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ORIGINAL ARTICLE

Are the hamstrings from the drive leg or landing leg more active in baseball pitchers? An electromyographic study

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Background: Ulnar collateral ligament reconstruction (UCLR) has become a common procedure among baseball players of all levels. There are several graft choices in performing UCLR, one of which is a hamstring (gracilis or semitendinosus) autograft. It is unclear whether the hamstring muscle from a pitcher's drive leg (ipsilateral side of the UCLR) or landing leg (contralateral side of the UCLR) is more active during the pitching motion. We hypothesized that the landing leg semitendinosus will be more electromyographically active than the drive leg.
Methods: Healthy, elite male pitchers aged 16-21 years were recruited. Sixteen pitchers (average age, 17.6 ± 1.6 years; 67% threw right handed) underwent electromyographic analysis. Pitchers threw 5 fastballs at 100% effort from the wind-up with electromyographic analysis of every pitch. Activation of the semitendinosus and biceps femoris in both legs was compared within pitchers and between pitchers.
Results: Hamstring activity was higher in the drive leg than in the landing leg during each phase and in sum, although the difference was significant only during the double support phase ($P = .021$). On within-pitcher analysis, 14 of 16 pitchers had significantly more sum hamstring activity in the drive leg than in the landing leg ($P = .043$).
Conclusion: During the baseball pitch, muscle activity of the semitendinosus was higher in the drive leg than in the landing leg in most pitchers. Surgeons performing UCLR using hamstring autograft should consider harvesting the graft from the pitcher's landing leg to minimize disruption to the athlete's pitching motion.
Level of evidence: Basic Science Study; Kinesiology

Keywords: Ulnar collateral ligament (UCL); Ulnar collateral ligament reconstruction (UCLR); baseball; pitcher; hamstring; electromyography; Tommy John; surgery

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Injuries in adolescent and elite-level pitchers have dramatically increased during the past 10 years.[7,8,11,12] One of the more common injuries seen in male baseball pitchers is a tear of the ulnar collateral ligament (UCL).[1,6,9] The primary restraint to valgus stress about the elbow is the UCL, and this

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comes under significant stress with each baseball pitch.[18] When a pitcher sustains a tear of the UCL and fails to respond to a period of nonoperative treatment, a UCL reconstruction (UCLR) is commonly offered as the surgical intervention for those pitchers who wish to return to sport at the same or higher level.[10] Results after this surgery have been encouraging in adolescent, collegiate, and professional baseball players.[1,6,21] In performing UCLR, several graft choices exist, including hamstring autograft, palmaris autograft, allograft, and others.[6,24] One of the graft choices that has become popular in recent years is the hamstring autograft.[6] Either the gracilis or semitendinosus tendon can be harvested for use, although the semitendinosus is commonly significantly larger than the gracilis.[6] This graft can be harvested through a small incision on the anteromedial tibia and has been shown in biomechanical studies to provide adequate stability to the elbow in pitchers.[5]

Whereas the semitendinosus and gracilis are commonly used as a graft to reconstruct the UCL, harvesting the hamstring tendons is not without morbidity, most notably hamstring weakness.[626] Prior studies have found a significant contribution from the lower extremity musculature to the overhand pitch.[2,19,29] However, no study to date has evaluated the specific contribution of the semitendinosus and gracilis of either lower extremity to the overhand baseball pitch. As such, it is unclear whether the semitendinosus and gracilis from the drive leg (also known as the trail leg, lag leg, or back leg) or landing leg (also known as the stride leg, lead leg, or front leg) play a larger role in generating power and velocity during a baseball pitch. If the hamstrings of 1 leg play a more significant role in the baseball pitch, it could be reasoned that surgeons should harvest this tendon from the opposite leg in baseball pitchers undergoing UCLR using a hamstring autograft in an effort to disrupt the pitcher's throwing motion as little as possible.

Therefore, the purpose of this study was to perform an electromyographic (EMG) analysis of elite, healthy, male baseball pitchers to determine the activation of the semitendinosus and gracilis of the drive leg and landing leg during the overhand baseball pitch. The authors hypothesized that the semitendinosus of the landing leg will be more electromyographically active during the baseball pitch than that of the drive leg. The reasoning behind the hypothesis is that the landing leg must eccentrically contract as it hits the ground, thereby potentially activating the hamstring muscles, whereas the drive leg necessitates a push-off force, likely more from the quadriceps muscle group than from the hamstrings.

Methods

There were 16 elite-level, in-season, male baseball pitchers from a local area recruited. These subjects included 9 collegiate pitchers, 6 elite travel baseball pitchers who also pitched for their high school, and 1 pitcher who pitched only for his high school. Participants younger than 18 years gave written consent, and written parental consent was also obtained. Those older than 18 years signed written consent forms to participate in this study. Incision criteria were male, elite-level pitchers between the ages of 16 and 21 years. All pitchers were currently pitching without pain and had no history of prior surgery on their hamstrings from either leg. All testing was performed in the human motion analysis laboratory at our institution. An a priori power analysis was conducted on the basis of activation of the semitendinosus muscle as the primary outcome to ensure that the study was adequately powered. A priori, the authors selected a 50% change in muscle activation as clinically significant. To determine a 50% difference in activation of the semitendinosus muscle during the baseball pitch between the drive leg and landing leg, it was determined that 15 subjects must be enrolled and complete the study. A total of 16 pitchers completed the study, and thus the study was appropriately powered to detect the primary outcome of a 50% difference in semitendinosus muscle activation.

Data collection

Before testing, demographic data, including current age, height, weight, number of years spent pitching, and prior injuries to the shoulder and elbow of the athlete's pitching arm, were recorded. Surface electromyography (sEMG) data of the muscle activity from each pitcher were collected using a wireless EMG system (Noraxon, Scottsdale, AZ, USA). Before electrode application, the skin was cleaned with antimicrobial wipes. Self-adhesive dual Ag/AgCl electrodes (Noraxon) were placed on the palpable muscle bellies of the semimembranosus/semitendinosus (SM/ST) and biceps femoris (BF) in parallel to the muscle fibers at the midpoint of each muscle, with the muscle held in midflexion to facilitate its recruitment and palpation. If the posterior thigh was divided into thirds, the SM/ST electrodes were placed in the medial third and the BF electrodes were placed in the lateral third. The EMG signals were preamplified near the electrodes, bandpass filtered between 10 and 500 Hz, and sampled at a rate of 1500 Hz.[19]

Testing protocol

For the purpose of this study, the pitching motion was divided into 4 distinct phases, as opposed to the traditional 6 phases used to describe the pitching motion that are based on upper extremity parameters.[13] As no prior study has isolated the hamstring tendons during the pitching motion, the authors developed the following 4 phases using surface markers on the subjects. Phase 1, termed the prep phase, began when the foot from the landing leg was lifted off the ground and ended when the foot reached the maximum height off of the ground. Phase 2, termed the stride phase, began with the landing foot at the maximum height and ended when the landing foot touched the ground. Phase 3, termed the double support phase, began when the landing foot touched the ground and ended when the foot from the drive leg lifted of the ground. Phase 4, termed the braking phase, began when the foot from the drive leg came off the ground and ended when the drive leg contacted the ground (Fig. 1).

A regulation major league baseball was used in the testing process. Before EMG activity was measured during the pitching motion, a manual muscle test was used to normalize muscle activation in each subject's SM/ST and BF. Three consecutive 3- to 5-second maximal voluntary isometric contraction (MVIC) manual muscle tests were performed with 3 seconds in between each test.[17] Once the maximal SM/ST and BF muscle activity was recorded by sEMG, the subjects were allowed to throw as many warm-up pitches as they wanted