In competitive swimming, improving stroke technique makes it possible to gain an advantage on an opponent. Stroke analysis is often based on subjective criteria, due to lack of data regarding propulsion. By using waterproof accelerometers, sport scientists can measure accelerations of the hand and wrist and analyze the impact these accelerations have on the forward motion of the body.

Previous studies show that the duration and acceleration of the different phases of the freestyle stroke cycle can be determined using accelerometers attached to the swimmers' wrists (Ogih et al., 2003). The accelerations of the body in a forward direction have also been analyzed using waist mounted accelerometers (Davey et al., 2008). Other studies have used both wrist and back mounted accelerometers (Bachlin & Tröster, 2011), but none have determined the effect that the different phases of the arm stroke cycle have on the forward propulsion of the body.

Methods

Procedures
• Participants were instructed to swim 25 meters as fast as possible.
• In order to look at stroke phases with a minimum of interference, the participants were instructed not to breathe during the 25 meter sprint.

Data Collection
• Tri-axial accelerometers were placed on the left wrist and lower back, at the 3rd lumbar vertebrae (L3) of the swimmer.
• Accelerometers sampled the data at 60 Hz.
• The participants were also video recorded using an underwater camera (Kodak PlaySport ZC5) that recorded at 60 Hz.
• The accelerometer data was smoothed with a low-pass digital filter (3 Hz cutoff).

Data alignment
• In order to align the data, subjects were instructed to jump on land, thereby creating a point of reference for both the accelerometers and the video.

Results

Results are shown for a representative participant.
• The pull and push phases of the stroke cycle cause the greatest positive (i.e., forward) acceleration of the hip/trunk.
• The down sweep, from the point at which the hand enters the water until the catch, is the longest single phase of the stroke.
• As the left hands enters the water, the right hand is stroking and causing positive forward acceleration of the hip.
• Peak accelerations in each of the three axes, can be used to determine specific stroke phases.

Discussion & Conclusions

• The change in hand orientation from horizontal to vertical, causes gravity to change from the z-axis to the y-axis of the accelerometer.
• The swimmer was kicking as well as arm stroking, which will have an effect on the positive and negative forward accelerations of the hip. Studies are ongoing that will attempt to quantify the contribution of the kick to the forward acceleration of trunk/hip.
• The intent of this research is to provide coaches with the opportunity to identify specific deficiencies in the various stroke phases/patterns of individual swimmers.

References

Figure 1: Left hand accelerometer axis description.

Figure 2: Lower back (L3) accelerometer axis orientation. The position of this accelerometer represents the forward motion of the swimmer’s centre of mass (COM).

Figure 3: The graph shows two full stroke cycles of freestyle. Data is from the accelerometers placed on the left hand and at L3 showing motion of the trunk/hip. Black vertical lines illustrate peaks used for stroke phase identification.