The Effect of Fatigue on Youth Pitcher Lateral Trunk Tilt

John P.Liffrig, BBmE[a,b], Robert A.Cecere, BS[a,b], Stone R.Streeter, BS[a,b], Anna B.Williams, BA[a], James B.Carr, MD[a], Stephen Fealy, MD[a], Joshua S. Dines, MD[a], Lawrence V. Gulotta, MD[a], Andreas Kontaxis, PhD[a]

a. Sports Medicine Institute, Hospital for Special Surgery, New York, NY, USA
b. Weill Cornell Medical College, New York, NY, USA

Introduction: Youth baseball is one of the most popular sports in the United States, and a particular emphasis has been placed on injury prevention in this group due to an increasing incidence of arm injuries. Extensive work has been done to connect biomechanical parameters with established risk factors, including pitching while fatigued[1], but little is known in regards to the connection in a youth cohort. Lateral trunk tilt at ball release has been correlated with several joint forces and torques potentially linked to arm injury, yet the change in trunk tilt within youth individuals throughout the course of an outing is unknown. The purpose of this study was to analyze differences in youth lateral trunk tilt throughout a simulated pitching performance.

Materials & Methods: Twelve male youth baseball pitchers (14.9 ± 0.7 years) were recruited to participate in this study. Subject were eligible for inclusion if they were (1) a healthy male between 13-18 years old and (2) had played team baseball for over a year. Subjects were excluded from the study if they had a history of shoulder, elbow, lower extremity or back pain within six months of testing. Three-dimensional marker trajectories were collected using a 12-camera optical motion capture system (Motion Analysis Corporation; Santa Rosa, CA) at 250 Hz. A radar gun placed behind home plate was used to collect ball velocity data (Sports Radar DT200; Sports Radar Ltd., Homosassa, FL). Subjects were asked to complete a simulated pitching outing of six sets of fifteen pitches from a regulation mound (60 ft 6 in) with five-minute breaks in between innings. Two out of six sets were included for analysis in this study: the "Peak Set" and "Fatigued Set". The "Peak Set" was defined as the inning with the highest average ball velocity, while the "Fatigued Set" had the lowest average ball velocity. Eleven of the twelve participants completed the simulated outing, with one completing only 5 sets due to arm discomfort. Visual3D software (C-Motion Inc., Germantown, MD) was utilized to analyze kinematic and kinetic variables at key instances in the pitching motion: knee up, foot contact, maximum external rotation, ball release, and maximum internal rotation.[1] Two subjects were excluded from analysis because forearm data was missing over an extended period during the simulated outing. A repeated measures analysis of variance with Bonferroni pairwise comparison was used to determine differences between "Peak" and "Fatigued" sets. SPSS statistical software (IBM Corp., Armonk, NY, USA) was used for data analysis, and significance was set at $P < .05$.

Results: The highest average ball velocity was observed in the second simulated inning (66.6 ± 5.9 mph, $p = 0.021$, "Peak Set") and the lowest average ball velocity was found in the last simulated inning (63.4 ± 5.8 mph, $p = 0.001$, "Fatigued Set"). There was a statistically significant decrease in lateral trunk tilt at ball release between the Peak and Fatigued Set (32.31 ± 8.70 vs. 29.60 ± 9.58 degrees, $p = 0.014$). There was a moderate positive correlation between trunk tilt and ball velocity (adjusted $R^2 = 0.40$, $p = 0.002$, Fig. 1) as well as between trunk tilt and elbow varus torque (adjusted $R^2 = 0.45$, $p = 0.001$, Fig. 2). Finally, there was a moderate positive correlation between trunk tilt and shoulder superior force (adjusted $R^2 = 0.25$, $p = 0.024$).

Discussion: The study showed that lateral trunk tilt decreased from Peak to Fatigued sets in a youth pitching cohort. This contrasts previous work done in an older cohort (mean age 22.8 ± 2.9 years) which found that lateral trunk tilt increased from the first to the ninth set of a simulated game. The difference is possibly accounted for by the difference in age and skeletal maturity of younger throwers as well as their technical throwing ability.[2] Additionally, trunk lateral tilt at ball release was positively correlated with ball velocity, elbow varus torque and shoulder superior force, all of which are consistent with previous work done in high school pitchers.[3] An increase in lateral trunk tilt at ball release may confer a performance gain (as denoted by pitch velocity increase), but was also shown to expose the shoulder/elbow joints to higher forces and torques. Because of that it is important to inform coaches to emphasize and enforce good pitching mechanics on youth pitchers even when they are not fatigued, since cumulative stress and depreciating ability of surrounding structures to stabilize the shoulder joint can increase risk of injury.

References: [1] Fleisig GS, *Sports Health,* 2012; [2] Aso T, *J Phys Ther Sci,* 2024; [3] Manzi JE, *J Shoulder Elbow Surg.,* 2022

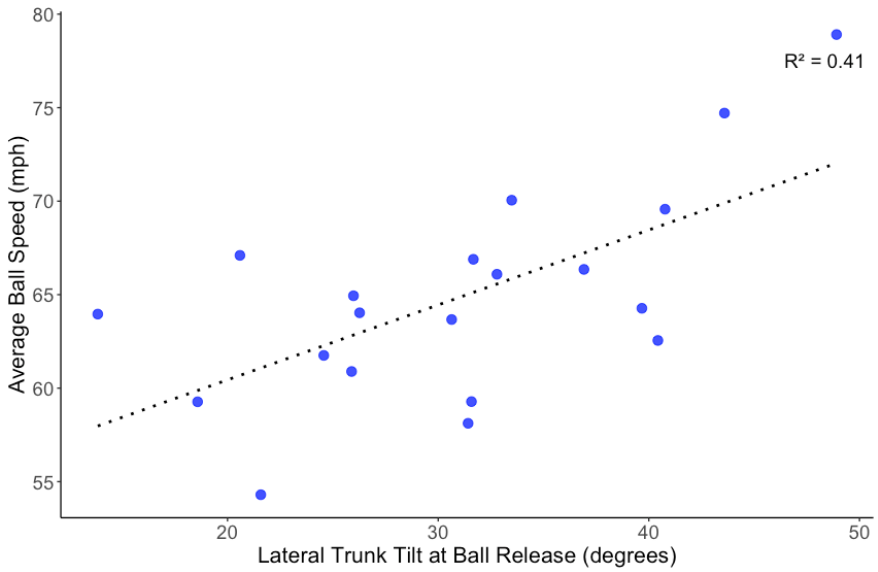

Fig. 1: Average Ball Speed (mph) vs. lateral trunk tilt at ball release (degrees)

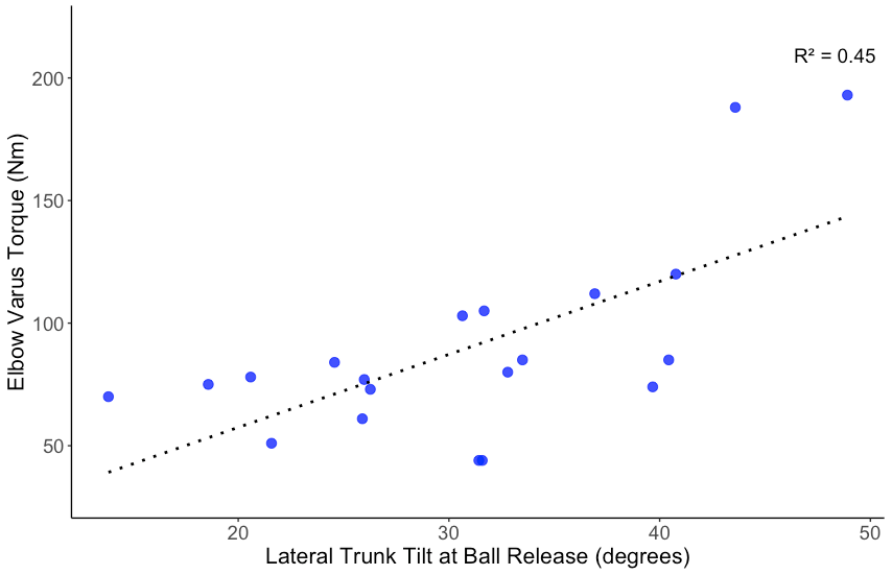

Fig. 2: Elbow Varus Torque (Nm) vs. lateral trunk tilt at ball release (degrees)