The Influence of Lead Knee Extension on Ball Velocity and Elbow Varus Torque in High School and Professional Baseball Pitchers

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INTRODUCTION: Proper positioning of the lower extremities facilitates efficient energy transfer through the kinetic chain to produce optimal ball velocity. When a pitcher's lead leg contacts the ground, the knee initially braces, then rapidly extends; thereby transferring energy to drive the pelvis and trunk into rotation. Pitchers who lack lead leg extension during a pitch are hypothesized to have reduced transfer of energy up the kinetic chain, potentially requiring the throwing arm to make up for the loss resulting in increased elbow varus torque. There remains a paucity of research investigating the influence of lead knee extension on ball velocity and elbow varus torque in high school and professional pitchers. Therefore, the purpose of this study was to investigate differences in lead knee extension, peak lead knee extension velocity, ball velocity, and elbow varus torque in high school and professional pitchers.

METHODS: Data from professional (n=50) and high school (n=50) pitchers were included in this retrospective review. Pitchers threw 8-12 fastballs under 3D motion analysis (480 Hz). The fastest pitch for each player was used for the analysis. The professional and high school groups were divided into 'High' and 'Low' lead knee extension group based on the individual average lead knee extension was greater than or less than 0.5 standard deviation from the entire group mean. One-way analysis of variance was used to analyze lead knee extension, lead knee extension velocity, ball velocity, absolute elbow varus torque, and normalized varus torque between groups. The pitch was broken down into four timepoints: foot contact, maximum external rotation, ball release, and maximum internal rotation. For all analyses, statistical significance was set at an alpha value of 0.05.

RESULTS: At foot contact, the four groups land with similar knee flexion. Both the professional and high school High groups had significantly less lead knee flexion at maximum external rotation, ball release, and maximum internal rotation compared to both the professional and high school Low groups (Figure 1). Professional High pitchers had faster knee extension velocity than the professional Low and high school Low but not the high school High (Table 1). There was no difference in timing for knee extension velocity between all groups. Professional High and Low had faster ball velocity than high school High and Low pitchers but there was no difference in ball velocity between the High and Low groups. The professional Low pitchers had greater absolute elbow varus torque compared to the professional High.

DISCUSSION AND CONCLUSION: Proper extension of the lead leg sets the rest of the body to efficiently transfer energy through the kinetic chain in order to produce optimal ball velocity and minimize elbow varus torque. Conversely, continuing to flex the knee after landing can result in energy dissipation; subsequently the throwing arm has to compensate and increased torque is experienced at the elbow. Instructing professional pitchers to improve the lead leg bracing technique that facilitates increased lead knee extension mechanics can contribute to faster ball velocity with minimal impacts on elbow varus torque. However, in high school pitchers there appears to be other mechanical attributes contributing to elbow varus torque and comparison between pitchers and further investigation is warranted.

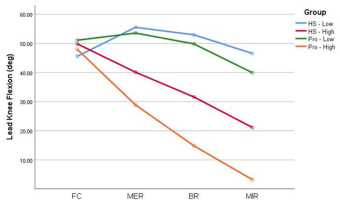

Figure 1: Lead knee extension during the pitch for professional and high school pitchers. FC, foot contact; MER, maximum external rotation; BR, ball release; MIR maximum internal rotation.

Table 1. Kinematic and kinetic differences between high and low knee extension in high school and professional pitchers

	HS Low (n=17)	HS High (n=16)	Pro Low (n=16)	Pro High (n=18)	Significance
Lead knee extension (°)	-7±5	18±6	1±8	33±7	a,b,c,d,e,f,g
Lead knee extension velocity (°/s)	124±77	270 ±65	187±122	409 ±76	a,b,d,e,f,g
Lead knee extension velocity timing (% pitch)	57±31	65±24	47±29	61±28	
Ball velocity (m/s)	31.2±1.8	34.1± 2.6	39.3±1.3	39.8 ±1.1	a,c,d,e,f,g
Elbow varus torque (Nm)	56.3±12.2	64.2±14.7	95.4±13.3	85.3±10.7	c,d,e,f,g
Elbow varus torque (%BH_BW)	4.2±0.6	4.7±0.6	5.2±0.8	5.0±0.7	c,d,e,f,g

Note: Negative lead knee extension represents knee flexion. Significant differences ($p<0.05$) between (a) HS Low and HS high, (b) Pro Low and Pro High, (c) HS low and Pro Low, (d) HS Low and Pro high, (e) HS High and Pro Low, (f) HS High and Pro Low, and (g) Pro High and HS High.