variables that related to higher velocity included decreased elbow flexion at the end of acceleration phase. Strength parameters including hip internal and external rotation strength were found to be related to higher velocities. These findings highlight the potential influence of lower extremity kinematic variables and strength on performance as measured by velocity. These results can benefit players or coaches who are teaching or learning how to do the overhand throw.

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Effects Of Weighted Baseball Throwing On Youth Glenohumeral Joint Reaction Force

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(No relevant relationships reported)

INTRODUCTION: Weighted baseball throwing programs are often used to increase pitch velocity. However, increased injury risk has been reported and questions regarding possible mechanism of injury exist. Kinematics and kinetics have been investigated with inverse dynamics approach, but the effects of individual muscle forces have rarely been taken into account by these models and in consideration of pitch mechanics. Analysis of shoulder joint reaction force with a musculoskeletal model including individual muscle forces may provide new insight on injury mechanism.
PURPOSE: To compare the effects of varied weighted baseballs on glenohumeral (GH) joint reaction forces during youth pitching.
METHODS: 7 baseball pitchers (Age 15.7 ± 2.4) participated in the study. Participants performed 5 pitches for strikes with 5oz, 7oz, and 9oz baseballs. Full body, 3D segment position data were collected using a motion capture system (200 Hz) and ball velocities were measured via radar gun. Highest velocities of 3 pitches were selected and 3D marker trajectories input into a 19 DOF musculoskeletal model utilizing a standard inverse dynamics and static optimization routine to produce individual muscle forces to yield GH joint reaction forces. Mean distraction force, anterior shear force, and superior shear force on GH joint were calculated and compared with RMANOVA (alpha = .05) during the acceleration phase of the pitch with Bonferroni post-hocs.
RESULTS: Differences were noted between the ball weights on ball velocity (5oz 66.9 ± 8.8mph, 7oz 61.6 ± 7.8 mph, 9 oz 56.9 ± 6.1 mph, $p<0.001$). Also, throwing heavier baseballs exhibited increased distraction forces (5oz 1987±472.5N, 7oz 2386±544.1N, 9oz 2414±601.1N, $p = 0.007$); while anterior shear force and superior shear force did not present distinct differences.
CONCLUSIONS: Distraction force pulls humeral head out of the glenoid fossa, and weighted baseball throwing program may cause more stresses on biceps brachii, rotator cuff, and surrounding structures by the increased distraction force.

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The Kinematic Sequence Of The Baseball Bat Swing And Associated Upper Extremity Torques

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(No relevant relationships reported)

PURPOSE: The Kinematic Sequence (KS) is the timing of peak angular velocities generated across connected body segments during a movement pattern. The most efficient KS reported in sport is when the timing occurs in a proximal-to-distal (PDS) pattern. This 'ideal' KS follows the order of pelvis, trunk, arm, forearm, and hand. Based on simulated models of the golf swing, the PDS KS results in greater ball distance and decreased joint stresses. Despite similarities to the golf swing, there is limited research on the KS during batting. Study aims: 1) Identify KSs during the baseball swing and 2) compare the leading upper extremity torques across the 3 primary KSs.
METHODS: 23 baseball players (professional=2, collegiate=11, high school=10) underwent 3D biomechanical swing analysis, totaling 47 trials. A 15-segment model was constructed using a 20 Vicon™ camera motion capture system (240 hz). Body segment and bat velocities as well as peak shoulder and elbow torques were calculated using Visual 3D™ biomechanical software. Time of peak angular velocity of the pelvis, trunk, arm, forearm, and hand was recorded. The torques were compared across the two most performed KS patterns as well as the KS representing the closest to a PDS pattern. The KS patterns were labeled by the first body segment that disrupted the PDS pattern: proximal (PUE) and distal (DUE) upper extremity. Analyses included an ANCOVA using bat velocity as a covariant.
RESULTS: 11 unique KS patterns were identified. The most commonly performed KSs were DUE (n=23) then PUE (n=13). No batter displayed the exact PDS KS. Therefore, 5 trials that most closely represent the PDS, those with forearm and hand velocities peaking simultaneously, were grouped as PDS. Peak elbow extension torque differed significantly between the 3 KS groups ($F(2,37)=4.95$, $\eta^2=0.21$, $p=0.012$) with lower values for PDS (PDS: 17.94 ± 12.83 Nm, PUE: 51.09 ± 25.19 Nm, DUE: 43.01 ± 22.26 Nm, $p=0.012$).
CONCLUSIONS: This foundational study is the first to apply a KS classification system to the baseball swing. Lower elbow extension torques for the PDS group are consistent with the idea that a PDS KS may result in decreased joint stress. KS analyses could potentially guide clinicians and hitting instruction to minimize biomechanical risk factors during batting.

B-73 Free Communication/Poster - Sports Biomechanics

Wednesday, May 27, 2020, 1:30 PM - 4:00 PM
Room: CC-Exhibit Hall

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The Measurement Of Thrust In Competitive Swimming: The Association Between Different Thrust Variables

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(No relevant relationships reported)

Swimming acceleration and velocity are the net balance between Drag Force and Thrust. It is a standard procedure to do the decomposition of the Thrust-Time curve, assessing the swimmer's thrust. However, there is not a convention or standard procedure on the variables to be selected. Researchers report on regular basis either the Peak Thrust, Mean Thrust or Thrust-Time Integral. It is yet unclear to which extend these variables can be used, reported and interpreted interchangeably. **PURPOSE:** To analyze the association between different thrust variables performing arm-pulls in competitive swimming. **METHODS:** 671 front-crawl arm-pull cycles of 14 competitive swimmers were analyzed. Thrust was collected by an in-house built system composed by differential pressure sensors and underwater camera (Aquanex, Swimming Technologies, USA). A customised software (LabVIEW®, v.2017) was used to acquire (f=50Hz) and streaming time-series and video signal. Data was transferred to interface by a 14-bit resolution acquisition card (NI-6001, National Instruments, Austin, USA). Then, it was imported into a signal processing software (AcqKnowledge v.3.9.1, Biopac Systems, USA). It was extracted the Peak Thrust, Mean Thrust and Thrust-Time Integral of each arm-pull. Coefficients of Determination were computed between the three thrust variables. **RESULTS:** All Coefficients of Determination were significant ($P<0.001$). Peak Thrust vs. Mean Thrust was $R^2=0.49$, Peak Thrust vs. Force-time Integral $R^2=0.51$, and Force-time Integral vs. Peak Thrust $R^2=0.61$. Interception on Y-axis at the origin of the pairwise variables noted in the same SI unit (i.e. Newton) were very close to zero ($-1.6948<c<4.5029$) and standard error of estimate acceptable ($6.54<S<12.14$). **CONCLUSIONS:** There is a strong association between different thrust variables, even though the proportion of the variance is about 50-60%. Supported by: NIE AcRF Grant (RI 6/17 TB); Portuguese Foundation for Science and Technology (UID/DTP/04045/2019); European Fund for regional development (FEDER)-COMPETE 2020 (POCI-01-0145-FEDER-006969).

1026 Board #152 May 27 1:30 PM - 3:00 PM

Power Parameters Appear Less Important To Water Polo Success Than Motor Control

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(No relevant relationships reported)

Conditioning programs for water polo players typically focus on muscular power to enhance the wrestling and shooting components of play. While improvements in strength training are easily quantifiable, the relationship between upper limb power and in-game performance has yet to be established. **PURPOSE**: To test the effect of upper limb force parameters on offensive performance in women's water polo players. **METHODS**: We conducted biomechanical testing on 12 D1 women's water polo players using Proteus (Proteus Motion, USA). After completing a familiarization and warm-up protocol, subjects performed a single set of 10 repetitions at 3lb of magnetic resistance in 3 different exercises: shoulder adduction, internal rotation of the shoulder while in horizontal abduction, and a throw motion. Proteus calculated peak power (PP), peak force development rate (PFDR), and consistency (accuracy of movement