How Smooth is your Tango Walk and Can the Accelerometers in Your iPhone be used to Measure This?

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Abstract:

Accelerometers in an iPhone are used to measure the g-forces (i.e., acceleration, or more loosely, the changes in motion) developed while walking solo forward and walking solo backward to tango music. The individuals tested and reported on in this study are a male tango teacher (myself), a male student and two female students of varying tango ability and experience. From the results it is clear that one can identify where each step is taken by changes in acceleration from side-to-side, changes in up-and-down motion, and change in the speed of the linear forward motion. Generally speaking, a smoother walk will result in lower acceleration readings, and, although of a more subjective nature, there also appears to be a correlation in the smoothness of a person's walk (low acceleration readings) and the experience and proficiency of the dancer.

Introduction

Several apps for the iPhone exist which allow access to the built in accelerometers. The one used for this study is a free app called "AccelGraph"—which records acceleration in separate X, Y and Z axis on either a graphical strip chart of in numerical printout which can then be emailed.

The Procedure

Ideally, all tests should have been done to the same tempo music, on the same dance floor and with the same style of shoes. However, I found this difficult to arrange and so these factors were not held constant. (BTW, several apps are available on the iPhone for measuring a song's "bpm"—i.e., beats per minute.) In these tests the tempo ranged from 125 bpm to 132 bpm, and shoes were low heels for men and high heels for women.

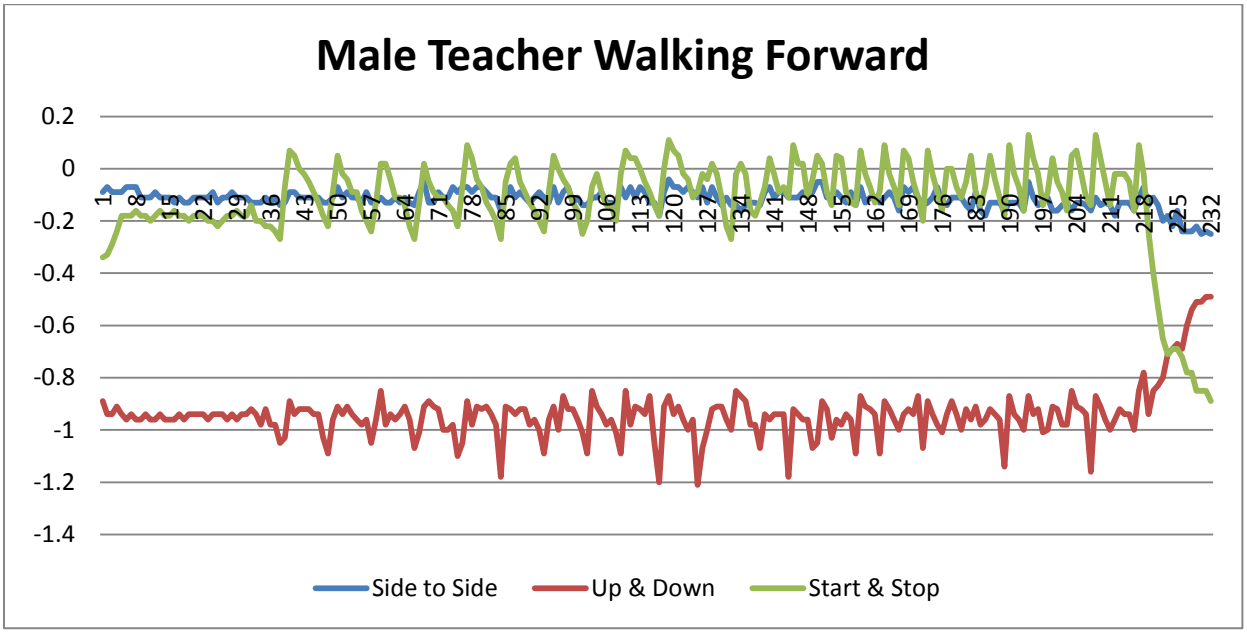
Settings for "AccelGraph" were as follows:

High-Pass Filter = Off
X-Axis = On
Y-Axis = On
Z-Axis = On
Mode = Recording (as opposed to the graphical strip chart)
Recording Frequency = 0.10s

The forward solo walking test was conducted with the subject holding the iPhone in a vertical position against their breast bone with their right hand. With the tango music playing, I pressed the "start" button of the AccelGraph app on the first beat of the music and the subject held for four slow counts of the music (2 measures). The subject then walked to the slow downbeats of the music (counts 1 & 3) for 30 steps, stopped walking, and I then pressed the "stop" button and emailed the results to myself.

The backward solo walking test was conducted in the same manner except the iPhone was held in the left hand and the subject walked backwards.

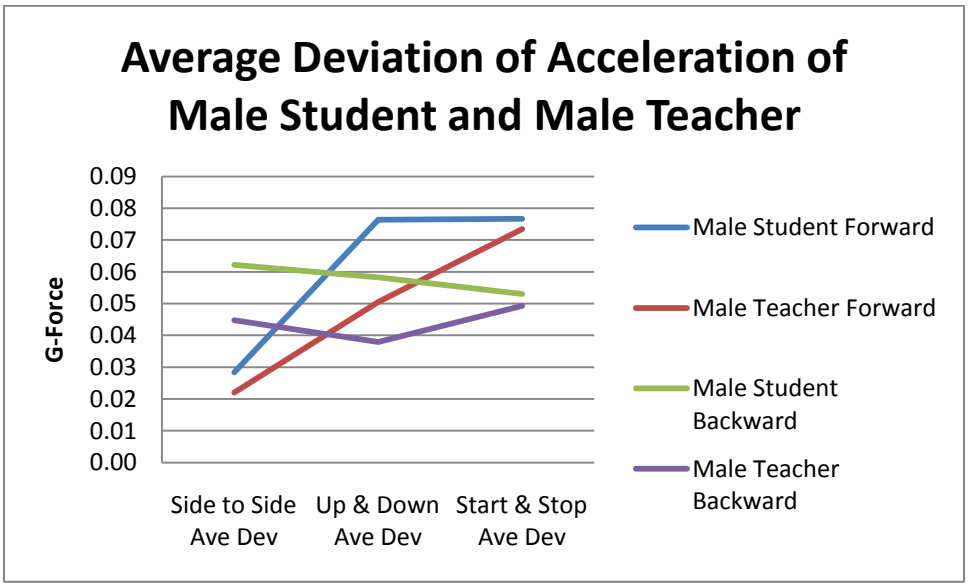
Once emailed to myself, I put the data into an excel spreadsheet to analyze the results. A typical graphical result of the raw is shown below.

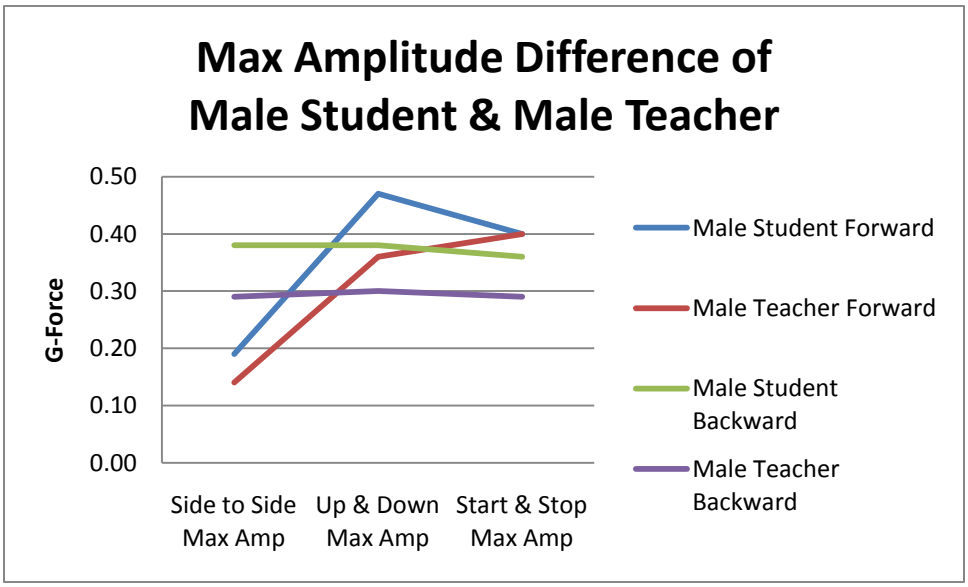


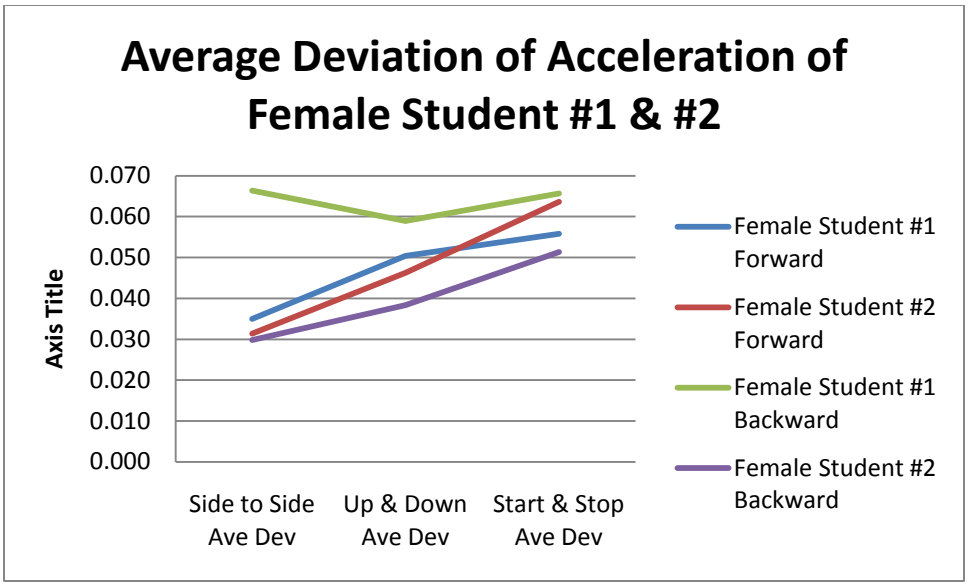
Note that the lines start fairly smooth as the subject stands still for the first 4 counts. After this smooth part, the walking motion is easily detected on the graph. Note also that the average "Up & Down" motion is displaced in the negative direction by a magnitude of approximately 1.0. This is a result of gravity pulling in the downward direction. Note also that the 'Side to Side" and "Start & Stop" motion do not average around zero as they should. This is because the iPhone was not held in a perfectly vertically aligned position. Thus there is a small component of the gravity vector acting in these other two directions.

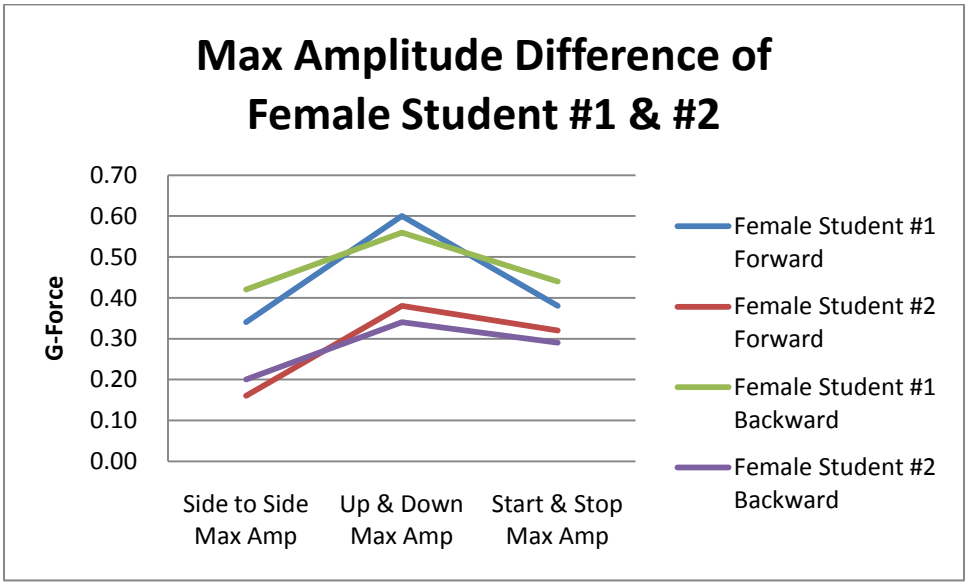
Analyzing and Comparing the Results

To eliminate including the smooth motion during the first four counts, and to eliminate the excessive motion detected while the AccelGraph was being turned off at the end of the 30 steps, only data points from 51 through 200 (roughly between 5 and 20 seconds) were used in the following comparisons. Also, to eliminate the gravity component, the only two measures that were used were the average deviation from the mean, and the difference between the maximum and minimum amplitudes—again only with data points 51-200. [Excel formulas to calculate these are; [AVEDEV(range), MAX(range) - MIN(range)]. Results are shown below:









Conclusions

1. Although more than four test subjects were actually measured for this study, for purposes of demonstrating the technique of using an iPhone to measure walking smoothness, I purposely chose only four subject's data that I felt would show significant differences.
2. It's clearly discernable from the raw data in the first graph where each step is being taken

3. Many other factors may affect the smoothness of a tango walk (i.e., height, weight, type of shoes, years and experience dancing etc). Perhaps all of these could be studied and correlated.
4. Obviously, many other factors also affect the quality of the tango experience beside just the "smoothness" of the walk. But a smooth walk does help!

Suggestion for Further Work

In some instances subjects walking solo did not stay on the beat of the music. Although in conducting these test I played the music on a separate sound system, it is possible to play music on the iTunes app in the iPhone while running AccelGraph. It would be really cool if someone could write an app to detect the beat of the music and then compare it to the acceleration data and measure the accuracy to which the test subject is walking to the beat of the music!