Adolescent Pitching Mechanics and Pitch Counts

Brandon J. Erickson, MD
Section Chief, Shoulder & Elbow Surgery: Phelps Hospital
Assistant Team Physician: Philadelphia Phillies
Rothman Orthopaedics New York
BSM: Game Changing Concepts: November 16, 2018

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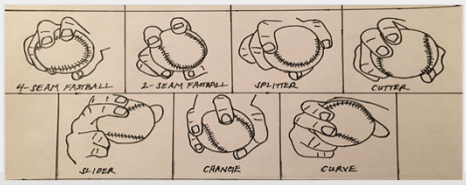
Disclosures

- AOSSM Committee Member
- Editorial Board PLOS One



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The Set Up

- Evolution of pitching motion with age
  - Hip to Shoulder separation
  - Velocity
- Pitch Counts
  - What does the data say?
  - Is this the best way to monitor "workload" in adolescents?

PITCH SMART USA BASEBALL

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Correlates With History of Injury in Youth and Adolescent Pitchers

Variable	Injured Pitchers Mean	Injured Pitchers SD	Uninjured Pitchers Mean	Uninjured Pitchers SD	*P* Value
Pitch velocity, mph	70.4	7.3	62.3	9.9	< .001*
Maximal knee height, % of participant height	65.1	7.2	65.2	7.4	.748
Stride length, % of participant height	78.2	6.0	77.0	7.3	.103
Elbow flexion at FFC	87.8	22.8	89.8	20.8	.436
Knee flexion at FFC	44.1	8.9	41.9	11.6	.048
Shoulder abduction at FFC	84.4	18.6	85.1	16.1	.604
Foot angle closed at FFC	22.0	17.2	22.3	21.2	.746
Maximal shoulder external rotation during AC	178.5	13.9	178.5	13.6	.584
Maximal shoulder abduction during AC	100.1	10.0	98.7	11.1	.193
Lateral trunk tilt at maximal external rotation	20.4	21.6	18.2	7.7	.580
Elbow flexion at BR	20.8	5.9	22.2	8.1	.167
Forward trunk tilt at BR	33.0	7.1	33.0	8.2	.948
Knee flexion at BR	31.2	14.2	32.0	16.4	.868
Shoulder abduction at BR	65.5	26.9	64.0	26.5	.580
Lead hip flexion at BR	91.2	11.6	89.6	13.1	.392
Lateral trunk tilt at BR	62.8	31.3	61.7	30.5	.655
% leading with hips	93	NA	91	NA	.623
% with hand on top of ball during stride	100	NA	97	NA	.100
% with arm in throwing position at FFC	73	NA	83	NA	.025
% with closed shoulders at hand-set position	81	NA	72	NA	.061
% with closed foot position at BR	86	NA	89	NA	.420
% with hip/shoulder rotational separation	53	NA	37	NA	.005
% in fielding position at follow-through	92	NA	93	NA	.638

The Impact of Fatigue on Baseball Pitching Mechanics in Adolescent Male Pitchers

Brandon J. Erickson, M.D., Terrance Sgori, B.S., Peter N. Chalmers, M.D., Patrick Vignona, B.S., Matthew Lesniak, B.S., Charles A. Bush-Joseph, M.D., Nikhil N. Verma, M.D., and Anthony A. Romeo, M.D.

- 28 elite youth/adolescent pitchers
  - Avg age: 14.6
- 6.3±1.7 years pitching experience
  - 46% pitched for multiple teams
  - 61% participated in showcases
- 43% Prior arm pain while pitching
- 39% Had a prior diagnosed injury

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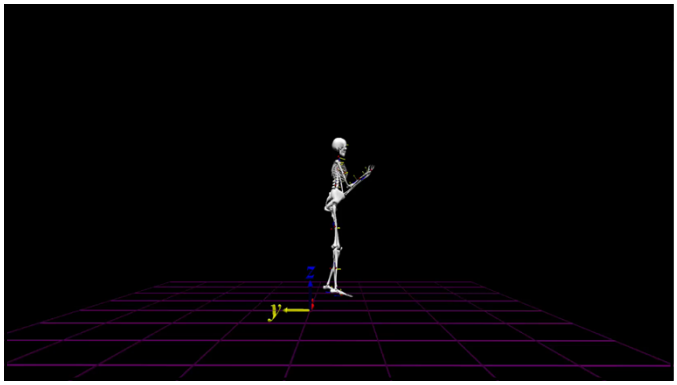
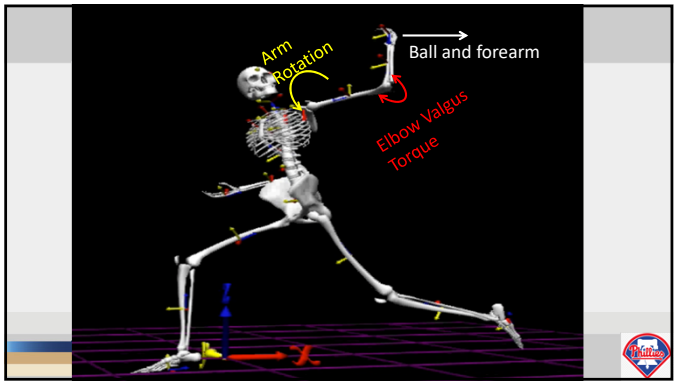
ARTHROSCOPY 2015





	Youth (n = 23)	High school (n = 33)	College (n = 115)	Professional (n = 60)	Significant differences
Front foot contact					
Stride length (% height)	85 ± 8	85 ± 9	85 ± 6	86 ± 5	
External rotation (°)	67 ± 28	64 ± 25	55 ± 29	58 ± 26	
Elbow flexion (°)	74 ± 17	82 ± 17	85 ± 18	87 ± 15	*(b,c)
Knee flexion (°)	43 ± 12	50 ± 9	48 ± 12	46 ± 8	
Arm cocking phase					
Maximum pelvis velocity (°/s)	650 ± 110	640 ± 90	670 ± 90	620 ± 80	**(f)
Maximum upper torso velocity (°/s)	1180 ± 110	1130 ± 110	1190 ± 100	1200 ± 80	**(a,d,e)
Maximum elbow flexion (°)	95 ± 12	100 ± 14	99 ± 15	98 ± 15	
Maximum horizontal adduction (°)	21 ± 8	20 ± 9	20 ± 8	17 ± 9	
Maximum external rotation (°)	177 ± 12	174 ± 9	173 ± 10	175 ± 11	
Arm acceleration phase					
Maximum elbow extension velocity (°/s)	2230 ± 300	2180 ± 340	2380 ± 300	2320 ± 300	**(b,d,e)
Maximum internal rotation velocity (°/s)	6900 ± 1050	6820 ± 1380	7430 ± 1270	7240 ± 1090	*(d)
Ball release					
Elbow flexion (°)	24 ± 7	23 ± 7	23 ± 6	23 ± 5	
Horizontal adduction (°)	11 ± 9	10 ± 8	9 ± 9	9 ± 10	
Trunk tilt (°)	32 ± 9	31 ± 9	33 ± 10	33 ± 9	
Knee flexion (°)	36 ± 11	43 ± 13	39 ± 13	38 ± 13	
Ball speed (m/s)	28 ± 1	33 ± 2	35 ± 2	37 ± 2	**(a,b,c,d,e,f)

Epidemio… Pitch Type, … at V…

Andrew J. Riff, M… Matthew Le… Brian …

- Purpose: determine… regarding pitching …
- 295 baseball pitche…
  - Players were gr… [mature], and 1…
- All pitchers threw fa…
- Older pitchers pithe… strike, lead with the…

Biomechanical Characteristic	Age, years 9-12	13-15	16-17	18-22	Total	p Value
Leading with hips, %	81	93	91	96	90	.042
Hand on top of ball, %	92	100	100	100	98	<.001
Arm in throwing position, %	87	84	80	63	82	.055
Closed shoulders at foot strike, %	62	79	83	67	76	.012
Foot closed, %	91	92	90	88	90	.927
Hip shoulder separation, %	21	39	60	58	43	<.001
Fielding position, %	87	94	95	86	93	.266
Max knee height, % of height	63	64	67	68	65	.001
Stride length, % of height	73	77	80	80	77	<.001
Elbow flexion at FFC	96	89	84	93	90	.009
Knee flexion at FFC	39	41	47	44	42	<.001
Shoulder abduction at FFC	83	84	86	92	85	.125
Foot closed at FFC	26	23	19	20	23	.016
Max external rotation at AC	179	179	178	180	179	.937
Max shoulder abduction at AC	99	99	100	102	99	.057
Lateral trunk tilt at Max ER	17	18	19	20	18	.580
Elbow flexion at BR	23	23	21	21	22	.705
Forward trunk tilt at BR	32	33	34	33	33	.731
Knee flexion at BR	38	43	48	44	44	.012
Shoulder abduction at BR	93	92	95	95	94	.014
Lead hip flexion at BR	78	85	87	88	84	.001
Lat trunk tilt at BR	25	26	27	29	26	.53

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…P.T., D.P.T., M.T… …erma, M.D., …, M.D.

…of competition …g pitches

…[pubescent], 16-17

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Epidemiologic Comparison of Pitching Mechanics, Pitch Type, and Pitch Counts Among Healthy Pitchers at Various Levels of Youth Competition

Andrew J. Riff, M.D., Peter N. Chalmers, M.D., Terrance Sgrol, P.T., D.P.T., M.T., Matthew Lesniak, D.P.T., Eli T. Sayegh, M.D., Nikhil N. Verma, M.D., Brian J. Cole, M.D., M.B.A., and Anthony A. Romeo, M.D.

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

The Effect of Pitching Biomechanics on the Upper Extremity in Youth and Adolescent Baseball Pitchers

Sports Medicine 2009

J. T. Davis,* MD, Orr Limpisvasti,†‡ MD, Derrick Fluhme,§ MD, Karen J. Mohr,† PT, Lewis A. Yocum,* MD, Neal S. ElAttrache,† MD, and Frank W. Jobe,* MD

- Purpose: define relationship between common biomechanical errors in youth pitchers and joint stress in the upper extremity using motion and video analysis
- 169 baseball pitchers aged 9-18
  - Broken down into two groups: (9-13 and 14-18)
- All pitchers threw 5 fastballs at maximum effort and were video recorded
- Humeral internal rotation torque and elbow valgus load was lower when pitchers were pitching correctly, especially in relation to “closed shoulder” and “hand on top” of ball

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Sports Medicine 2018

Qualitative Mechanics Improve With Age

	Youth (n, 86) n (%)	Adolescent (n, 83) 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

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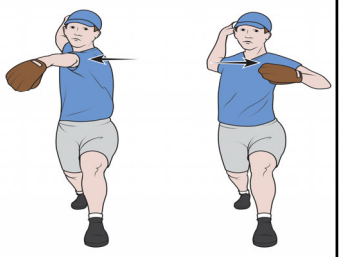
	9-12	13-15	16-17	p-value
Hip shoulder separation	21%	39%	60%	<0.001

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



Closed shoulder

Open shoulder

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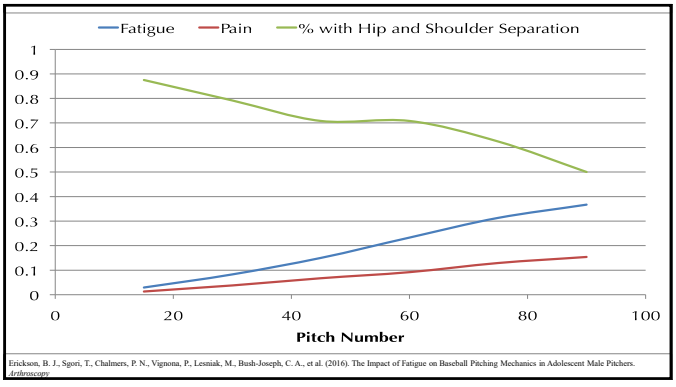
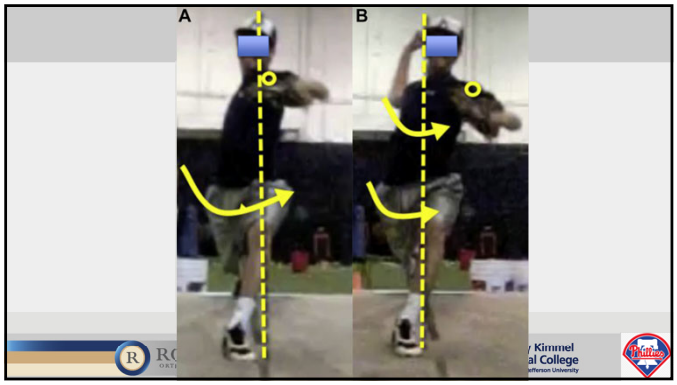


Erickson, B. J., Sgori, T., Chalmers, P. N., Vignona, P., Lesniak, M., Bush-Joseph, C. A., et al. (2016). The Impact of Fatigue on Baseball Pitching Mechanics in Adolescent Male Pitchers. *Arthroscopy*



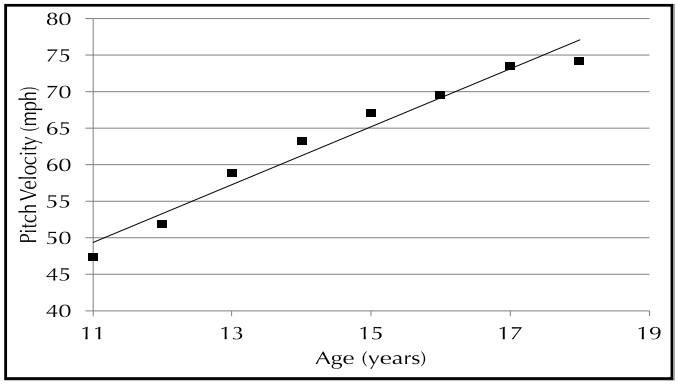
IJSPT

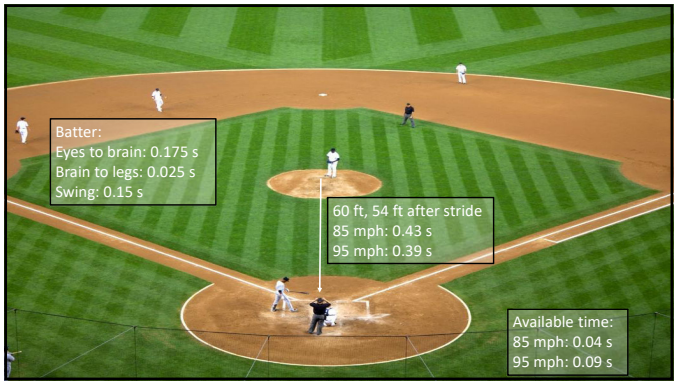
ORIGINAL RESEARCH

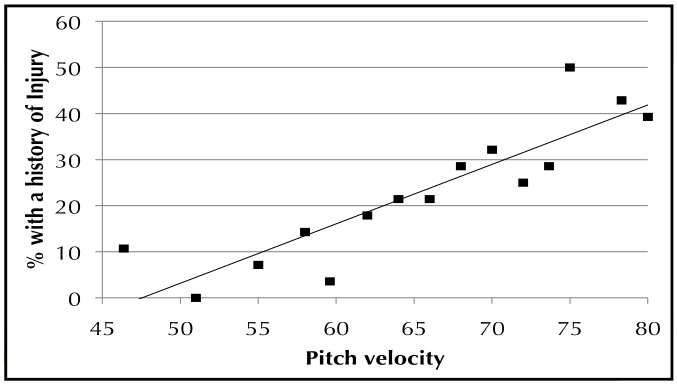
A SPEED DISTANCE-BASED CLASSIFICATION SYSTEM FOR INJURY PREVENTION AND RESEARCH IN INTERNATIONAL AND DOMESTIC YOUTH BASEBALL PLAYERS

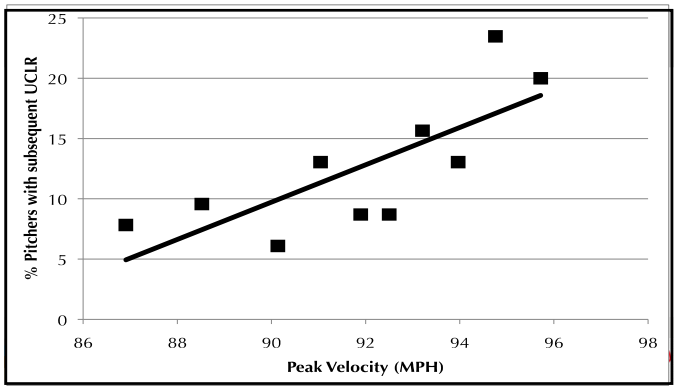
Michael J. Axe, MD[1,2]
Michael Strube, PhD[3]
David Osinski[1]
James R. Andrews, MD[4,5,7,8]
Lynn Snyder-Mackler, PT, ScD[1]

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



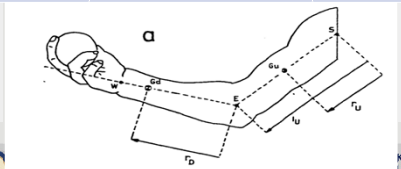

Batter:
Eyes to brain: 0.175 s
Brain to legs: 0.025 s
Swing: 0.15 s
60 ft, 54 ft after stride
85 mph: 0.43 s
95 mph: 0.39 s
Available time:
85 mph: 0.04 s
95 mph: 0.09 s


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


% Pitchers with subsequent UCLR
0
5
10
15
20
25
86
88
90
92
94
96
98
Peak Velocity (MPH)

Weight/Height Increase with Age

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



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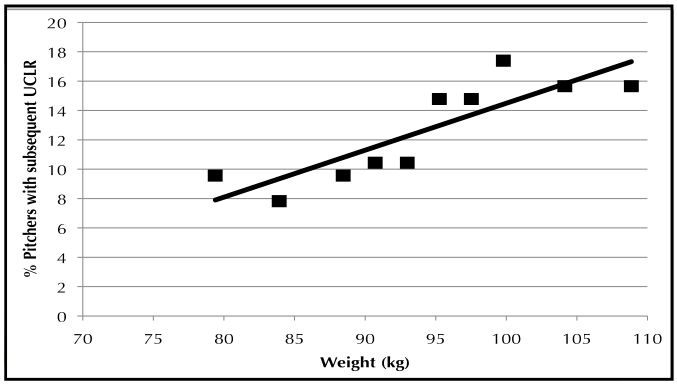

Pitch Counts

Effect of Pitch Type, Pitch Count, and Pitching Mechanics on Risk of Elbow and Shoulder Pain in Youth Baseball Pitchers

Stephen Lyman,* PhD, Glenn S. Fleisig,*† PhD, James R. Andrews,* MD, and E. David Osinski,‡ MA

Sports Medicine 2002

- Purpose: evaluate association between pitch counts, pitch types, and pitching mechanics and shoulder and elbow pain in young pitchers
- Followed 476 baseball pitchers (ages 9 to 14 years) for one season
- Authors collected data from pre- and postseason questionnaires, injury and performance interviews after each game, pitch count logs, and video analysis of pitching mechanics
- 50% experience shoulder or elbow pain during the season
- Significant association between the number of pitches thrown per game and during the season, and rate of elbow pain and shoulder pain

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Sports Medicine 2002

Relationship Between Game Pitch Counts and Joint Pain

Game pitch counts	No. of appearances	Elbow		Shoulder	
		Odds ratio	*P* value	Odds ratio	*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	

Risk of Serious Injury for Young Baseball Pitchers: A 10-Year Prospective Study

Glenn S. Fleisig, James R. Andrews, Gary R. Cutter, Adam Weber, Jeremy Loftice, Chris McMichael, Nina Hassell and Stephen Lyman

Am J Sports Med 2011 39: 253 originally published online November 23, 2010

Risk Factor	Pitchers With an Injury, % (n)		Odds Ratio (95% Confidence Interval)	*P*[a]
	With Risk Factor	Without Risk Factor		
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

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Sports Medicine 2011

Correlates With History of Injury in Youth and Adolescent Pitchers

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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

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Exceeding Pitch Count Recommendations in Little League Baseball Increases the Chance of Requiring Tommy John Surgery as a Professional Baseball Pitcher

Brandon J. Erickson,*† MD, Peter N. Chalmers,† MD, Michael J. Axe,§ MD, and Anthony A. Romeo,† MD

- 638 youths pitched in the LLWS between 2001-2009

Age	Daily Max (Pitches in Game)	0 Days Rest	1 Days Rest	2 Days Rest	3 Days Rest	4 Days Rest	5 Days Rest
7-8	50	1-20	21-35	36-50	N/A	N/A	N/A
9-10	75	1-20	21-35	36-50	51-65	66+	N/A
11-12	85	1-20	21-35	36-50	51-65	66+	N/A
13-14	95	1-20	21-35	36-50	51-65	66+	N/A
15-16	95	1-30	31-45	46-60	61-75	76+	N/A
17-18	105	1-30	31-45	46-60	61-80	81+	N/A
19-22	120	1-30	31-45	46-60	61-80	81-105	106+

- 0% of those who also played other positions required UCLR

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Orthopaedic Journal of Sports Medicine 2017

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

Orthopaedic Journal of Sports Medicine 2017

Conclusions

- We're not there yet
- Pitching mechanics mature with age, 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
- Pitch counts are just one way to try to reduce injury

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Sidney Kimmel Medical College at Thomas Jefferson University

Thank You

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Sidney Kimmel Medical College at Thomas Jefferson University