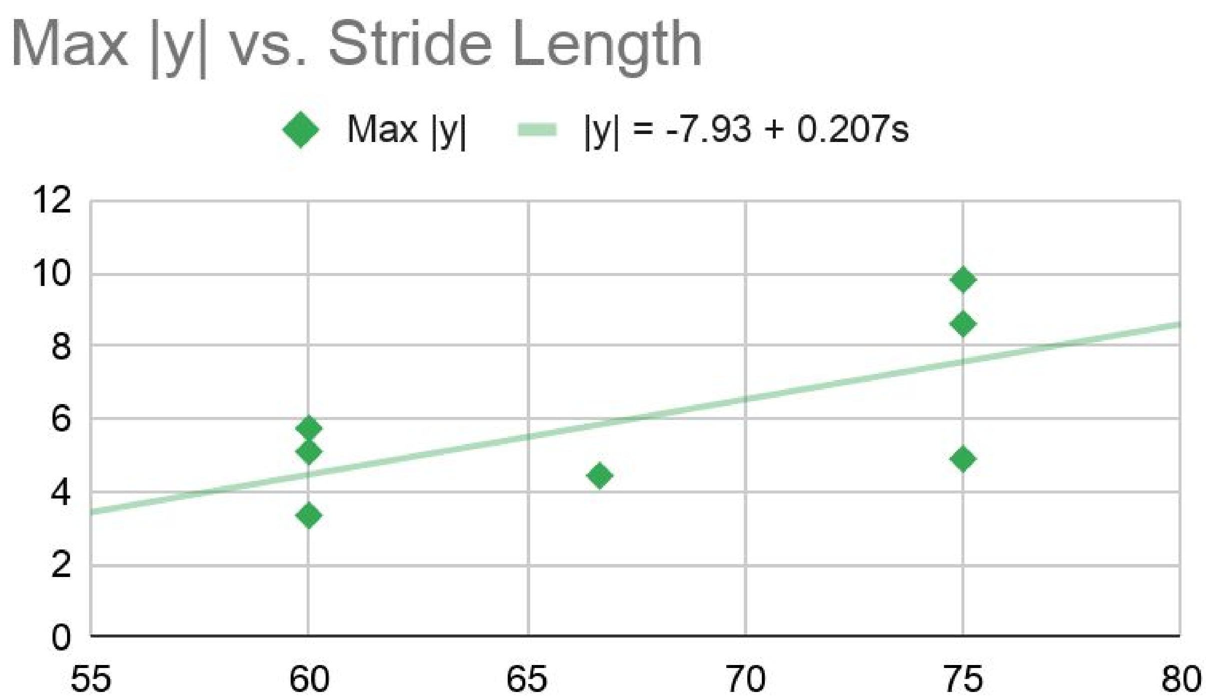
In conducting a linear regression analysis, we found that $R^2 = 0.577$, which means that a little over half of the variability in maximum forward acceleration can be explained by an individual's leg length. According to our model, every extra inch of leg length increases the maximum forward acceleration by 0.400m/s^2.

The next correlation we found was between gender and average forward acceleration.



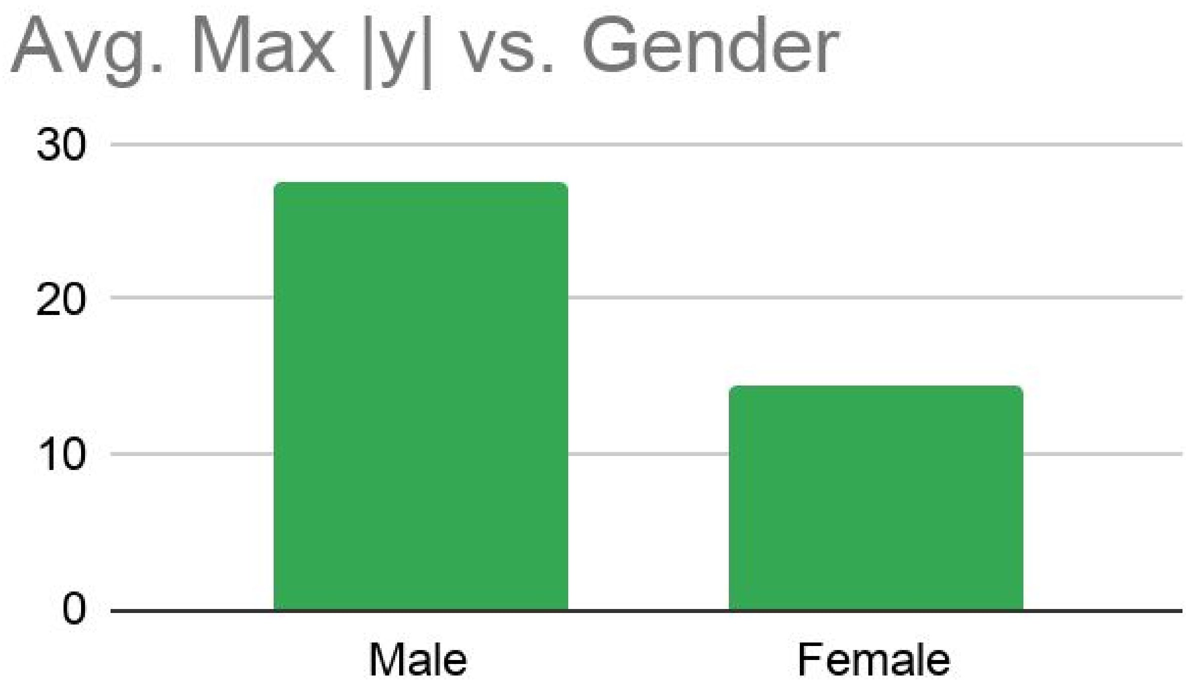
According to our data, males' maximum forward acceleration is, on average, about 1.4m/s^2 higher than that of females. When looking at the first correlation we found, this difference is likely caused by the fact that females generally have shorter legs than males.

After examining forward acceleration, we looked at horizontal acceleration, and found that it was correlated with the stride length of an individual.



During our linear regression analysis, we found that $R^2 = 0.438$, which means that stride length explains only part of the variability in maximum horizontal acceleration. Our model predicts that, for every centimeter of stride length, an individual's maximum horizontal acceleration will increase by $0.207 m/s^2$.

The fourth significant correlation that we found is between maximum horizontal acceleration and gender.



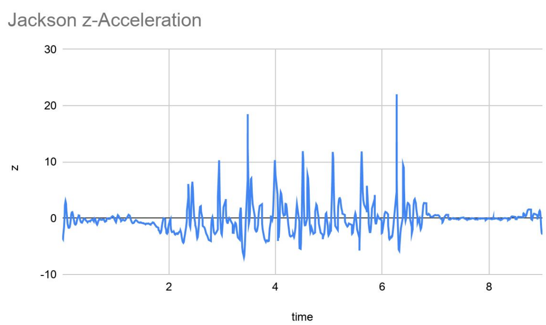
Our data shows that males, on average, have a maximum horizontal acceleration about $2m/s^2$ higher than females. Gender is likely the cause of this correlation, as none of the other variables we measured explain this difference.

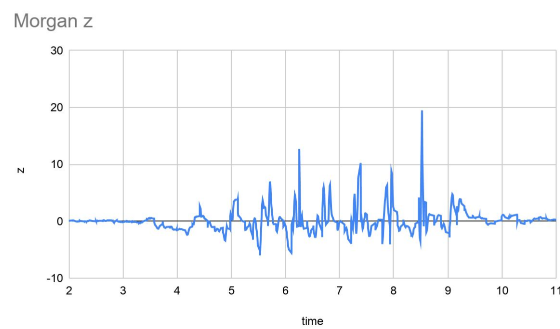
References:

1. Physics Toolbox Accelerometer by Vieyra Software

Appendix A: Another Correlation

Another correlation that we found was that individuals with hazel eyes, and only individuals with hazel eyes, had two spikes in forward acceleration at approximately the same relative times during the test.





Appendix B: Data Table

Leg Length (inches)	Height(in)	Weight (lbs)	Gender(binary)	Eye Color(approx.)	Dogs/Cats	Age(years)	# of Steps	Stride length (cm)	Max x (upward)	Max |y|	Max z (forward)
37	66	110	Male	Brown	No	17	10	60	7.91	5.74	5.96
37	71	150	Male	Blue	Yes	18	8	75	8.91	8.61	6.47
36	70	120	Male	Hazel	Dogs	17	8	75	14.61	9.82	6.93
33	61	2?	Female	Brown	Yes	16	9	67	6.75	4.44	4.41
34	65	115	Female	Hazel	Dogs	17	8	75	8.14	4.90	5.99
38	70	130	Male	Brown	Dogs	17	10	60	8.03	3.35	6.81
35	67	2?	Female	Brown	Cats	17	10	60	9.42	5.10	4.93

Conclusion:

Overall, this testing went well but there were certain errors in our performance that could be improved upon. The method of how we held the phone to the subject we were testing changed as we realized the limitations of our original choice of taping the directly to the subject's lower back and shifted to taping the phone to the back of the subject's shirt through tape wrapped around the subject's abdomen. Our method of measuring distance was slightly inaccurate as well due to people stopping at different relative places. This was not and could not be accounted for with the data we collected.