Adolescent Pitching Mechanics and Pitch Counts

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Is injury common with pitching?

Community youth/adolescent study:

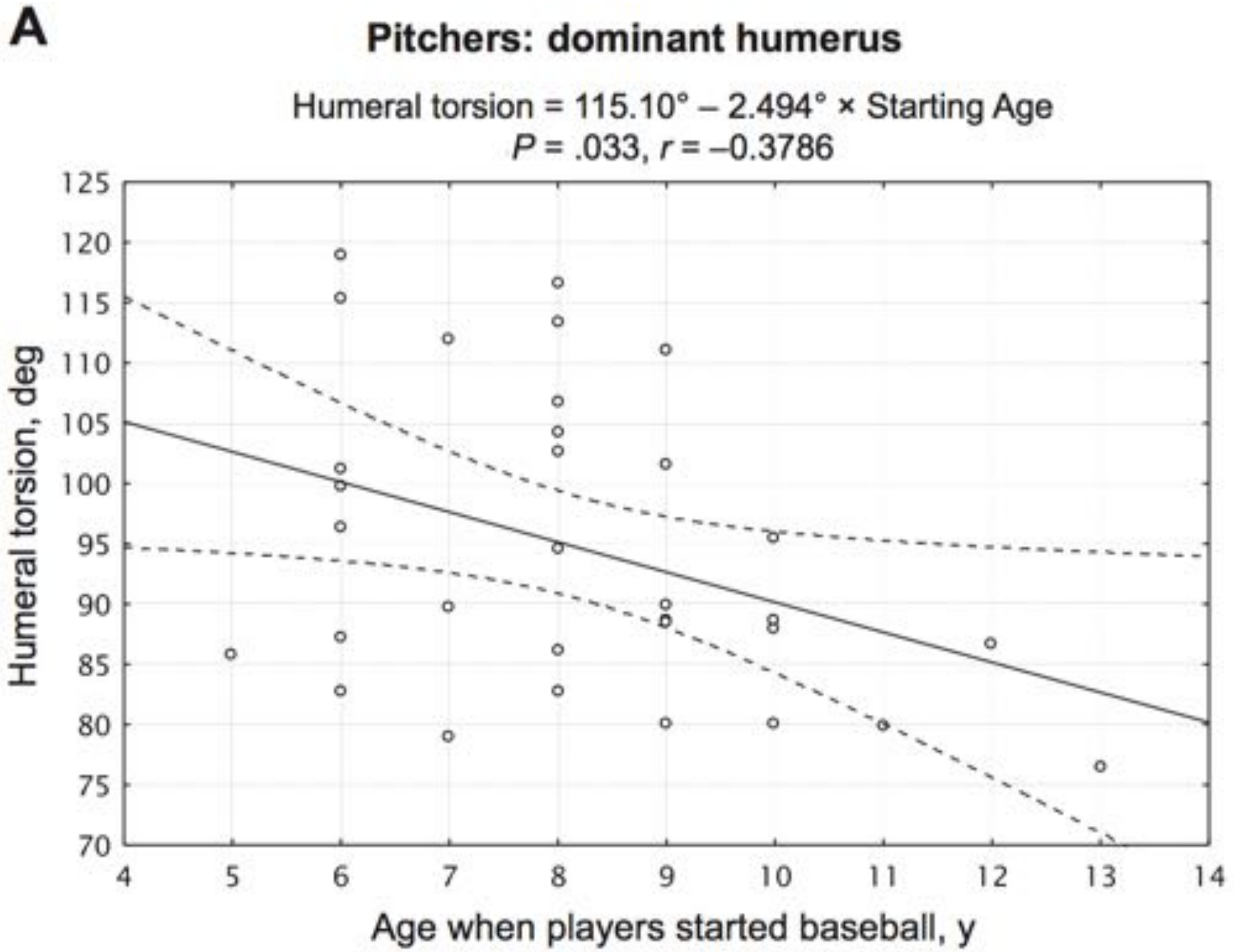
- 420 Subjects
- 30% Shoulder/elbow pain
- 31% History of injury

Elite youth/adolescent pitcher study:

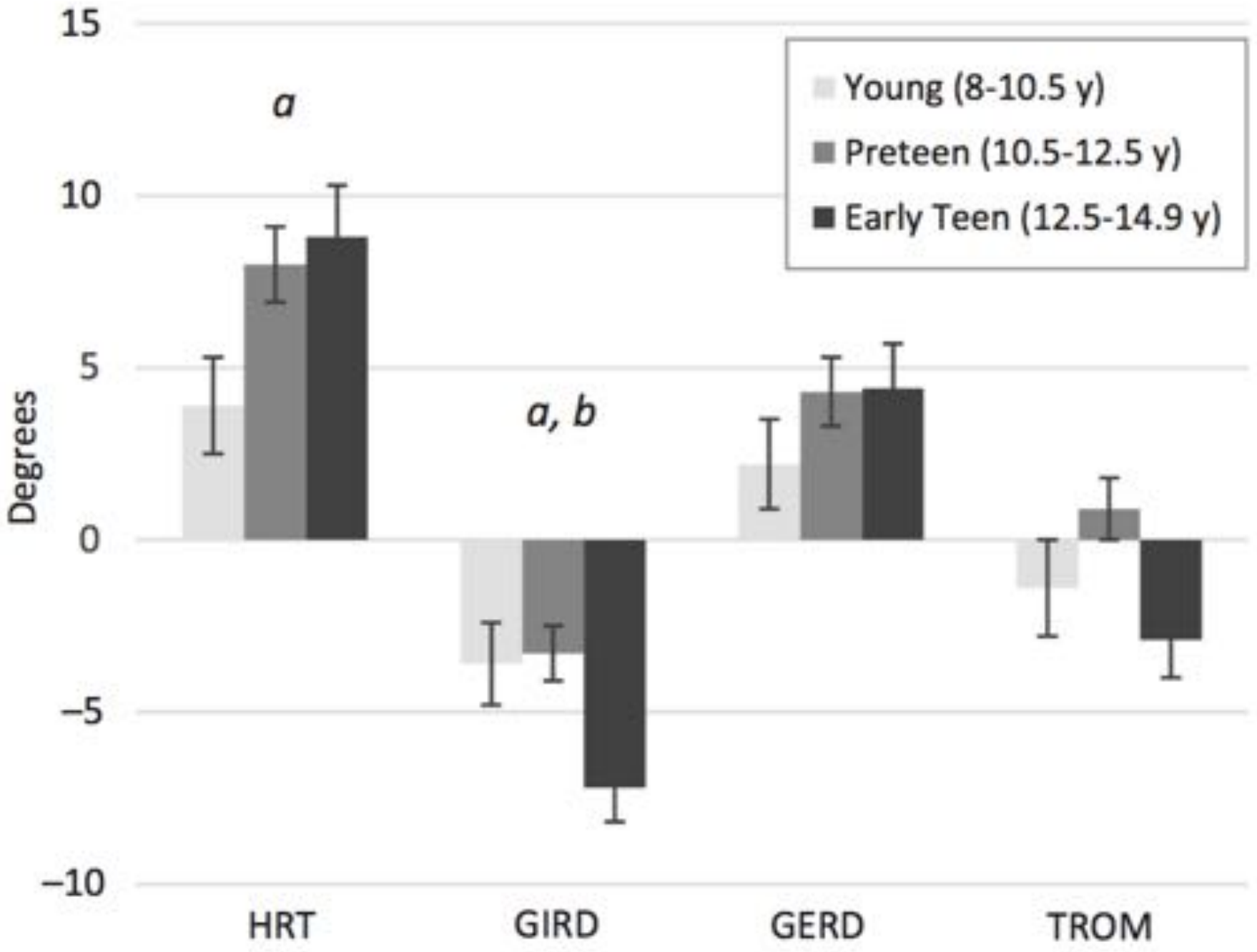
- 28 subjects
- 6.3±1.7 years pitching experience
- 43% Prior arm pain while pitching
- 39% had a prior diagnosed injury

Chalmers, P. N., Sgroi, T., Riff, A. J., Lesniak, M., Sayegh, E. T., Verma, N. N., et al. (2015). Correlates With History of Injury in Youth and Adolescent Pitchers. *Arthroscopy*

Erickson, B. J., Sgori, T., Chalmers, P. N., Vignona, P., Lesniak, M., Bush-Joseph, C. A., et al. (2016). The Impact of Fatigue on Baseball Pitching Mechanics in Adolescent Male Pitchers. *Arthroscopy*



Nakase C, Mihata T, Itami Y, Takeda A, Neo M. Relationship Between Humeral Retroversion and Length of Baseball Career Before the Age of 16 Years. *Am J Sports Med*. 2016;44(9):2220-2224.



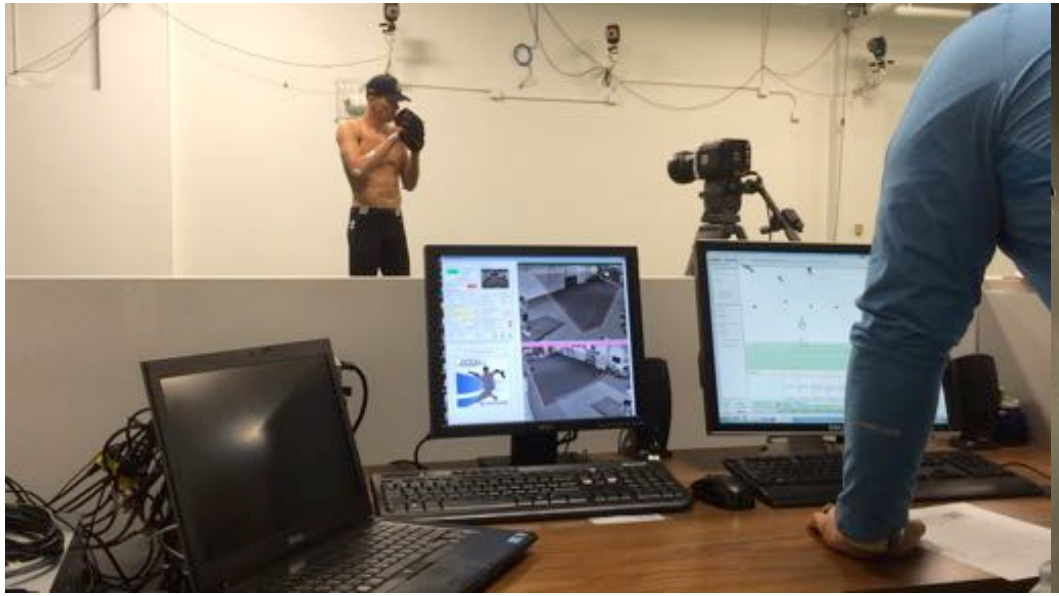
Greenberg EM, Lawrence JTR, Fernandez-Fernandez A, McClure P. Humeral Retrotorsion and Glenohumeral Motion in Youth Baseball Players Compared With Age-Matched Nonthrowing Athletes. *Am J Sports Med*. 2017;45(2):454-461.

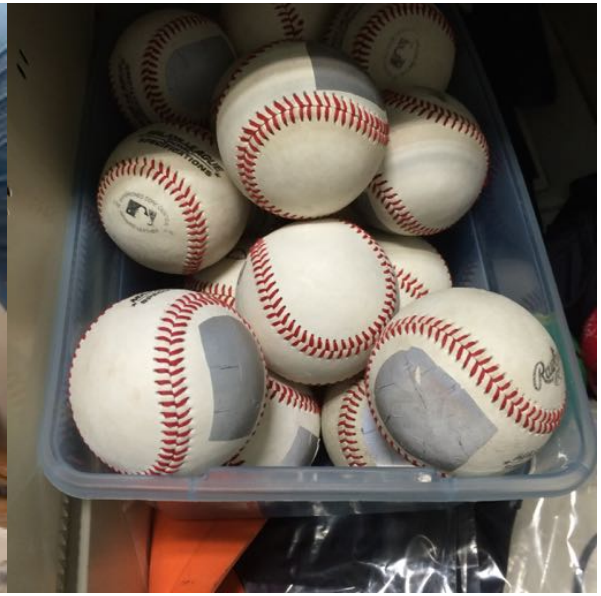
Fleisig Diffendaffer 2017

- Prospective, longitudinal study
- Retested annually with markered motion analysis
- Maximum of seven years
- Difficult study: Substantial attrition, Small sample size

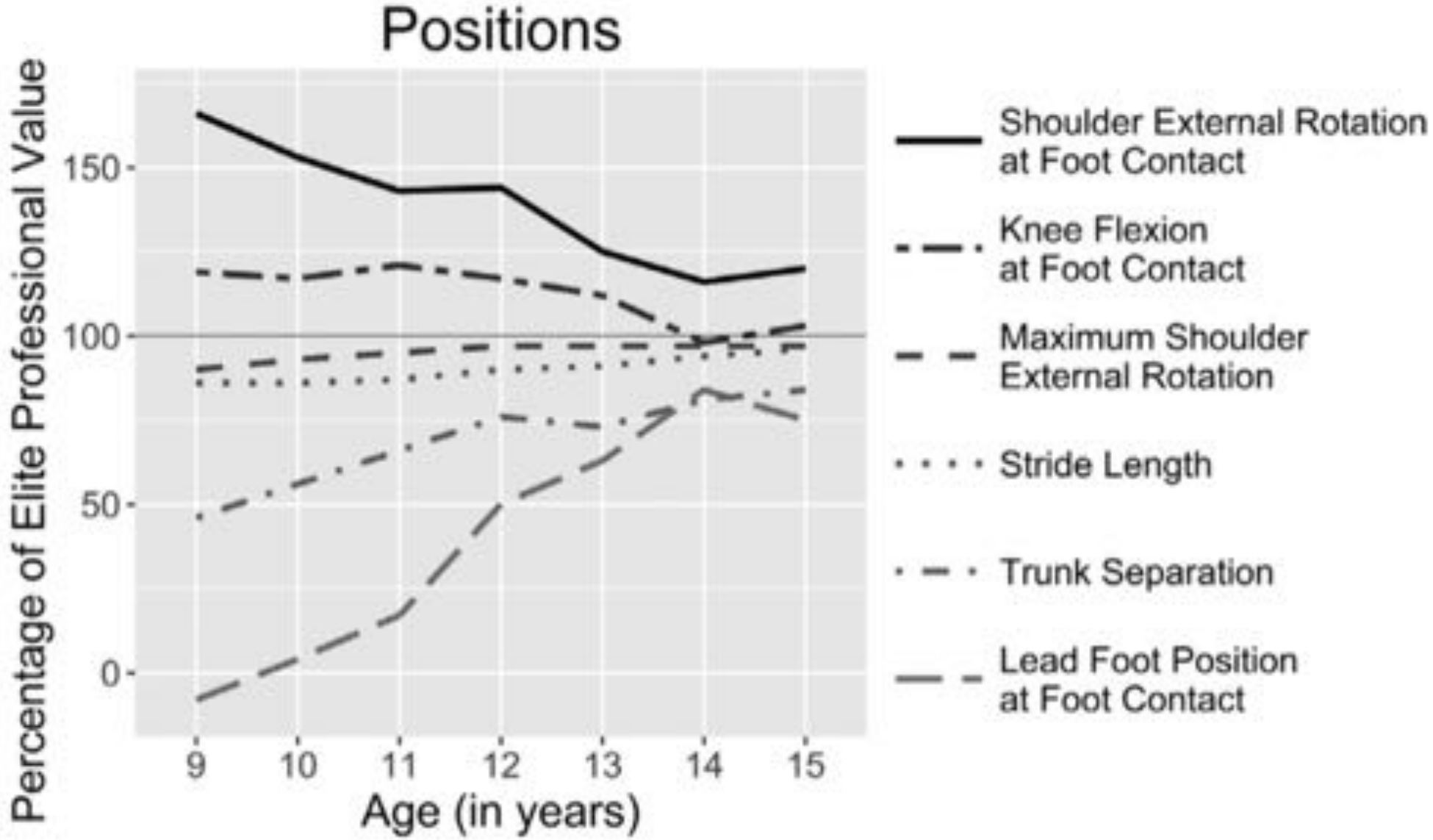
Age, in years

9 (n = 27)	10 (n = 34)	11 (n = 33)	12 (n = 25)	13 (n = 20)	14 (n = 11)	15 (n = 10)





Fleisig GS, Diffendaffer AZ, Ivey B, et al. Changes in Youth Baseball Pitching Biomechanics: A 7-Year Longitudinal Study. *Am J Sports Med*.



Fleisig GS, Diffendaffer AZ, Ivey B, et al. Changes in Youth Baseball Pitching Biomechanics: A 7-Year Longitudinal Study. *Am J Sports Med*.

Motus Sleeve Data

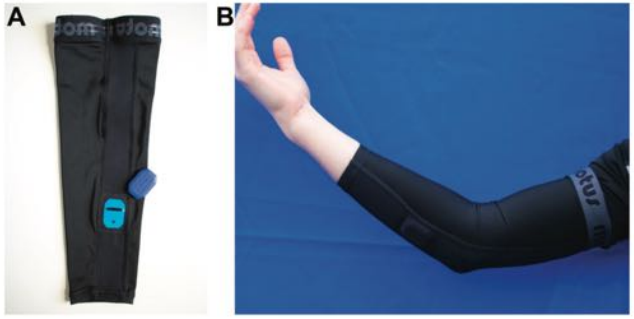
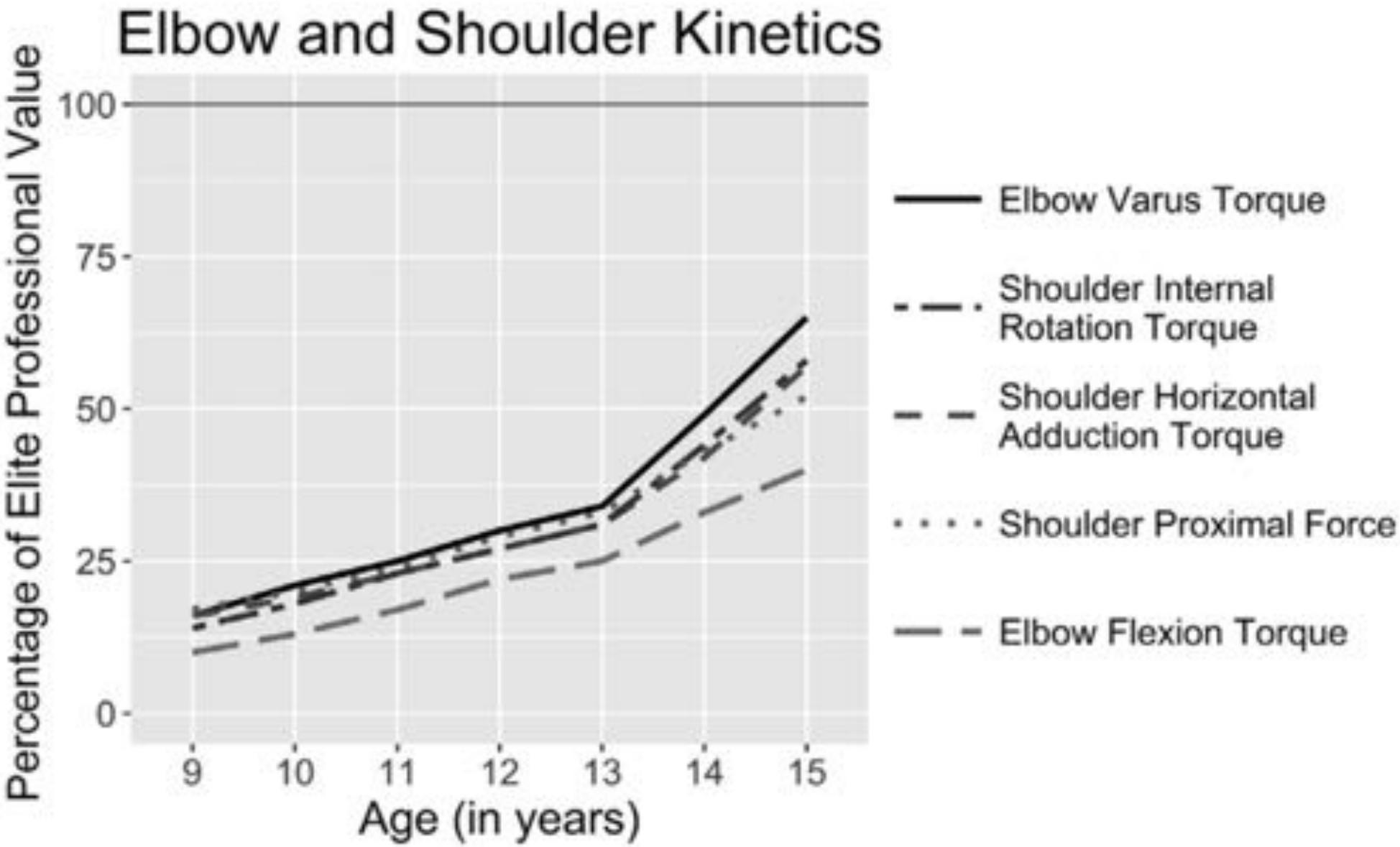


TABLE 2
Variables Significantly Associated With Elbow Varus Torque

	Change With 1-N·m Increase of Elbow Varus Torque	χ^2	*P* Value
Arm slot, deg	–13	428	<.001[a]
Arm speed, deg/s	116	57,683	<.001[a]
Arm rotation, deg	8	1392	<.001[a]

[a]Significant at $P < .05$.

Camp CL, Tubbs TG, Fleisig GS, et al. The Relationship of Throwing Arm Mechanics and Elbow Varus Torque: Within-Subject Variation for Professional Baseball Pitchers Across 82,000 Throws. *Am J Sports Med*. August 2017.



Fleisig GS, Diffendaffer AZ, Ivey B, et al. Changes in Youth Baseball Pitching Biomechanics: A 7-Year Longitudinal Study. *Am J Sports Med*.

Prior ASMI results: no change in kinematics with age

	Youth ($n = 23$)	High school ($n = 33$)
Front foot contact		
Stride length (% height)	85 ± 8	85 ± 9
External rotation (°)	67 ± 28	64 ± 25
Elbow flexion (°)	74 ± 17	82 ± 17
Knee flexion (°)	43 ± 12	50 ± 9
Arm cocking phase		
Maximum pelvis velocity (°/s)	650 ± 110	640 ± 90
Maximum upper torso velocity (°/s)	1180 ± 110	1130 ± 110
Maximum elbow flexion (°)	95 ± 12	100 ± 14
Maximum horizontal adduction (°)	21 ± 8	20 ± 9
Maximum external rotation (°)	177 ± 12	174 ± 9
Arm acceleration phase		
Maximum elbow extension velocity (°/s)	2230 ± 300	2180 ± 340
Maximum internal rotation velocity (°/s)	6900 ± 1050	6820 ± 1380
Ball release		
Elbow flexion (°)	24 ± 7	23 ± 7
Horizontal adduction (°)	11 ± 9	10 ± 8
Trunk tilt (°)	32 ± 9	31 ± 9
Knee flexion (°)	36 ± 11	43 ± 13
Ball speed (m/s)	28 ± 1	33 ± 2

Fleisig, G. S., Barrentine, S. W., Zheng, N., Escamilla, R. F., & Andrews, J. R. (1999). Kinematic and kinetic comparison of baseball pitching among various levels of development. *Journal of Biomechanics*, *32*(12), 1371–1375.

How do video kinematics change as pitchers mature?

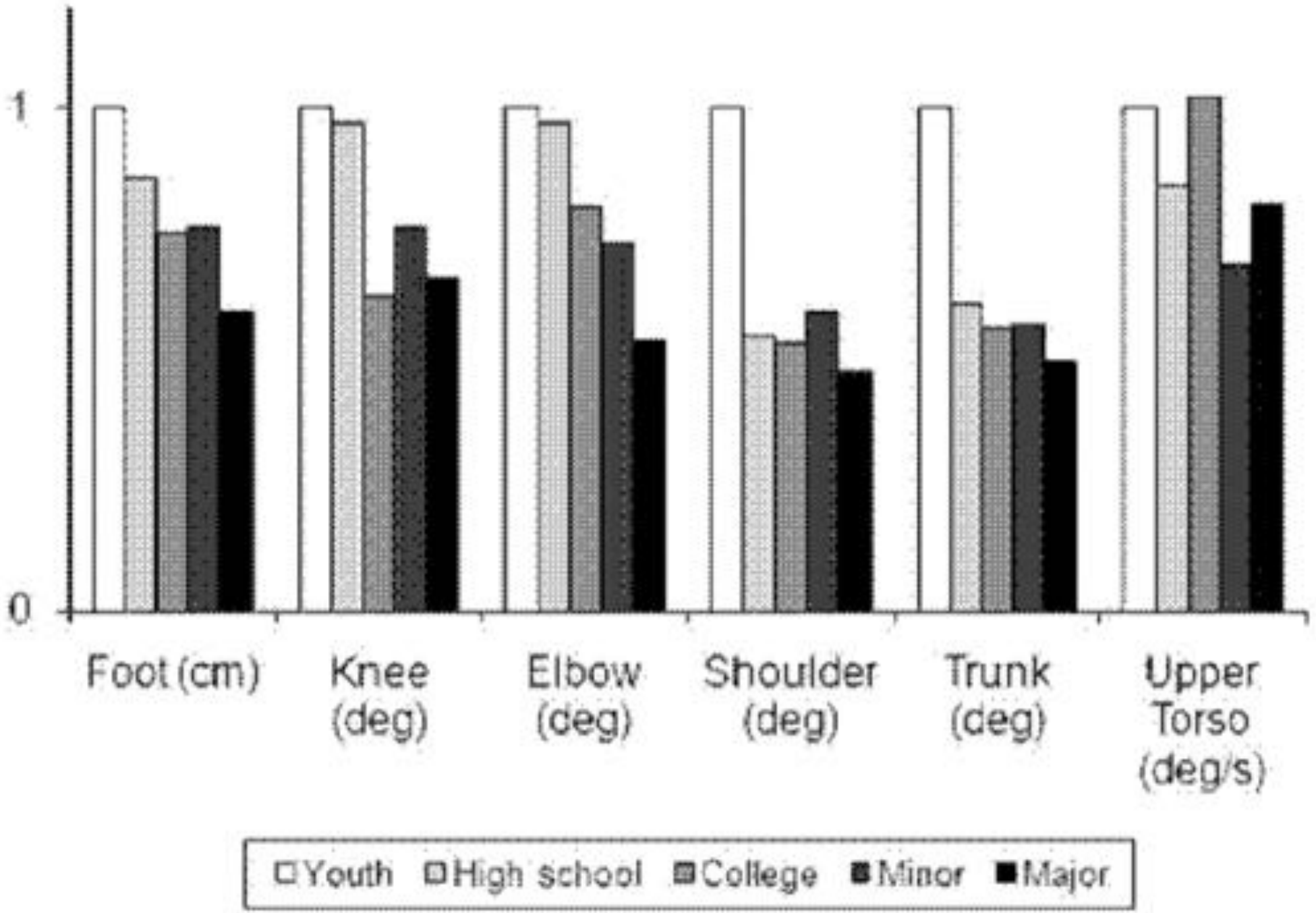
	9-12	13-15	16-17	p-value
Hand on top of Ball	92%	100%	100%	<0.001
Closed shoulders at foot strike	62%	79%	83%	0.012
Hip shoulder separation	21%	39%	60%	<0.001
Max knee height (% of height)	63%	64%	67%	0.001
Stride length (% of height)	73%	77%	80%	<0.001
Elbow flexion at FFC (°)	96	89	84	0.009
Knee flexion at FFC (°)	39	41	47	<0.001
Lead hip flexion at BR (°)	83	89	94	<0.001
Lat trunk tilt at BR (°)	50	60	69	0.002

Stride mechanics/thoracic rotational timing improve, ball release unchanged

Qualitative mechanics improve with age

	Youth (n, 86)	Adolescent (n, 83)	
	n (%)	n (%)	*P*
Lead with hips	83 (97)	77 (93)	.155
Hand on top	57 (66)	76 (92)	.001
Arm in throwing position	5 (6)	7 (8)	.561
Closed shoulder	20 (23)	31 (37)	.065
Stride foot toward home plate	74 (86)	55 (66)	.004
Performed 3 or more parameters correctly	55 (64)	67 (81)	.017

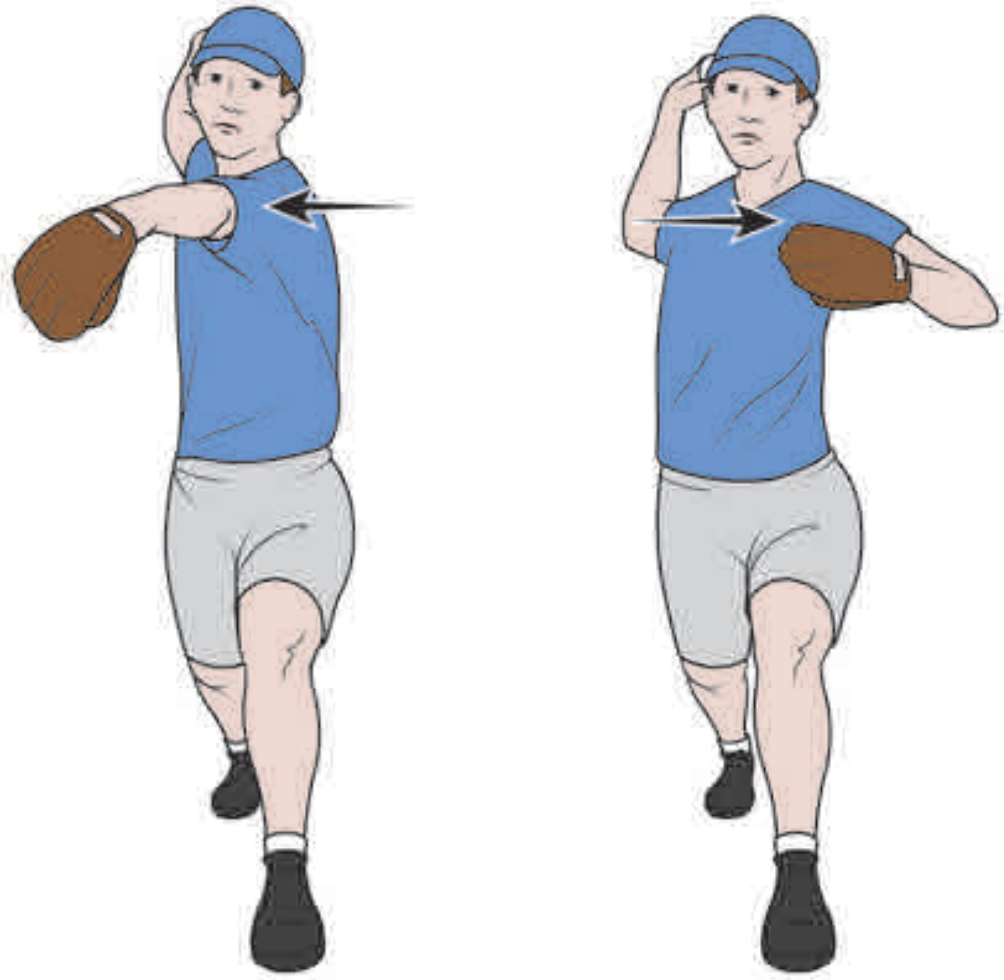
Davis, J. T., Limpisvasti, O., Fluhme, D., Mohr, K. J., Yocum, L. A., Elattrache, N. S., & Jobe, F. W. (2009). The effect of pitching biomechanics on the upper extremity in youth and adolescent baseball pitchers. *The American Journal of Sports Medicine*, *37*(8), 1484–1491.



Fleisig, G., Chu, Y., Weber, A., & Andrews, J. R. (2009). Variability in baseball pitching biomechanics among various levels of competition. *Sports Biomechanics*, *8*(1), 10–21.

	9-12	13-15	16-17	p-value
Hip shoulder separation	21%	39%	60%	<0.001

- Separation of the hips and shoulders:
- **Those with a history of injury:** 53%
- **Those without a history of injury:** 37%
- p=0.005



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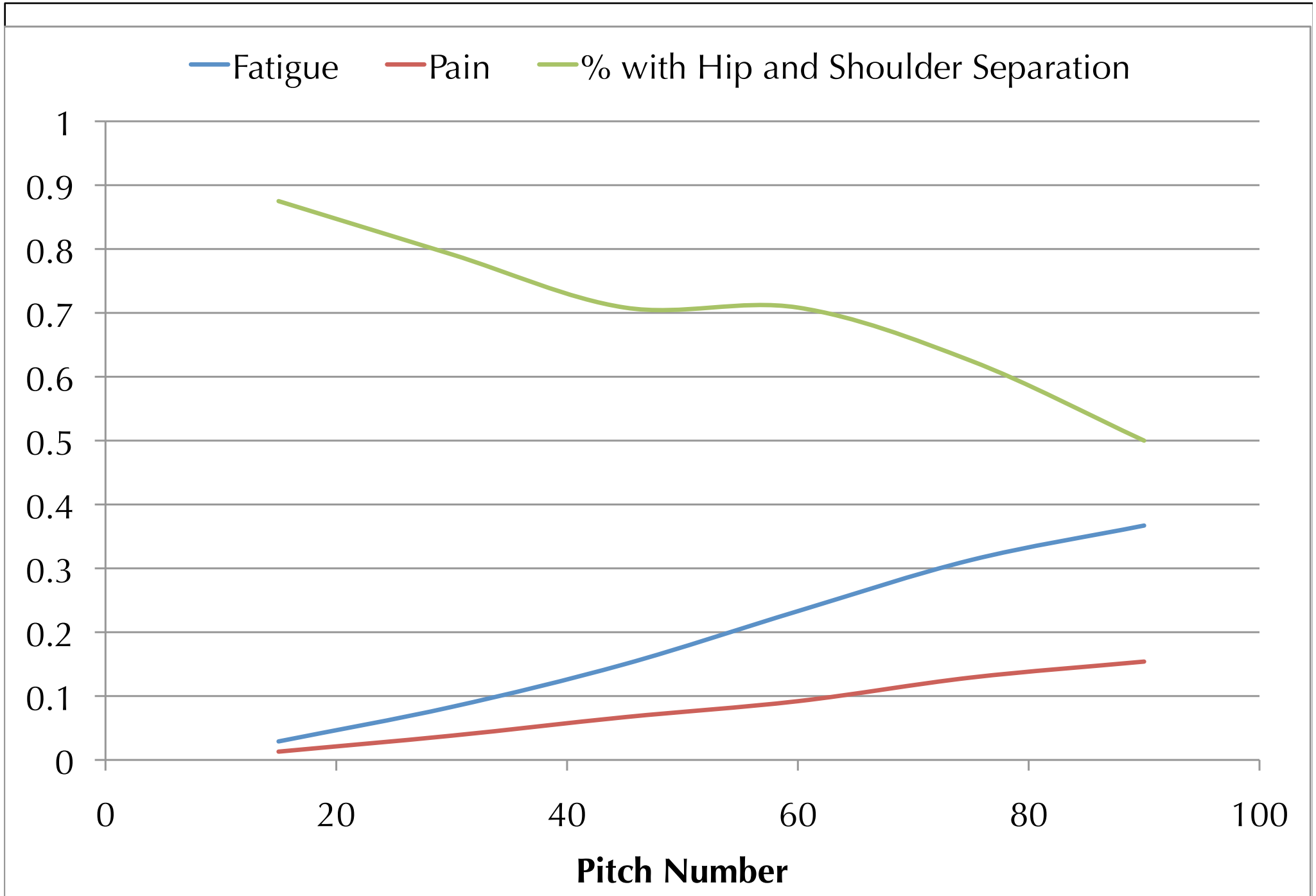

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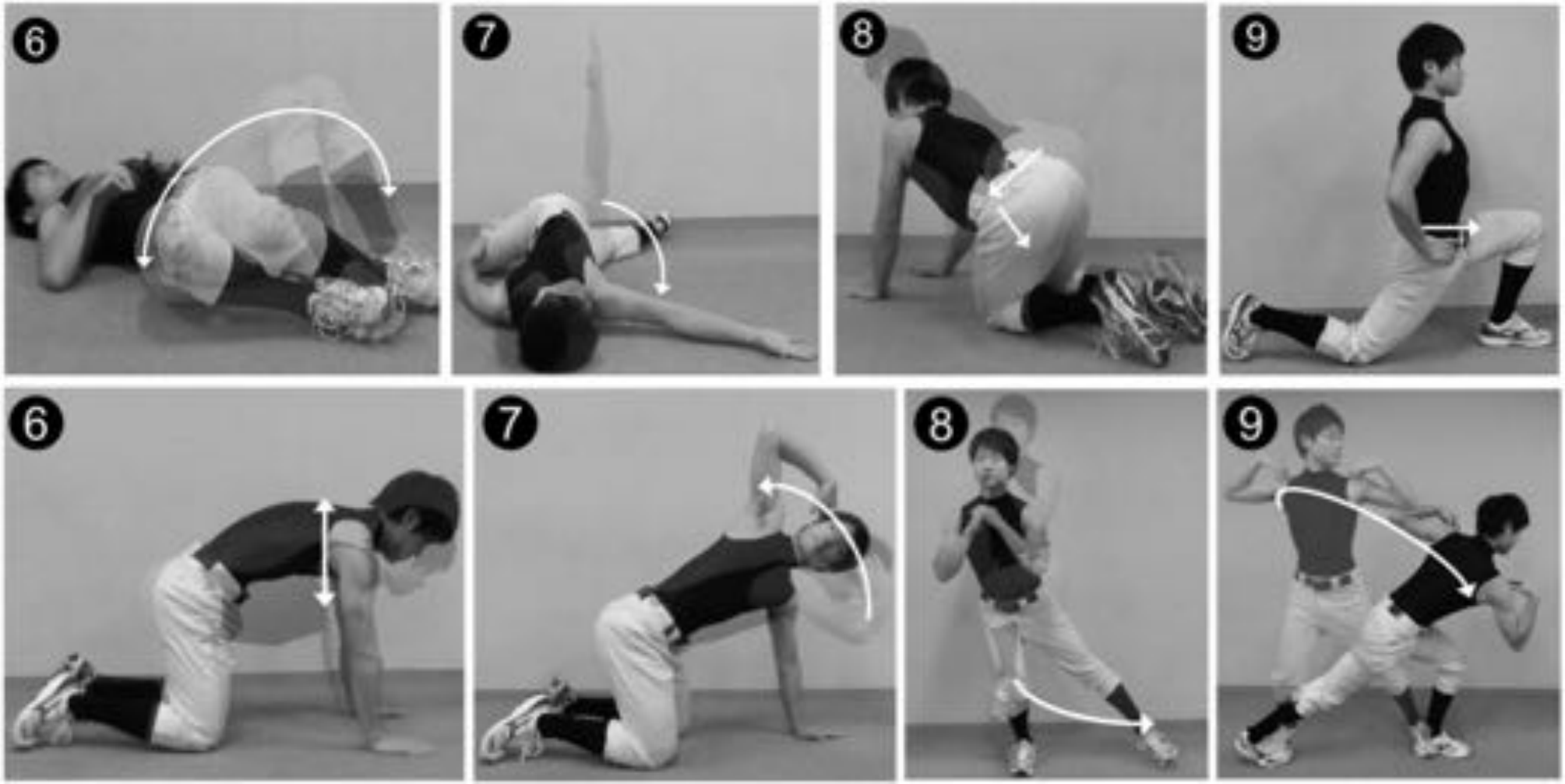
Good Separation (+2.6 mph)

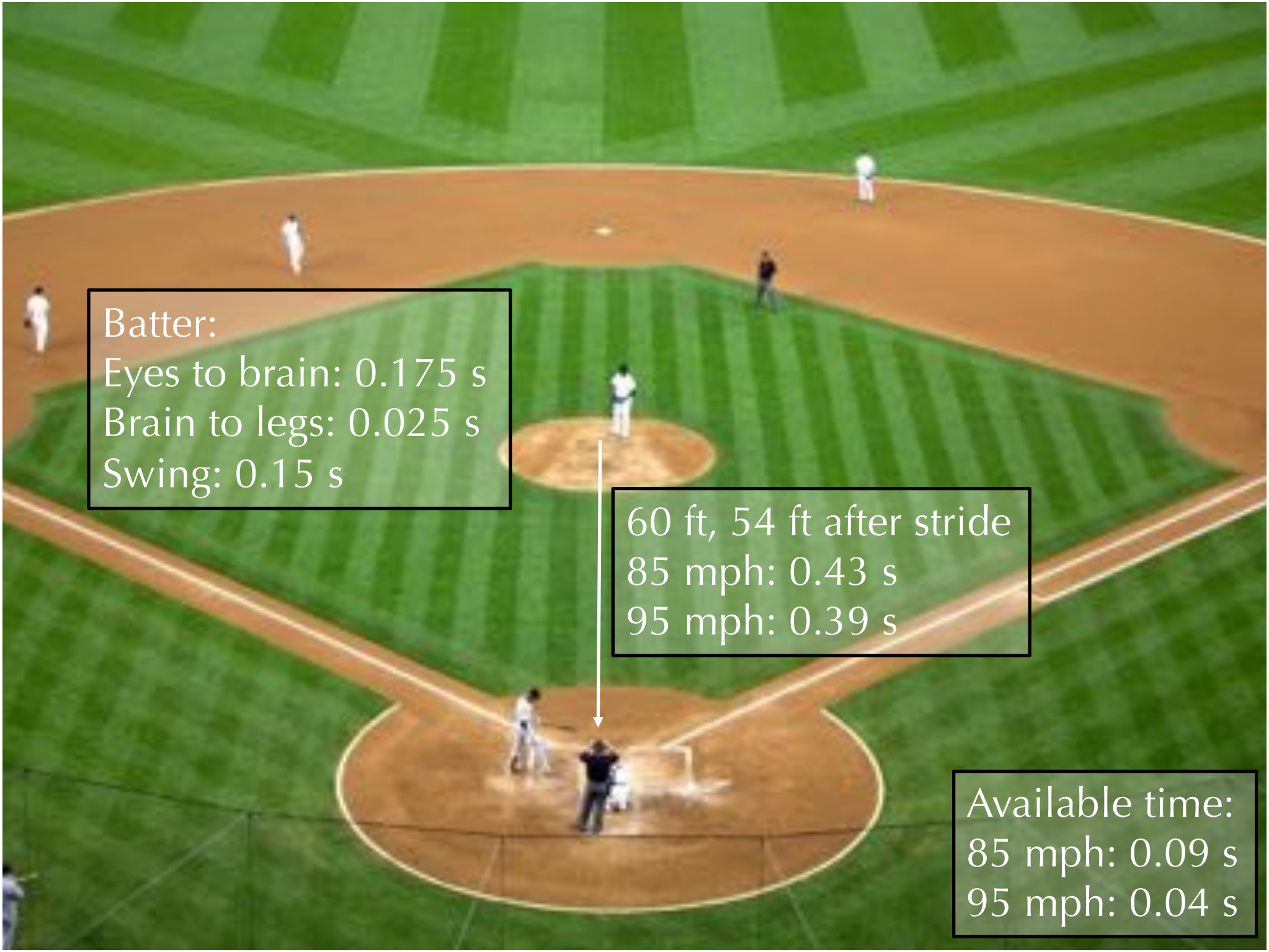
Bad Separation

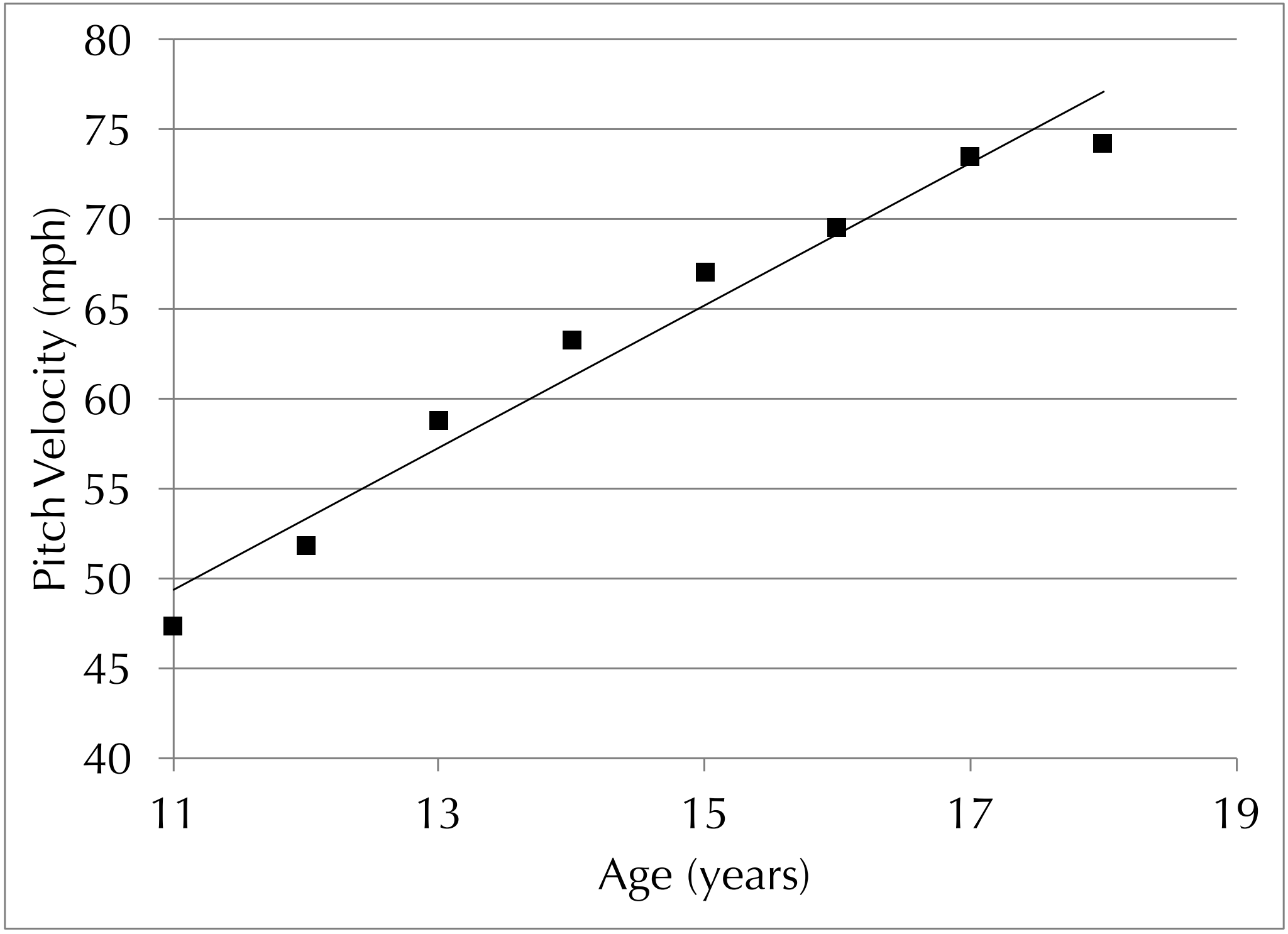
Sgroi, T., Chalmers, P. N., Riff, A. J., Lesniak, M., Sayegh, E. T., Wimmer, M. A., et al. (2015). Predictors of throwing velocity in youth and adolescent pitchers. *Journal of Shoulder and Elbow Surgery*

Sakata (2017): A prospective comparative study: 50% injury reduction



Sakata J, Nakamura E, Suzuki T, et al. Efficacy of a Prevention Program for Medial Elbow Injuries in Youth Baseball Players. *Am J Sports Med*. November 2017:363546517738003.


Batter:
Eyes to brain: 0.175 s
Brain to legs: 0.025 s
Swing: 0.15 s
60 ft, 54 ft after stride
85 mph: 0.43 s
95 mph: 0.39 s
Available time:
85 mph: 0.09 s
95 mph: 0.04 s


80
75
70
65
60
55
50
45
40
Pitch Velocity (mph)
11
13
15
17
19
Age (years)

Age (years)	Speed (mph)	SD
8	40.3	3.51
9	42.8	3.76
10	46.1	3.82
11	48.2	4.19
12	50.4	4.76
13	54.3	4.85
14	60.4	5.71

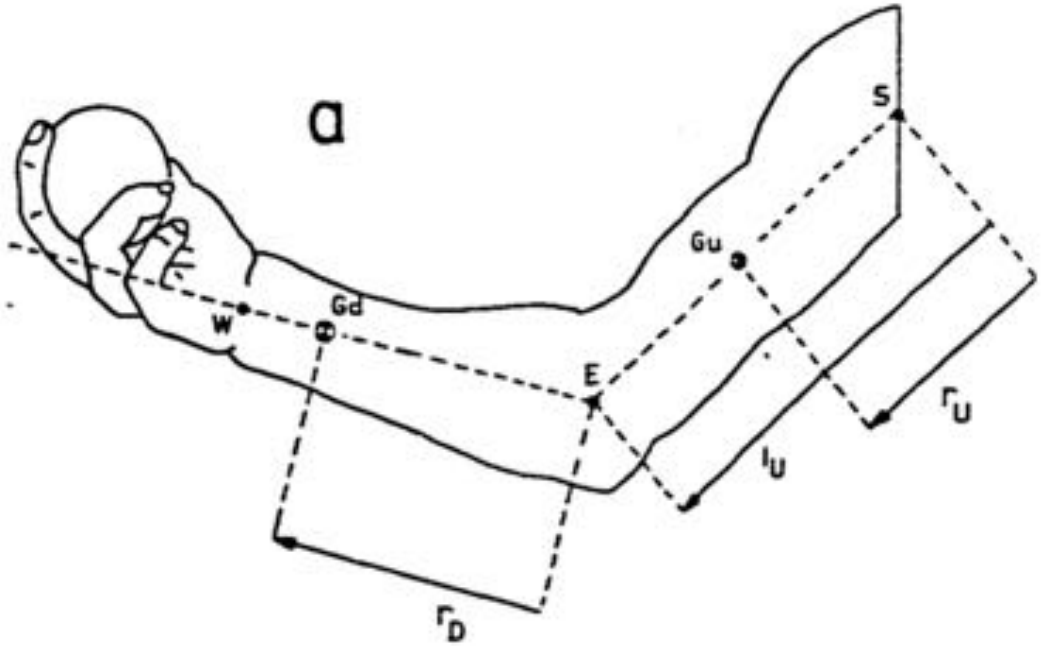
AGE	SPEED M.P.H. (STANDARD DEVIATIONS)					
	Avg.	1SD	2SD	3SD	4SD	5SD
8	40	43	47	50	54	57
9	43	47	51	55	59	63
10	46	50	54	58	62	66
11	48	52	56	60	64	68
12	50	55	60	65	70	75
13	54	59	64	69	74	79
14	60	66	72	78	84	90

Axe, M. J., Snyder-Mackler, L., Konin, J. G., & Strube, M. J. (1996). Development of a distance-based interval throwing program for Little League-aged athletes. *American Journal of Sports Medicine*, *24*(5), 594–602.

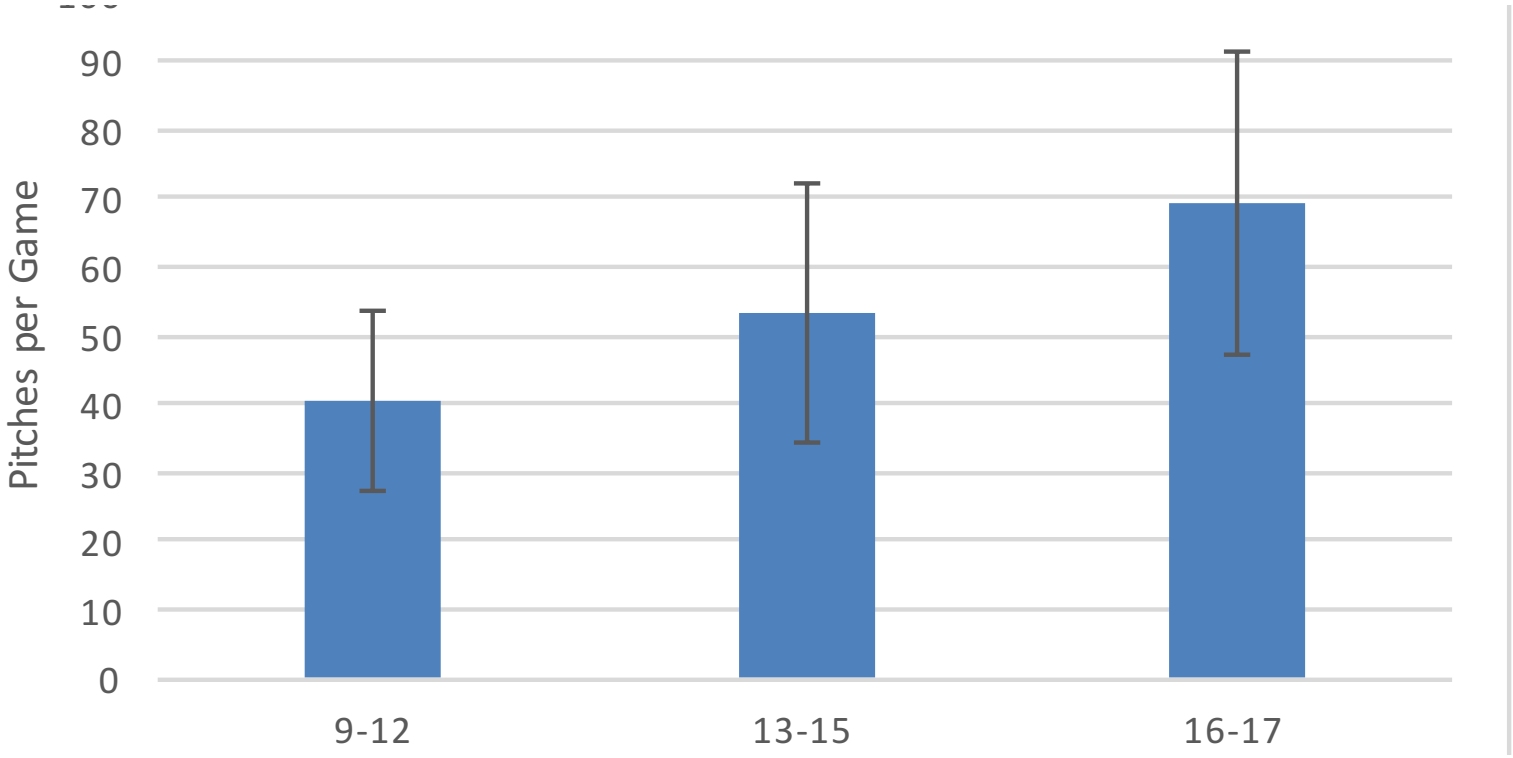
Axe, M. J., Strube, M., Osinski, D., & Andrews, J. R. (2014). A SPEED DISTANCE-BASED CLASSIFICATION SYSTEM FOR INJURY PREVENTION AND RESEARCH IN INTERNATIONAL AND DOMESTIC YOUTH …. ... *Journal of Sports* ….

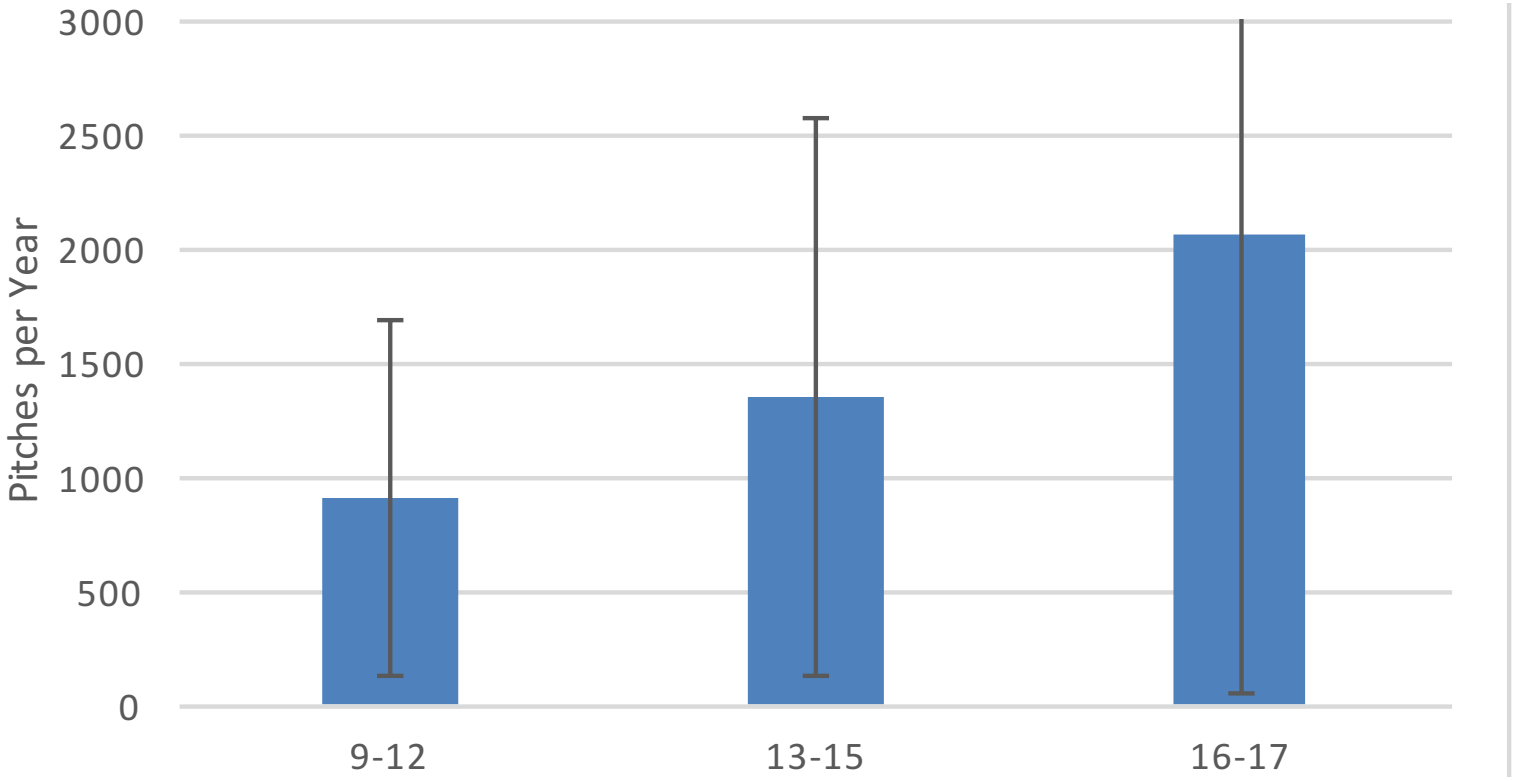
Weight/Height Increase with Age

Age	Height (in)	Weight (lb)
9-12	60	100
13-15	67	139
16-17	71	169



Feltner, M. E., & Dapena, J. (1989). Three-dimensional interactions in a two-segment kinetic chain. Part 1; General model. *International Journal of Sports Biomechanics*, *5*, 403–419.


Pitches per Game
90
80
70
60
50
40
30
20
10
0
9-12
13-15
16-17


Pitches per Year
3000
2500
2000
1500
1000
500
0
9-12
13-15
16-17

Community cohort

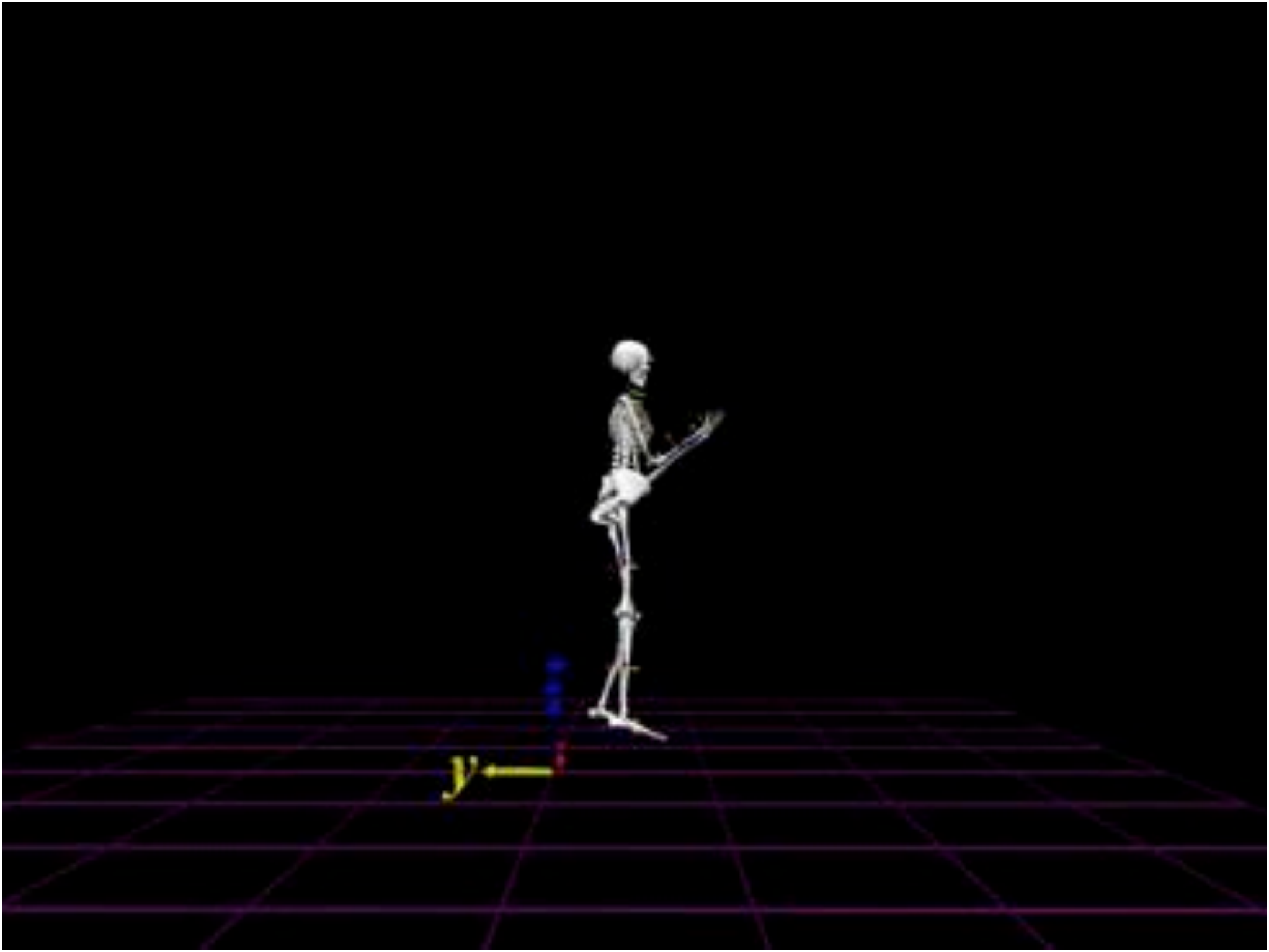
% of players violating ON AVERAGE	
Age	Per Day
9-10	0%
10-11	0%
12-13	3%
13-15	0.5%
16-17	5%

Elites: 10% over weekly counts

Conclusions

- Pitching mechanics do mature with age, particularly from 9-13 years old and this maturation is associated with increased velocity, increased torque, etc.
- With age velocity, height, weight, and pitch counts all increase, all of which are injury predictors and thus each must be interpreted in the setting of age norms
  - Watch the pitcher who “grows up” before his UCL


Thank you!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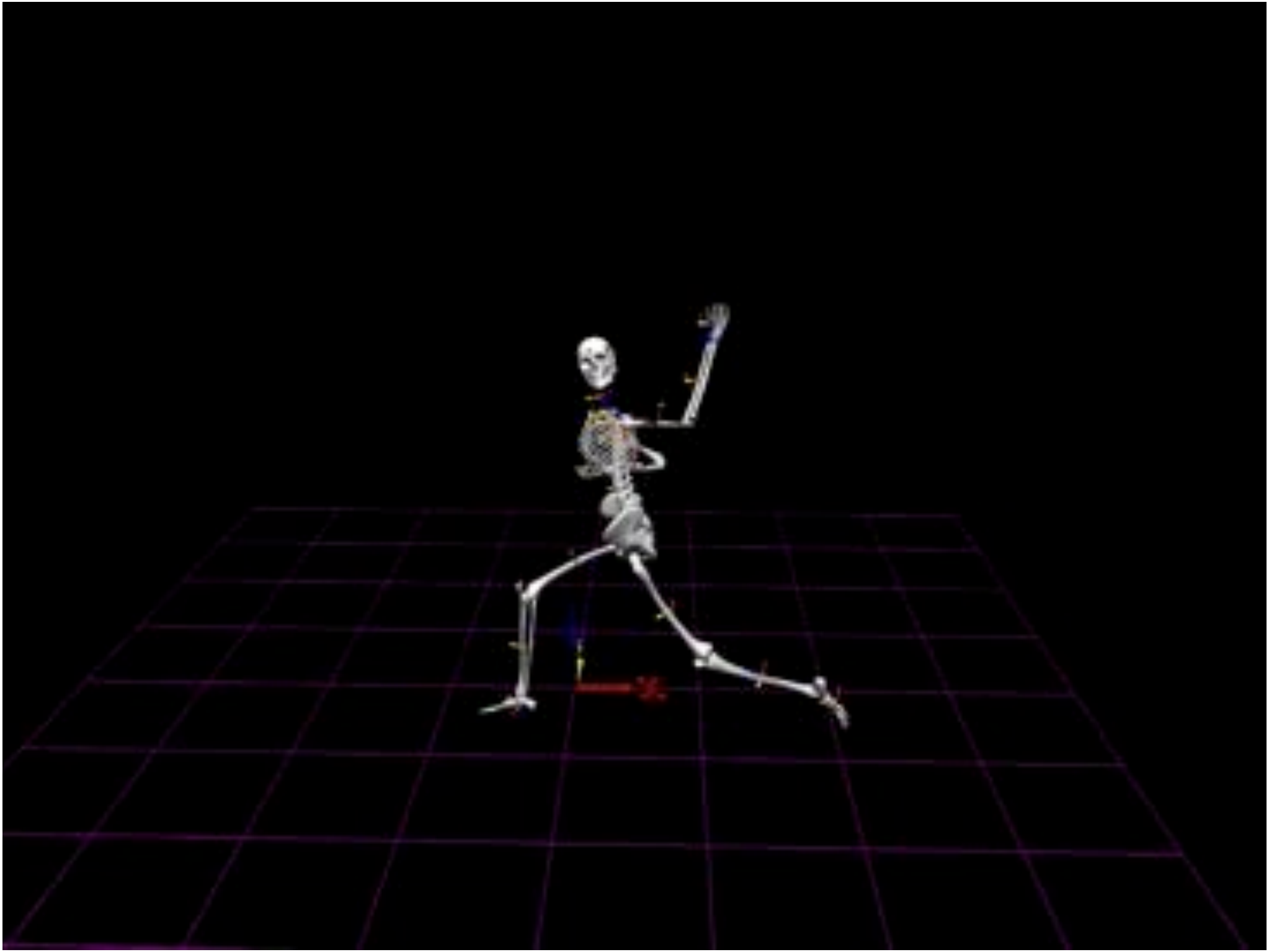
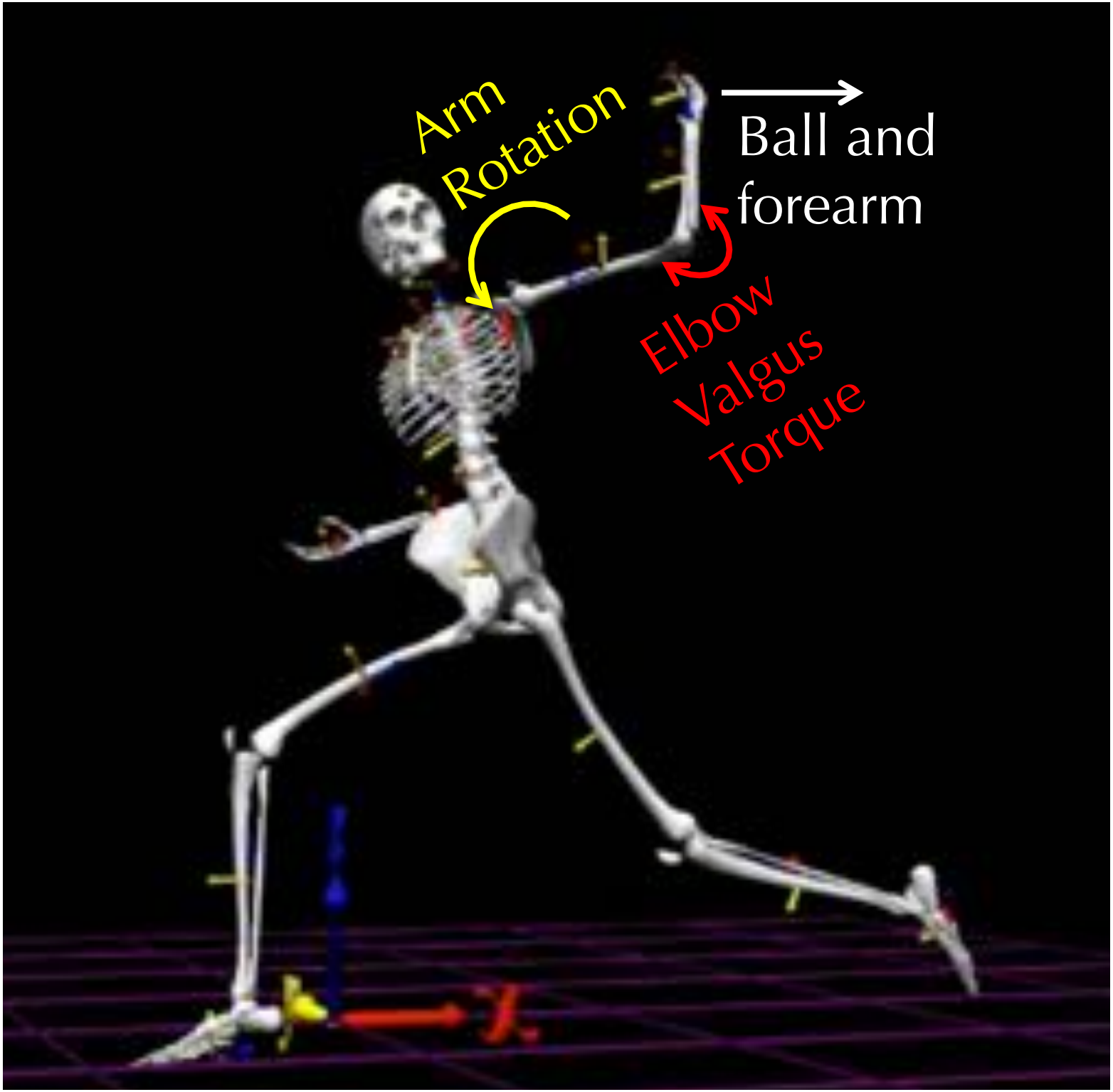
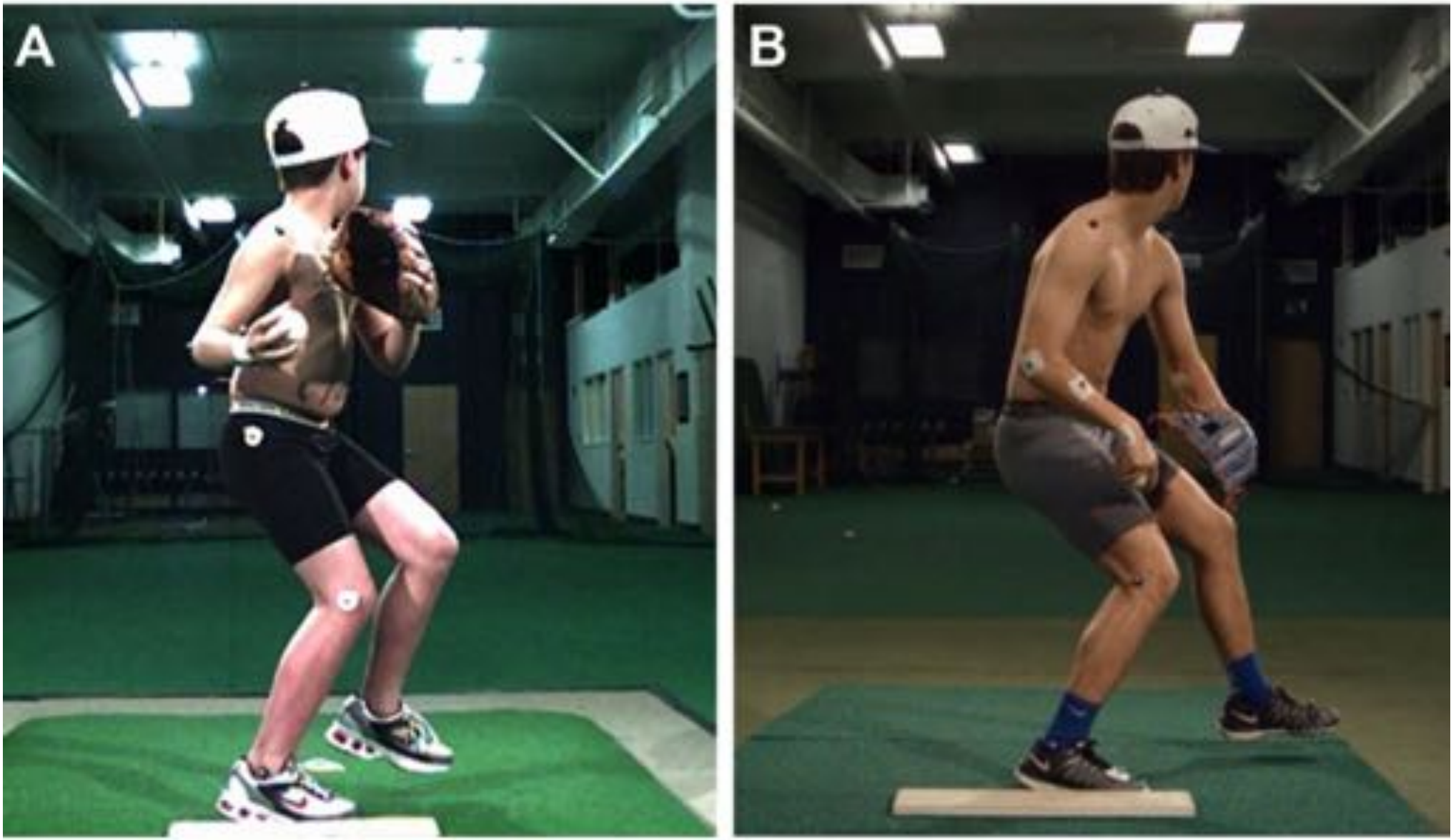



Arm
Rotation
Ball and
forearm
Elbow
Valgus
Torque



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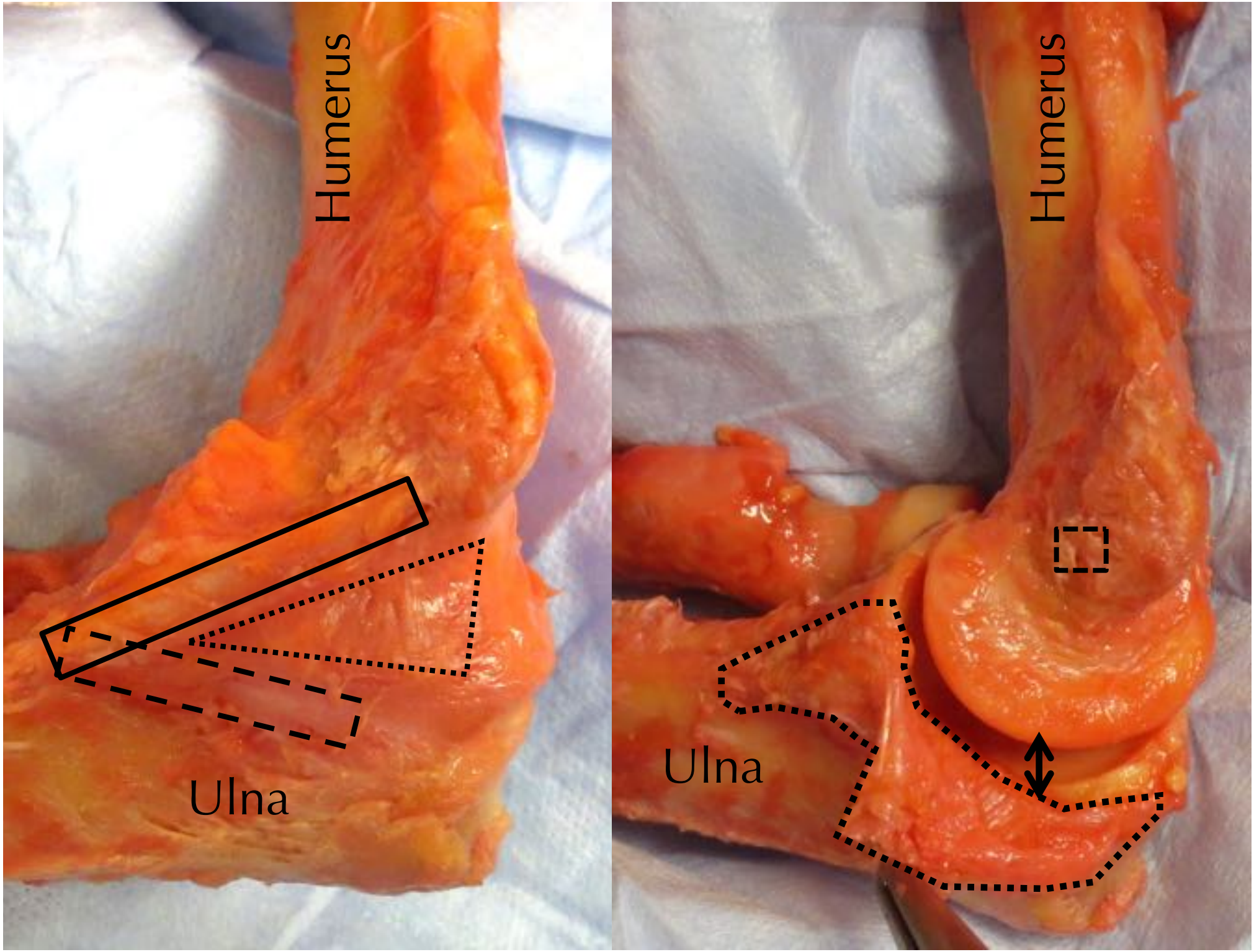
Humerus
Ulna
Humerus
Ulna

Pitch counts

Age	Pitch Counts	Rest
17-18	105/day	31-45 pitches = 1 day rest 46-60 pitches = 2 days rest 61-75 pitches = 3 days rest 76+ pitches = 4 days rest
15-16	95/day	
13-14	95/day	21-35 pitches = 1 day rest 36-50 pitches = 2 days rest 51-65 pitches = 3 days rest 66+ pitches = 4 days rest
12-13	85/day	
10-11	75/day	
9-10	50/day	

PITCH SMART

USA BASEBALL