

# Two-Dimensional Sequential Analysis of the Underhand Softball Pitch

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## INTRODUCTION

Proximal to distal sequencing is a process most readily associated with extension motions such as kicking and overhand throwing. Unfortunately, motions dominated by flexion movements have gone largely ignored in the literature. Therefore, the purpose of this research was to determine if the upper extremity exhibits the quantitative criteria of proximal to distal sequencing during the underhand windmill pitch via kinematic, kinetic, and electromyographic analysis.

## METHODS AND PROCEDURES

5 Collegiate Varsity Softball Pitchers (ht:  $1.83 \pm .065$  m, mass:  $87.27 \pm 5.44$  kg) were asked to throw 5 pitches at game speed. The pitch with the highest velocity was used for analysis. The motions of the upper extremity and the muscle activity of the triceps and biceps brachii were captured using an integrated Motion Reality Inc. (Marietta, GA) motion capture and Noraxon Electromyography (EMG) (Scottsdale, AZ) system. Further mathematical analyses allowed for a description of moments at the joints of interest.

## RESULTS AND DISCUSSION

The results from velocity and moment calculations revealed that the underarm throwing pattern does indeed follow the proximal to distal sequencing as expected. The velocity (figure 1 and figure 2) followed the expected pattern where the distal segment's (lower arm) peak velocity is

achieved at a point near the proximal segment's (upper arm) minimum velocity with the appropriate corresponding changes in acceleration.

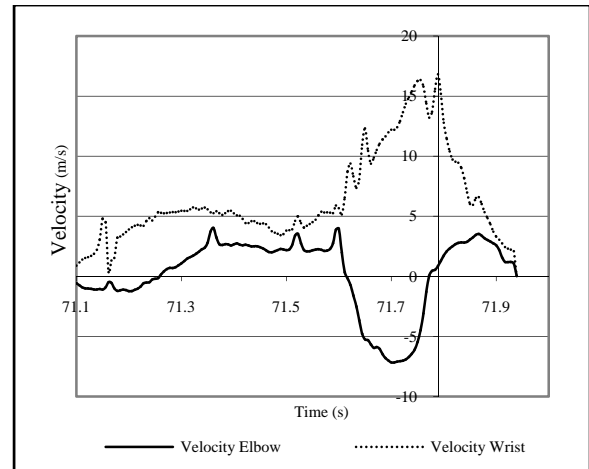


Figure 1. Linear velocity of elbow and wrist

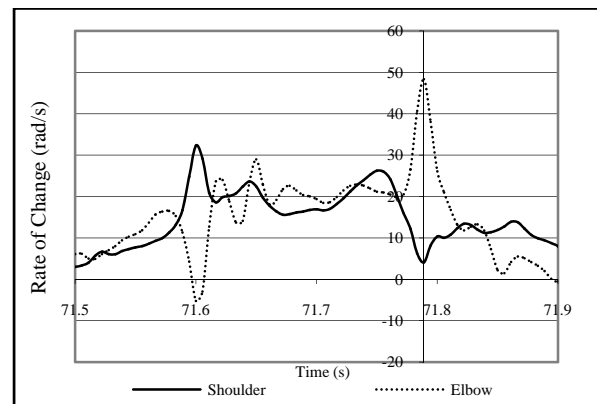
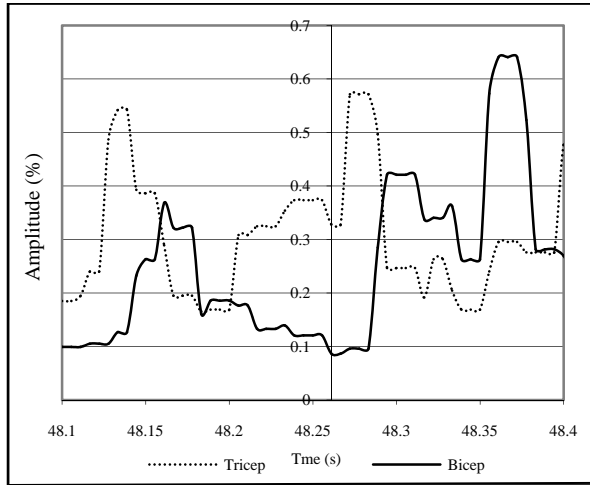


Figure 2. Sagittal plane angular rate of change of elbow and wrist.

The EMG results (figure 3) revealed an attenuated bicep and increased tricep activation at the time of peak distal segment

velocity, suggesting little elbow flexion muscle contribution.

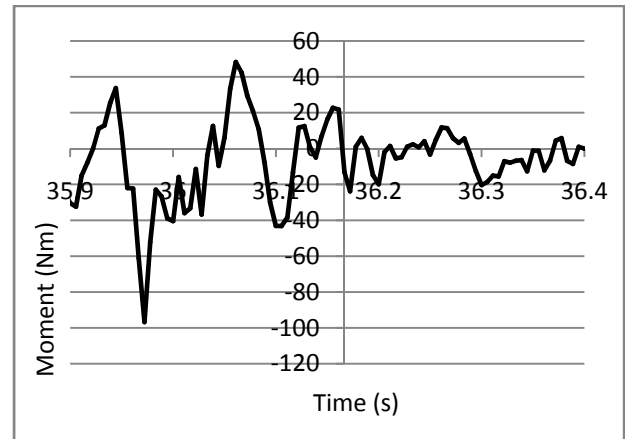


**Figure 3.** Electromyographic Analysis of Biceps and Triceps

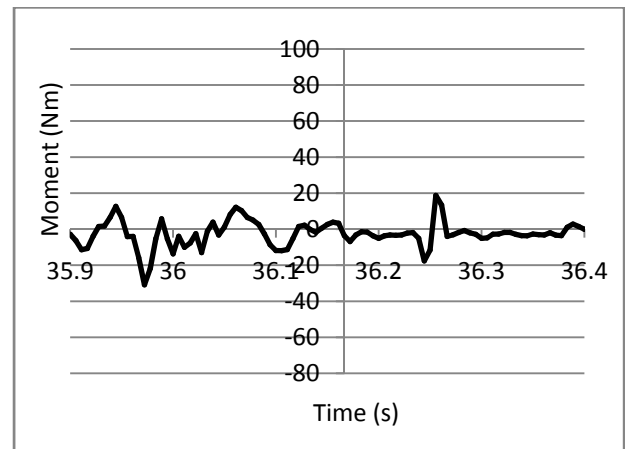
The reversal of accelerations and velocities seen in the results of this study confirmed the existence of a proximal to distal sequential motion in the windmill pitch. It also provides evidence that this summation of speed at the elbow occurs through a reversal of accelerations caused by an inertial acceleration of the lower arm with a negative acceleration of the upper arm rather than an activation of the elbow flexion musculature. Furthermore, the moment graphs indicating the direction of the moment at the shoulder, in conjunction with the moment at the elbow further allowed the researcher to classify the action of the underhand pitch as classic proximal to distal sequencing. Figure 4 is a graphical representation of the moment about the shoulder during the underhand pitch. Figure 5 is a graphical representation of the moment about the elbow during the underhand pitch.

The instant of release is marked by the location of the y-axis on the graph. The negative moment at the shoulder with the small negative moment at the elbow, during the time of separation of velocity lines between the upper arm and lower arm,

suggest that there is a negative acceleration of the proximal segment with a corresponding positive acceleration of the distal segment, conserving angular momentum. Furthermore, the negative moment seen at the elbow may be indicative of the reactive moments produced by the hard end point of the bone on bone contact at the joint during the transfer of momentum from the proximal to distal segments.



**Figure 4.** Sagittal plane moment about the shoulder



**Figure 5.** Moment about the elbow

These findings in conjunction with velocities and accelerations that rival those seen in overhand pitching, are a vital step in understanding the injury mechanisms and performance enhancements that may be associated with windmill pitching.