Proteus Motion Inc.
473 Grand St
Brooklyn, NY 11211

Introduction

Before Proteus could be able to show real-time velocity recording, it was necessary to validate Proteus' internal velocity calculations with an external measurement device. This was so that we could ensure the quality of the data that was being measured and make any modifications necessary so that the data would be as accurate as possible and would be comparable to that of other types of velocity measuring devices. We decided the best course of action would be with a device that could be mounted on the handle to record the movement velocity of the user over the full range of motion for any specific exercise.

Vmaxpro and IMU

For validating Proteus' velocity calculation, we used the Vmaxpro Velocity-Based Training Device. The Vmaxpro is typically used by athletes to measure the velocity and range of motion of their exercise movements. It can be attached to a barbell or dumbbell when performing specific movements and outputs this data to an application on a phone or computer. The Vmaxpro utilizes an on-chip Inertial Measurement Unit (IMU), which contains a 3-axis accelerometer, a 3-axis gyroscope, and a 3-axis magnetometer that the device uses to measure velocity and orientation. IMUs utilize Earth's magnetic field and the acceleration of gravity to calculate its own orientation and acceleration in all 3 dimensions of space. It then uses this data to calculate its velocity both in single axes and in the resultant 3-axis. IMUs are significantly common devices that are utilized in cell-phones, GPS, automobiles, and aircraft/spacecraft, among several other applications where location and velocity data are necessary.

External Validation Procedure

When using the Vmaxpro with Proteus, we ran several tests with the device mounted on the handle when performing selected movements. We focused on 6 movements in particular: horizontal press, vertical press, straight arm trunk rotation, two-hand chop up, bicep curl, and full-body rotational press. These exercises were picked so that the velocity can be validated in each of the planes individually as well as multiple planes at a time. We ran through these tests at varying resistances: 5, 15, and 25 pounds, as well as varying speeds: "slow", "medium", and "fast". For each of these tests, we recorded the peak velocity for the movement from both Proteus and the Vmaxpro and compared the recorded data.

The following is the data recorded from our final validation testing when performing the test at 15 pounds of resistance for the 3 speed categories:

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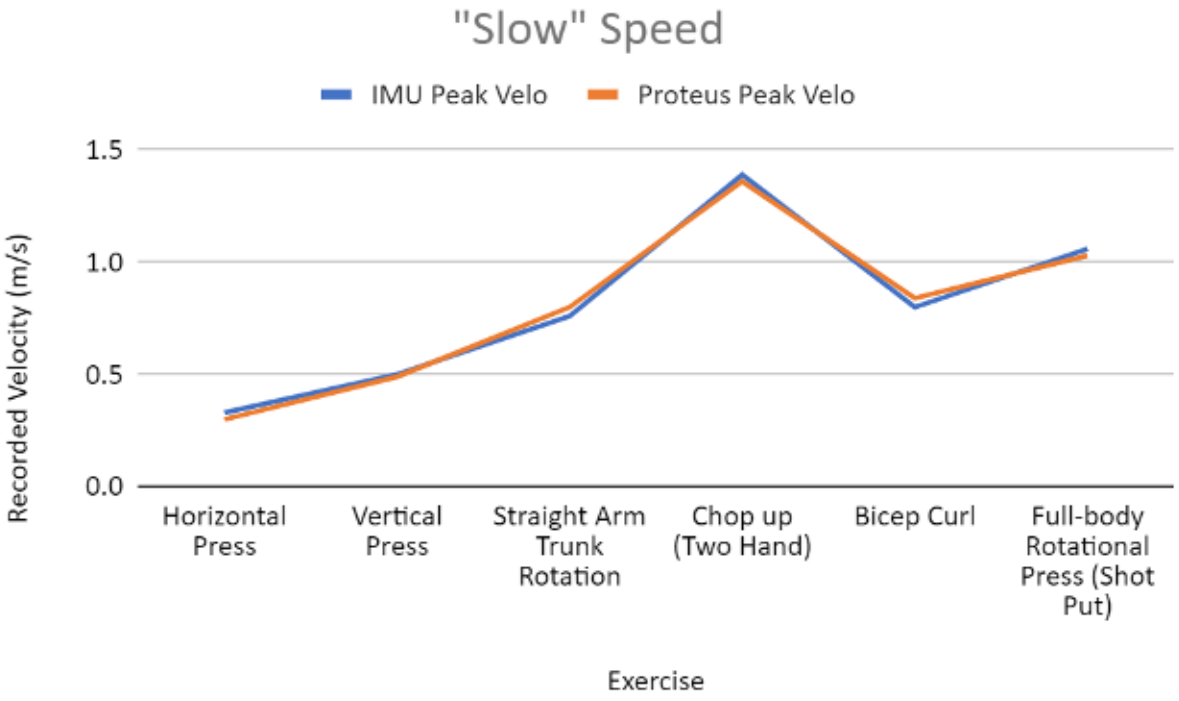
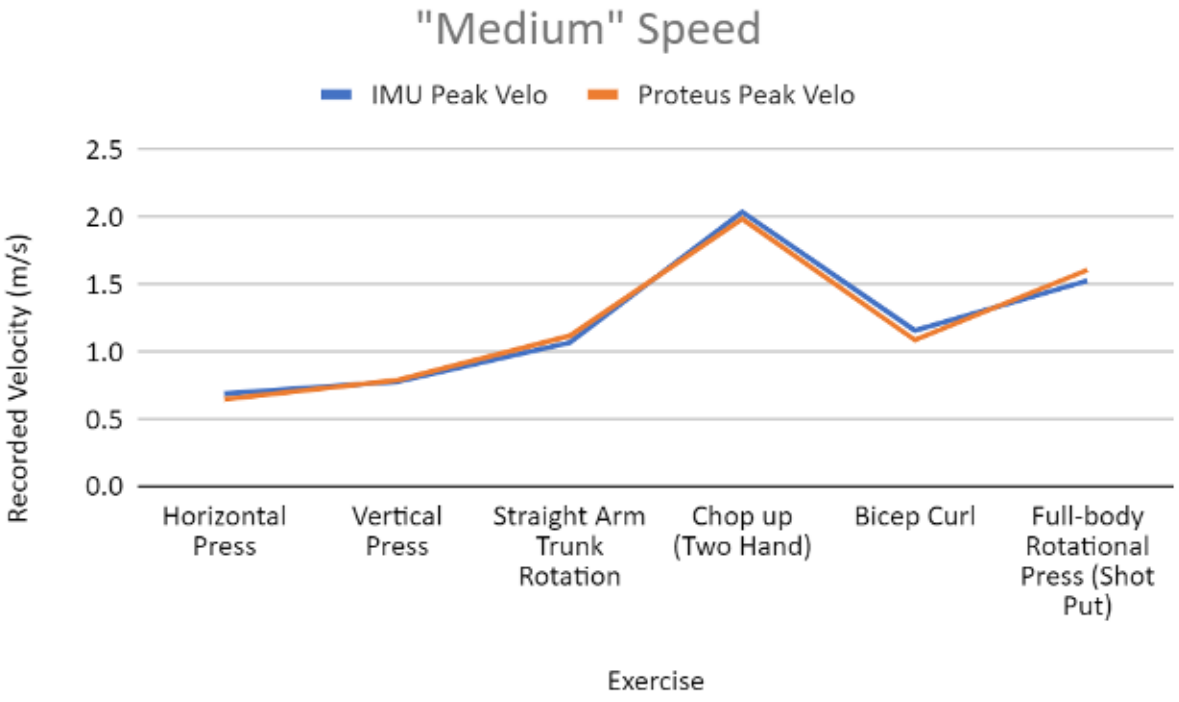
“Slow” Speed:



“Medium” Speed:



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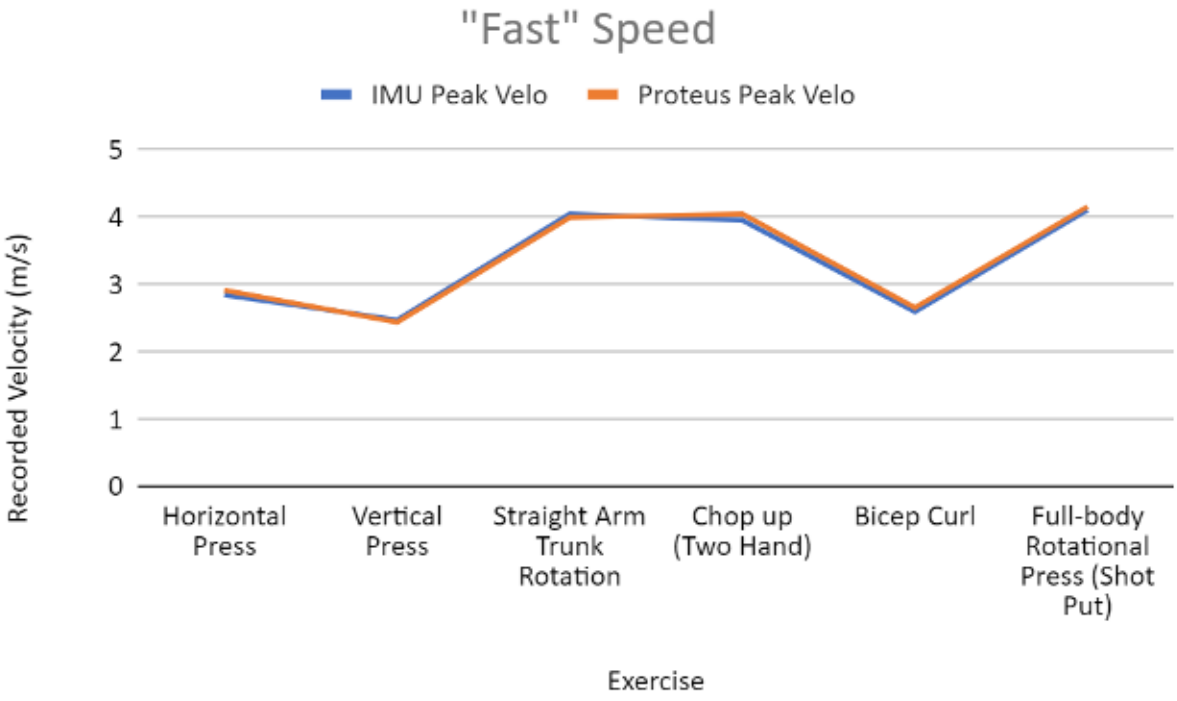
“Fast” Speed:



Data Analysis

In examining this data, we found marginal differences between the IMU velocity data and Proteus’ measured velocity data. A typical margin of error for any 3-axis measurement device is between 5-7% due to fluctuations in the devices internal magnetic field, as well as external mechanical factors such as vibration, static electricity, and orientation as well several others. For Proteus’ velocity calculations, we measured an average percent difference of 4.38%, 4.25%, and 1.83% for “slow”, “medium”, and “fast” movements, respectively, spread across all movements in all planes of motion and varying resistances. This is well within the expected margin of error, and was repeated across large sets of measured data to confirm.

Conclusion

With this data, along with the data recorded at other resistances, we were able to verify the accuracy of Proteus’ velocity calculations both in terms of the data from the IMU as well as the expected velocity range for each movement. The differences in calculations were well within the expected margin of error for all movements at all speeds and resistances. This confirmed that Proteus’ internal velocity calculations were both accurate and reliable.