

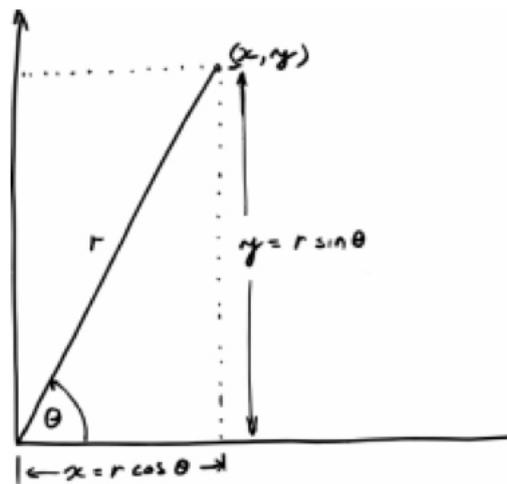
## GymAware Angle Measurement

GymAware data points comprise of Time, Displacement and Angle. Where time is the time the point was recorded, displacement is the length of extension of the tether, and angle is the angle of the tether in degrees from horizontal.

The position and angle form a polar coordinate in the form  $(r, \theta)$  where  $r$  is position and  $\theta$  is the angle.

Since we are only interested in the vertical ( $y$ ) component of the lift a simple polar to rectangular coordinate conversion is done to give the  $y$  component of each data point. That is:  $y = r \sin \theta$  Once converted to a rectangular coordinate the  $y$  values can be summed to give total lift height.

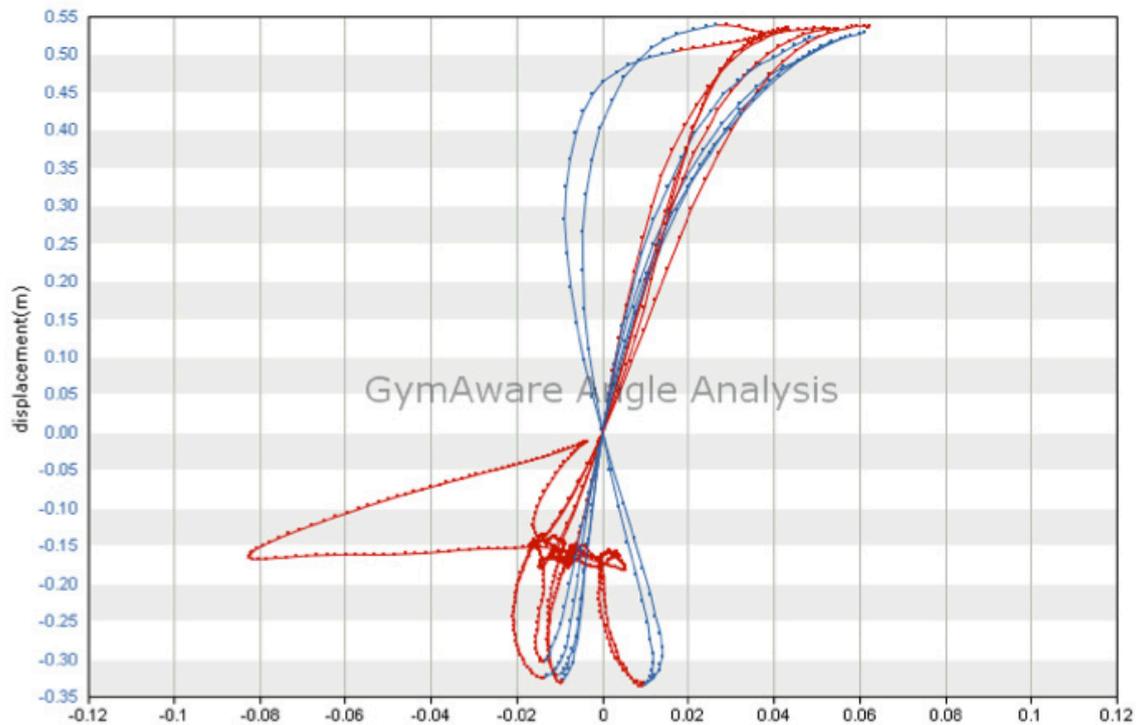
GymAware reports both raw (distance) and corrected (vertical height) values and power and work are always reported using vertical height values. This is particularly convenient for angular leg press and hack squat exercises as the vertical lift is automatically calculated.



### Limitations

The purpose of the angle sensor is to correct errors on lifts that contain a relatively small horizontal component; exercises such as Olympic lifts etc. Shown on the next page is an example of a power clean.

The blue part of the line indicates the concentric phase of the lift, the red- the remainder of the measurement including the eccentric movements. This example shows that lifts are not all perfectly linear and without the horizontal component being measured and the subsequent vertical displacement corrected, larger errors would be present. In this example, the overall vertical displacement was corrected from 0.56m to 0.54m



In addition to the vertical displacement correction, the angle measurement is used to automatically alert the practitioner to poor protocol. If the angle component changes greatly within a set, the data is flagged as having a large change in angle. This could indicate poor protocol and therefore lead to large errors in measurement. It is not intended to give a complete 2 dimensional measurement from 0 to 90 degrees.

When the sensor is placed too far in front or behind the athlete as shown below, the tether angle is approaching horizontal, the vertical component will be seen by the sensor as a change in angle as opposed to a change in displacement – in this case the set will trigger a suspect result alert due to poor protocol (angle changing by more than a threshold)

This is just one of the data integrity checking features of GymAware, ensuring that practitioners only record high quality data sets.

Last but not least, the measurement and correction for angle enables users to accurately use equipment such as the leg press or hack squat machines. It is not possible to accurately measure and calculate power and work, if the vertical component of the lift cannot be measured.

