**Study Title: Modeling Trunk Kinematics in Collegiate Baseball Pitchers Using a Damped Torsion Spring Oscillator**

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**Background, Significance and Context:**

In Baseball, many athletes struggle to utilize the energy transfer of the kinetic chain. When most players throw, somewhere along the chain there is a leak of energy due to inefficient timing or bad mechanics.

The Pitching kinetic chain starts from ground reaction force (GRF), then transfers into the separation of the pelvis and thorax, and finally into the upper extremities for ball release. When separation is achieved and held efficiently, the energy from the GRF is then transmitted through the trunk to efficiently transfer the energy from the lower extremities to the upper extremities2. These chain of events allows the efficient transfer of energy from the lower extremities via GRF, to the upper extremities by efficient hip to shoulder separation.

When looking at the kinetic chain, many have observed that the lower extremities and core musculature reduce the kinetic contributions of the shoulder joint,1,2causeing a loss in the total energy transfer. The energy leaks from the trunk are caused by inefficient trunk mechanics via lack of pelvis and torso

To construct a simple model, we will be looking the trunk, incorporating the pelvis and the torso, components of the kinetic chain. This will allow us to exam the energy transfer between the lower extremities and upper extremities using the initial time of maximum pelvis angular velocity, and the final time at maximum torso angular velocity.

**Hypothesis**

In this experiment we are looking to analyses the trunk mechanics of the pitching motion using energetics with our 2-part model of the trunk. This study has 3 aims:

1. To compare trunk energetic and arm speed effects between bullpen and “game-like” situations.

2. Examine throwing arm fatigue between bullpen and “game-like” situations.

3. To comparison of cardiovascular stress between conditions (Polar).

We believe that If during a “game-like” setting the rotational kinematics of the pelvis and torso are increased, then the ball kinematics will also increase.

**Methods**

* Upon session, participants will have their hands, thorax and pelvis measured
  + Thorax circumference measured from xiphoid process
  + Pelvis circumference measured in line of Right and Left Anterior Superior Iliac Spine (ASIS)
  + Hand measurements from thumb to pinky
  + Individual modeling of each athlete’s trunk to model moment of inertias for each player.
* Each participant will complete pre-testing of an isometric internal and external rotation testing before throwing to measure fatigue factors of the trunk biomechanics
  + Using Armcare Dynamometer
* Upon Pitching Session:
  + 2 Catapult sensors will be strapped onto the athlete to measure rotational positions and velocities of the trunk (Appendix B). One on the xiphoid process, and the other one in between both ASIS.
  + Participants will throw warm-up pitches with baseball, if desired, before data collection.
* The participant will throw each of their pitch type at most 3 times each from a standard pitching mound to a Major League distance of 60.6 feet using a PitchLogic Baseball.
* 4D Motion Vest will then be removed, and participant will complete post-testing of isometric strength for internal and external rotation.
* Participants involvement for the session is complete.

**Outcome Measure(s)**

In this study we are measuring rotational velocities of the pelvis and thorax within the global space. This will be used to derive our energy equation for our torsional spring of the trunk. We will use these measurements along with the circumference measurements of the pelvis and torso to construct an individual model for each individual athlete. We will then compare these individual models to the ball kinematic metrics to not only compare the effects of the play environment from a bullpen to a game, and to find a correlation between the calculated rotational quantities and the tangential and angular velocities of the baseball. Measurements such as hand size, grip strength, and throwing arm isometric internal and external rotation forces will be measured to further ball kinematic variables, as well as throwing arm fatigue pre and post sessions.

**Analytical Plan**

Results will be analyzed initially using descriptive statistics. The mean values for the K/I ratio will be compared for all participants tangential and angular ball velocity by use of repeated-measures analysis of variance (ANOVA). If a significant difference (P < .05) is found among the created metric K/I, pairwise differences will be analyzed with a post hoc Tukey test (P < .05). This will tell us how values differed

A linear regression model will be will further analyze correlations amongst observed measured outcomes and the predicted ball kinematics. Using this model, a residuals plot will be constructed using the linear regression model to assess the quality of each model. We will also use these models to describe the relationship amongst playing environment types.

**Plan of Action:**

Our goal is to start collecting data during the first week of March. This is to align with RIT’s capstone guidelines which requires all data collection along with final presentations to be complete by mid-April. We see a great potential to broaden the horizon of baseball biomechanics as we are testing kinematics of game-like environments, along with how to increase spin without the use of a foreign substance. To gather these measurements, we would like assistance in obtaining 2 Catapult GPS/gyrometer wearable sensors that attach to the pelvis and torso. With your help and involvement, we can truly make a powerful impact on Sports Biomechanics and the game of Baseball.