Adolescent Pitching Mechanics and Pitch Counts

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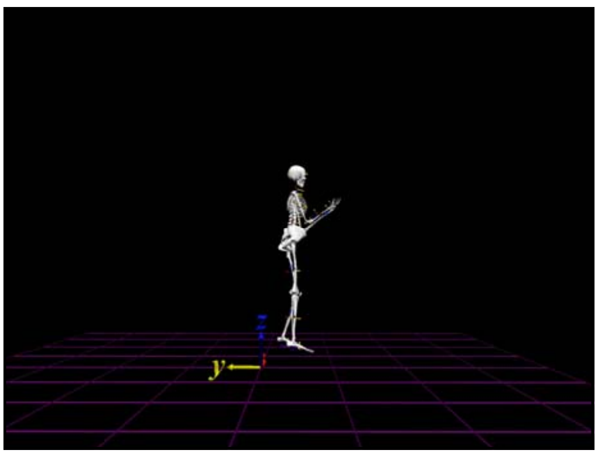
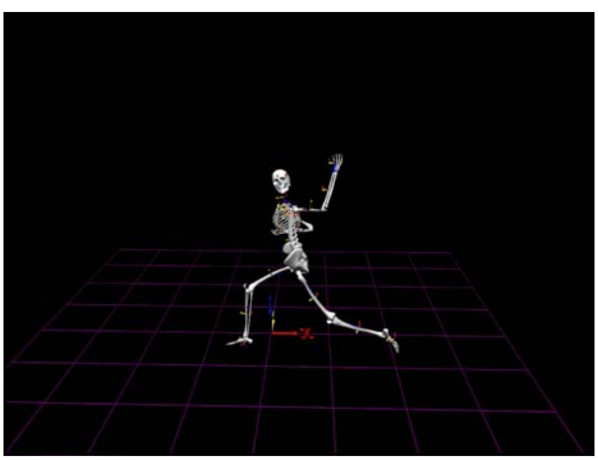
Is injury common with pitching?

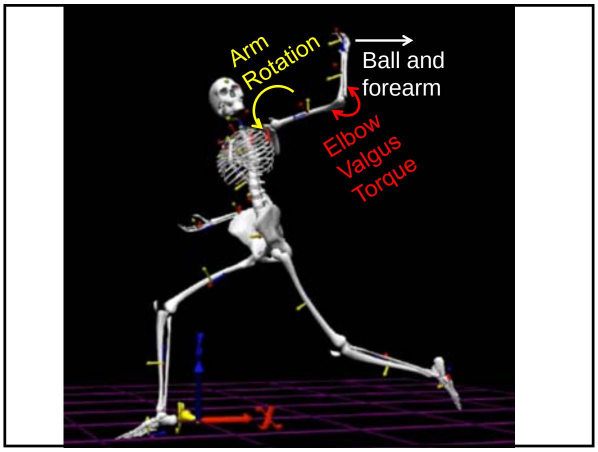
Community youth/adolescent study:
- 420 Subjects
- 30% Shoulder/elbow pain
- 31% History of injury

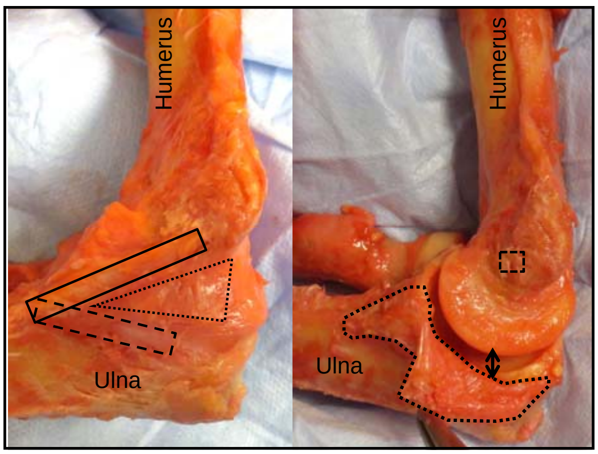
Elite youth/adolescent pitcher study:
- 28 subjects
- 6.3±1.7 years pitching experience
- 43% Prior arm pain while pitching
- 39% had a prior diagnosed injury

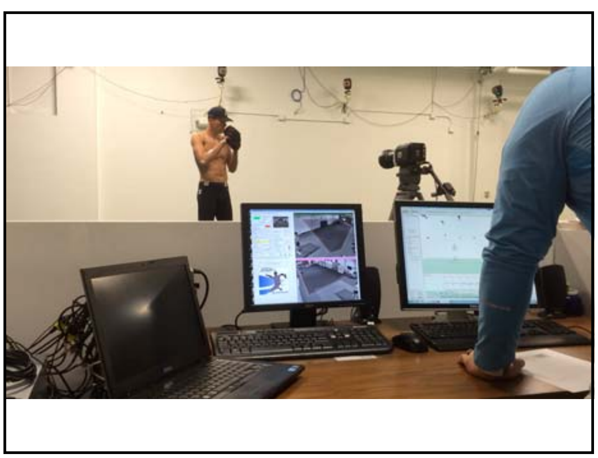
Chalmers, P. N., Sgroi, T., Riff, A. J., Lesniak, M., Sayegh, E. T., Verma, N. N., et al. (2015). Correlates With History of Injury in Youth and Adolescent Pitchers. *Arthroscopy*
Erickson, B. J., Sgori, T., Chalmers, P. N., Vignona, P., Lesniak, M., Bush-Joseph, C. A., et al. (2016). The Impact of Fatigue on Baseball Pitching Mechanics in Adolescent Male Pitchers. *Arthroscopy*

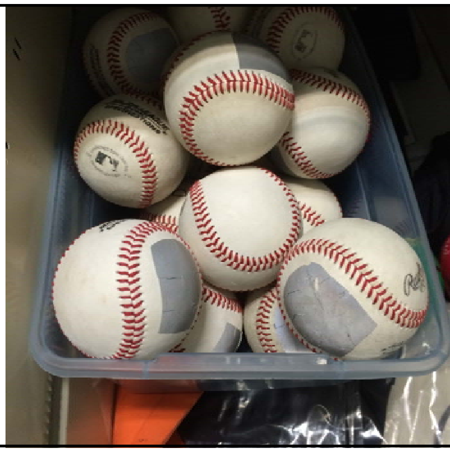





Arm
Rotation
Ball and
forearm
Elbow
Valgus
Torque


Humerus
Ulna
Humerus
Ulna





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?

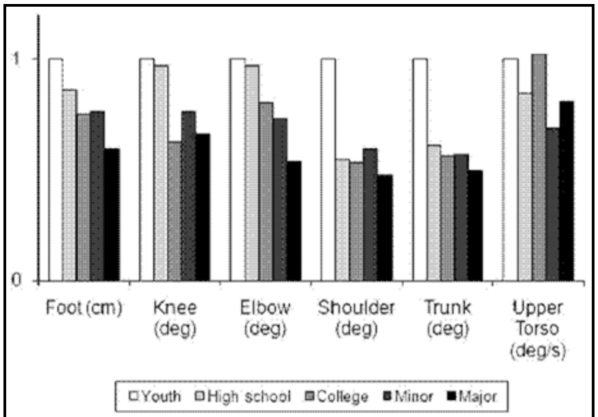
	9-12	13-15	16-17	p-value
Hand on top of Ball	92%	100%	100%	<0.001
Closed shoulders at foot strike	62%	79%	83%	0.012
Hip shoulder separation	21%	39%	60%	<0.001
Max knee height (% of height)	63%	64%	67%	0.001
Stride length (% of height)	73%	77%	80%	<0.001
Elbow flexion at FFC (°)	96	89	84	0.009
Knee flexion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

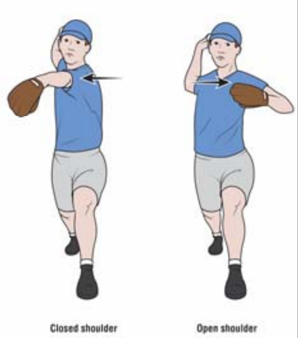
Davis, J. T., Limpisvasti, O., Fluhme, D., Mohr, K. J., Yocum, L. A., Elattrache, N. S., & Jobe, F. W. (2009). The effect of pitching biomechanics on the upper extremity in youth and adolescent baseball pitchers. *The American Journal of Sports Medicine*, 37(8), 1484–1491.



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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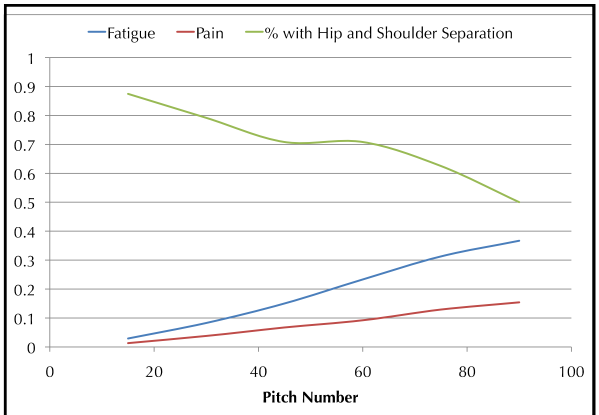


Erickson, B. J., Sgori, T., Chalmers, P. N., Vignona, P., Lesniak, M., Bush-Joseph, C. A., et al. (2016). The Impact of Fatigue on Baseball Pitching Mechanics in Adolescent Male Pitchers. *Arthroscopy*

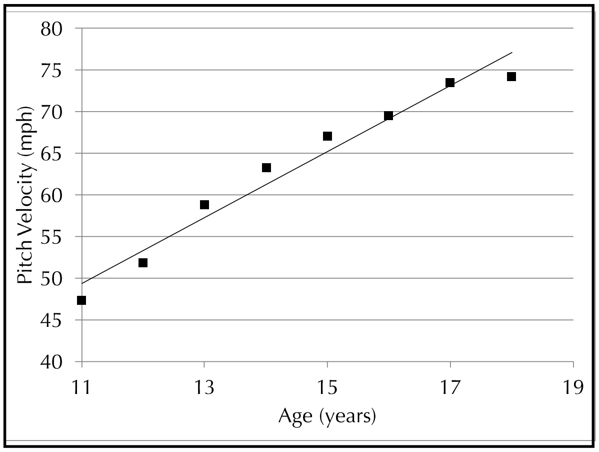
Good Separation (+2.6 Bad Separation

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*

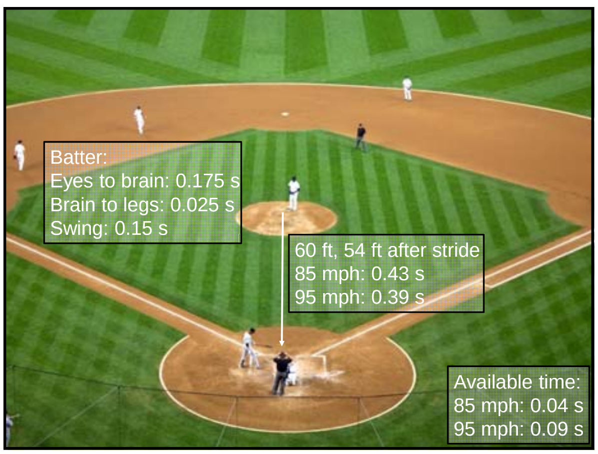
Age (years)	Speed (mph)	SD
8	40.3	3.51
9	42.8	3.76
10	46.1	3.82
11	48.2	4.19
12	50.4	4.76
13	54.3	4.85
14	60.4	5.71

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

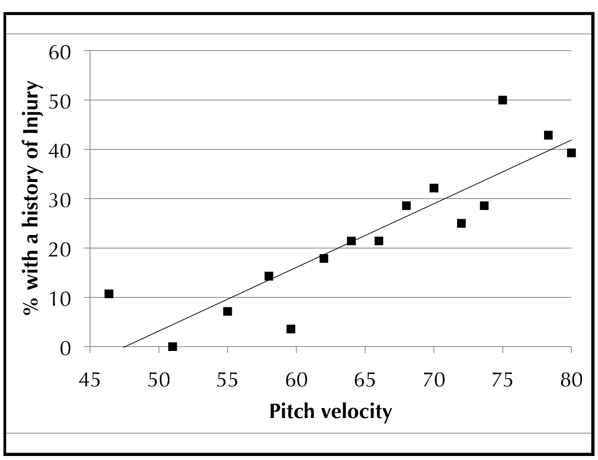
Axe, M. J., Snyder-Mackler, L., Konin, J. G., & Strube, M. J. (1996). Development of a distance-based interval throwing program for Little League-aged athletes. *American Journal of Sports Medicine*, *24*(5), 594–602.
Axe, M. J., Strube, M., Osinski, D., & Andrews, J. R. (2014). A SPEED DISTANCE-BASED CLASSIFICATION SYSTEM FOR INJURY PREVENTION AND RESEARCH IN INTERNATIONAL AND DOMESTIC YOUTH …. … *Journal of Sports* ….



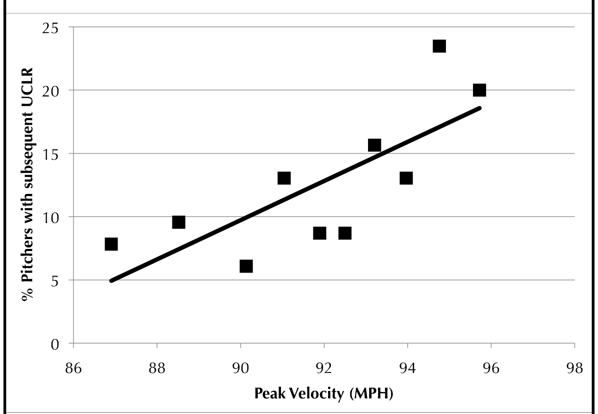
Pitch Velocity (mph)
80
75
70
65
60
55
50
45
40
11
13
15
17
19
Age (years)



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: 0.04 s
95 mph: 0.09 s

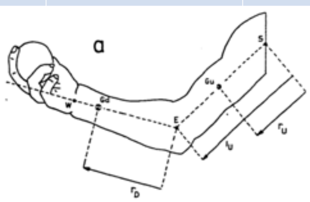


% with a history of Injury
60
50
40
30
20
10
0
45
50
55
60
65
70
75
80
Pitch velocity

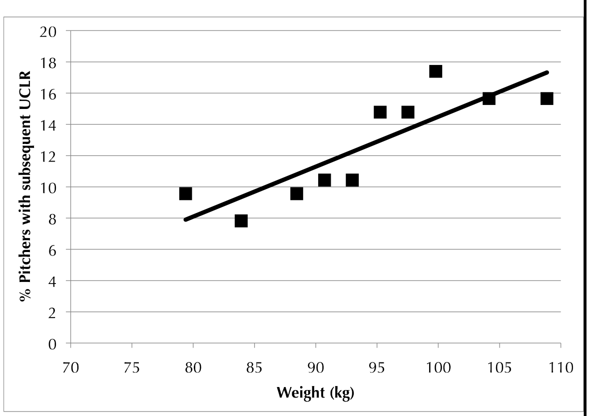


Weight/Height Increase with Age

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.



Game pitch counts	No. of appearances	Elbow Odds ratio	Elbow P value	Shoulder Odds ratio	Shoulder P value
Overall					
1–24	1023	Referent	0.07	Referent	<0.01
25–49	1060	1.03		1.15	
50–74	992	1.21		1.23	
75–99	476	1.35		1.52	
100+	238	1.44		1.77	
9 to 10 years old					
1–24	430	Referent	0.67	Referent	0.01
25–49	373	1.20		0.97	
50–74	346	1.40		1.11	
75–99	149	0.91		1.32	
100+	90	1.33		2.01	
11 to 12 years old					
1–24	319	Referent	0.60	Referent	0.94
25–49	353	0.84		0.98	
50–74	319	0.83		1.10	
75–99	164	1.30		1.14	
100+	70	0.87		0.76	
13 to 14 years old					
1–24	274	Referent	0.06	Referent	0.02
25–49	334	1.12		1.51	
50–74	327	1.38		1.65	
75–99	163	1.59		2.17	
100+	78	2.22		2.15	

Season pitches to date	No. of such appearances	Elbow Odds ratio	Elbow P value	Shoulder Odds ratio	Shoulder P value
1–200	2126	Referent	<0.01	Referent	<0.01
201–400	957	1.63		1.65	
401–600	460	2.81		2.34	
601–800	194	3.34		2.90	
800+	52	2.61		3.29	

Lyman, S., Fleisig, G. S., Andrews, J. R., & Osinski, E. D. (2002). Effect of pitch type, pitch count, and pitching mechanics on risk of elbow and shoulder pain in youth baseball pitchers. *American Journal of Sports Medicine*, *30*(4), 463–468.

Counts: Further evidence

Risk Factor	Pitchers With an Injury, % (n) With Risk Factor	Pitchers With an Injury, % (n) Without Risk Factor	Odds Ratio (95% Confidence Interval)	P^a
Pitched at least 4 years in study	6 (10 of 154)	4 (14 of 327)	1.6 (0.69 to 3.51)	.37
Pitched more than 100 innings in 1 year	14 (4 of 29)	4 (20 of 452)	3.5 (1.16 to 10.44)	.049
Threw curveballs before 13 years old	7 (7 of 103)	4 (8 of 187)	1.6 (0.60 to 4.47)	.41
Played catcher at least 3 years in study	11 (4 of 35)	4 (20 of 446)	2.7 (0.93 to 8.19)	.088

TABLE 4
Odds Ratios of Arm Tiredness and/or Arm Pain by Risk-Prone Pitching Activity and Type of Pitching (N = 754)[a]

	Arm Tiredness When Pitching		Arm Pain When Pitching		Pitching-Related Injury	
	OR[b]	95% CI	OR[b]	95% CI	OR[b]	95% CI
Pitching competitive baseball for >8 months a year[c]						
Yes vs no	0.74	0.35-1.55	1.68	0.82-3.44	0.76	0.34-1.71
Pitching in leagues without pitch counts or limits						
Yes vs no	0.93	0.69-1.32	0.99	0.71-1.39	0.76	0.53-1.09
Pitching back-to-back days[c]						
Yes vs no	**4.36**	**1.87-10.15**	**2.53**	**1.14-5.60**	1.95	0.84-4.49
Pitching multiple games a day[c]						
Yes vs no	1.87	0.98-3.55	**1.89**	**1.03-3.49**	0.96	0.49-1.87
Pitching for multiple teams within the same season[c]						
Yes vs no	**3.37**	**1.76-6.30**	**1.85**	**1.02-3.38**	0.83	0.43-1.60

Yang, J., Mann, B. J., Guettler, J. H., Dugas, J. R., Irrgang, J. J., Fleisig, G. S., & Albright, J. P. (2014). Risk-Prone Pitching Activities and Injuries in Youth Baseball: Findings From a National Sample. *The American Journal of Sports Medicine*, *42*(6), 1456–1463.

Fleisig, G. S., Andrews, J. R., Cutter, G. R., Weber, A., Loftice, J., McMichael, C., et al. (2011). Risk of serious injury for young baseball pitchers: a 10-year prospective study. *The American Journal of Sports Medicine*, *39*(2), 253–257.

How much of a difference in pitch counts leads to injury?

Variable	History of injury	No history of injury	P
Pitches/Game	64±21	54±22	<0.001
Pitches/Year	1978±1679	1408±1491	0.001

10 pitches per game
500 pitches per year

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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

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

Pitch counts	Did not follow	Followed	P
MLB/MiLB	11%	10%	0.779
UCLR	50%	2%	0.009

Conclusions

- There's much left to be done
- Pitching mechanics do mature with age, particularly from 9-13 years old and this maturation is associated with increased velocity
  - Hip and shoulder separation is one example
- Among youth/adolescent pitchers velocity, height, and weight may be injury predictors
  - Watch the pitcher who grows before his UCL
- Emphasize pitch counts as a way to reduce injury