Current Concepts in Workload Monitoring: When Does a Day Off Prevent Injury and Enhance Performance

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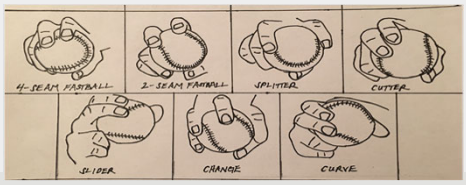
Disclosures

- AOSSM Committee Member
- Editorial Board PLOS One



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The Set Up

- What is **Workload**?
- How long should pitchers rest?
- Future Directions

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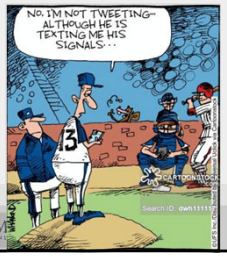
How Do We Define Workload?

Workload = ???



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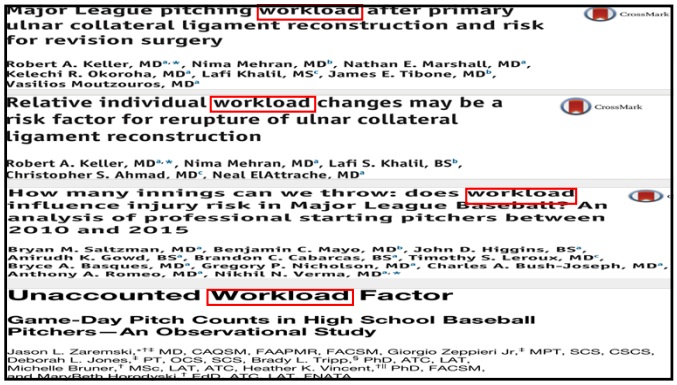

Major League pitching workload after primary ulnar collateral ligament reconstruction and risk for revision surgery

Robert A. Keller, MD[a,*], Nima Mehran, MD[b], Nathan E. Marshall, MD[a], Kelechi R. Okoroha, MD[a], Lafi Khalil, MS[c], James E. Tibone, MD[a], Vasilios Moutzouros, MD[a]

Relative individual workload changes may be a risk factor for rerupture of ulnar collateral ligament reconstruction

Robert A. Keller, MD[a,*], Nima Mehran, MD[a], Lafi S. Khalil, BS[b], Christopher S. Ahmad, MD[c], Neal ElAttrache, MD[a]

How many innings can we throw: does workload influence injury risk in Major League Baseball? An analysis of professional starting pitchers between 2010 and 2015

Bryan M. Saltzman, MD[a], Benjamin C. Mayo, MD[b], John D. Higgins, BS[a], Anirudh K. Gowd, BS[a], Brandon C. Cabarcas, BS[a], Timothy S. Leroux, MD[c], Bryce A. Basques, MD[a], Gregory P. Nicholson, MD[a], Charles A. Bush-Joseph, MD[a], Anthony A. Romeo, MD[a], Nikhil N. Verma, MD[a,*]

Unaccounted Workload Factor

Game-Day Pitch Counts in High School Baseball Pitchers—An Observational Study

Jason L. Zaremski,[*†‡] MD, CAQSM, FAAPMR, FACSM, Giorgio Zeppieri Jr.,[†] MPT, SCS, CSCS, Deborah L. Jones,[‡] PT, OCS, SCS, Brady L. Tripp,[§] PhD, ATC, LAT, Michelle Bruner,[†] MSc, LAT, ATC, Heather K. Vincent,[‖¶] PhD, FACSM, and MaryBeth Horodyski,[‡] EdD, ATC, LAT, FNATA

How Do We Define Workload?

Workload = ???

Games pitched, Innings pitched, Pitch counts

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Journal of Shoulder and Elbow Surgery 2018

- Goal: Determine if there was a risk of subsequent DL placement with:
  - Average pitch count per game
  - Cumulative pitch counts
  - Cumulative innings pitched
  - Cumulative number of starts over a multi-year period
- Looked at DL placement for any reason, and specifically UE reason
- Evaluated all MLB starting pitchers w/ min 5 starts (2010-2015)
- 161 starting MLB pitchers were included

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How many innings can we throw? does workload influence injury risk in Major League Baseball? An analysis of professional starting pitchers between 2010 and 2015

Journal of Shoulder and Elbow Surgery

Table III Year-by-year comparison of workload for players with upper extremity injuries and uninjured players

	Overall	No DL	UE DL	*P* value*
Injury year 2011	n = 141	n = 107	n = 34	
Starts (2010)	25 ± 9	25 ± 9	26 ± 7	.403
Count (2010)	2535 ± 870	2525 ± 908	2564 ± 749	.642
Innings (2010)	154.8 ± 55.6	154.4 ± 58.2	155.9 ± 47.0	.691
Pitches per start (2010)	102 ± 18	103 ± 20	99 ± 5	.204
Injury year 2012	n = 119	n = 90	n = 29	
Starts (2010-2011)	52 ± 14	51 ± 14	54 ± 12	.260
Count (2010-2011)	5163 ± 1461	5083 ± 1529	5414 ± 1219	.251
Innings (2010-2011)	316.1 ± 93.1	310.5 ± 97.5	333.4 ± 76.7	.209
Pitches per start (2010-2011)	100 ± 7	100 ± 7	101 ± 6	.500
Injury year 2013	n = 82	n = 54	n = 28	
Starts (2010-2012)	81 ± 16	83 ± 15	77 ± 18	.144
Count (2010-2012)	8072 ± 1862	8341 ± 1736	7552 ± 2014	.139
Innings (2010-2012)	495.5 ± 119.8	511.2 ± 114.2	465.3 ± 126.5	.191
Pitches per start (2010-2012)	99 ± 5	100 ± 5	98 ± 5	.184
Injury year 2014	n = 55	n = 39	n = 16	
Starts (2010-2013)	110 ± 21	110 ± 22	112 ± 18	.618
Count (2010-2013)	11,057 ± 2404	11,001 ± 2547	11,194 ± 2086	.628
Innings (2010-2013)	682.9 ± 157.1	675.6 ± 164.0	700.6 ± 142.4	.446
Pitches per start (2010-2013)	100 ± 5	100 ± 5	100 ± 4	.762
Injury year 2015	n = 47	n = 33	n = 14	
Starts (2010-2014)	142 ± 20	143 ± 20	139 ± 21	.684
Count (2010-2014)	14,273 ± 2337	14,414 ± 2281	13,940 ± 2520	.728
Innings (2010-2014)	876.1 ± 153.8	887.8 ± 155.6	848.7 ± 151.3	.634

Relative individual workload changes may be a risk factor for rerupture of ulnar collateral ligament reconstruction

Robert A. Keller, MD[a,*], Nima Mehran, MD[a], Lafi S. Khalil, BS[b], Christopher S. Ahmad, MD[c], Neal ElAttrache, MD[a]

Journal of Shoulder and Elbow Surgery 2017

- Goal: Determine workload was a risk factor for revision UCLR:
- Compared 28 MLB pitchers who underwent revision UCLR to 137 MLB pitchers who underwent primary UCLR and did not require revision surgery
- Evaluated games pitched, pitch counts and innings pitched 3 years before and after primary UCLR
- Pitchers who underwent revision UCLR increased games pitched by 14.1% after UCLR while no-revision group pitched 13.6% fewer games than before UCLR ($P < .01$)
- Total Pitch Count:
  - Revision group: threw 6.6% more pitches after UCLR (1138.9 after vs. 1068.6 before)
  - No revision group: threw 19.6% fewer pitches after UCLR than before UCLR
    - Difference was not statistically significant ($P = .08$)

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Table III Year-by-year workload by group over time (before and after surgery)

	Years before and after reconstruction	No revision	Revision
Games	−3	34.4 (1.6)	32.1 (4.2)
	−2	39.0 (1.5)	31.2 (3.6)
	−1	39.4 (1.5)	28.7 (3.4)
	1	26.0 (1.5)	29.4 (3.4)
	2	35.9 (1.7)	39.2 (3.6)
	3	37.9 (1.8)	36.7 (3.7)
Total innings	−3	110.9 (5.0)	107.1 (13.5)
	−2	121.8 (4.9)	101.5 (11.5)
	−1	117.2 (5.0)	93.0 (10.8)
	1	64.3 (4.9)	77.0 (10.8)
	2	98.3 (5.4)	89.3 (11.5)
	3	103.8 (5.9)	105.9 (12.0)
Total pitches	−3	1486.7 (100.0)	841.9 (348.1)
	−2	1592.2 (91.8)	1070.9 (263.1)
	−1	1623.4 (86.4)	1173.4 (238.8)
	1	880.8 (91.0)	754.2 (209.9)
	2	1500.7 (96.1)	1065.7 (205.3)
	3	1483.4 (101.6)	1600.0 (209.9)

Current Workload

Risk factor for revision UCLR

Not correlated with placement on DL

How Do We Define Workload?

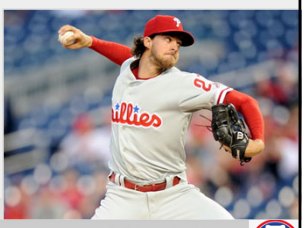
Workload = ???

Games pitched, Innings pitched, Pitch counts

What else should we include???

Other Possible Variables to Factor into Workload

- Pitch type?
  - Fastball % vs. breaking ball %; % fastballs in 1st vs. 6th inning?
- Average fastball velocity?
- Peak fastball velocity?



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Fastball Pitch Velocity Helps Predict Ulnar Collateral Ligament Reconstruction in Major League Baseball Pitchers

Peter N. Chalmers, Brandon J. Erickson, Brian Ball, Anthony A. Romeo and Nikhil N. Verma

- Purpose was to determine factors predictive of UCLR among MLB pitchers
- Pitch velocity, number, and type (fastball, curveball, etc.) for every pitcher and game within MLB from 2007 to 2015
- 1327 pitchers included; 309 (26.8%) had undergone UCLR
- Peak pitch velocity was significantly higher among preinjury pitchers than control pitchers: 93.3 vs. 92.1 mph P<.001
- Same w/ avg pitch velocity: 87.8 vs. 86.9 mph P=.001

Sports Medicine 2016

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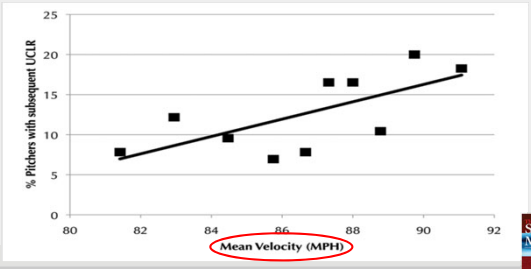

Sports Medicine 2016

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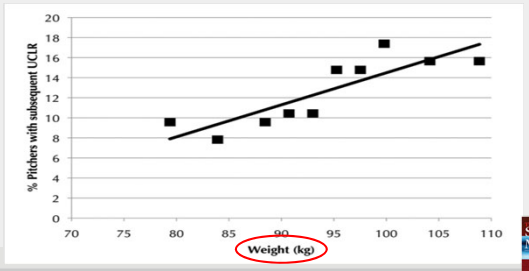

Sports Medicine 2016

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Predictors of Ulnar Collateral Ligament Reconstruction in Major League Baseball Pitchers

David Whiteside,*†‡§ PhD, Douglas N. Martini,‖ PhD, Adam S. Lepley,¶ PhD, ATC, Ronald F. Zernicke,†#** PhD, and Grant C. Goulet,† PhD

Sports Medicine 2016

- Goal was to create a model that would predict who underwent UCLR
- Compared 104 pitchers who underwent UCLR to matched controls
- Used binary logistic regression to evaluate several variables as predictors of UCLR
- The model was able to predict 67% of who underwent UCLR based on
  - **Smaller repertoire of pitches**
  - **Greater mean pitch speed**
  - **Fewer days between consecutive games**
  - **Greater mean pitch counts per game**
  - Less pronounced horizontal release location

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Other Possible Variables to Factor into Workload

- Pitch type?
  - Fastball % vs. breaking ball %; % fastballs in 1st vs. 6th inning?
- Average fastball velocity?
- Peak fastball velocity?
- Days of rest between outings?

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What is the Ideal Number of Days of Rest?

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The Impact of Pitch Counts and Days of Rest on Performance Among Major-League Baseball Pitchers

John C. Bradbury[1] and Sean L. Forman[2]

- Purpose was to quantify the effects of number of pitches thrown and days of rest on pitcher performance
- From 1988-2009 included starting pitchers in MLB in regular-season games who pitched after <15 days of rest
- The study included games started by 1,058 pitchers over 22 seasons
  - Total of 77,131 observations
- Did not evaluate injury rates

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2012

The Impact of Pitch Counts and Days of Rest on Performance Among Major-League Baseball Pitchers

John C. Bra

Table 2. Impact of pitches thrown on ERA by age cohort.*

	Previous game	5-Game mean	10-Game mean
Marginal impact to ERA			
All	0.0066†	0.0135	0.0220
<25	0.0076	0.0132	0.0212
25–34	0.0076	0.0134	0.0214
>34	0.0043	0.0154	0.0225
Pitches needed to raise ERA by 0.25			
All	38	19	11
<25	33	19	12
25–34	33	19	12
>34	58	16	11

*ERA = earned run average.
†Nonlinear estimate, estimated impact at 100 pitches.

Figure 3.

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2012

Should Rest Be Pitcher Specific?

4 for some and 6 for others?

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

Lower Extremity Strength and Recovery Time in Youth Baseball Pitchers: A Pilot Study

Jennifer L. Livingston, PhD, ATC
Nicholas M. Tavoukjian, MS, ATC, CSCS, TSAC-F

- Purpose was to investigate Little League pitching regulations by measuring the change in lower extremity force production after a pitching performance and the subsequent days of rest required for youth baseball pitchers to recover
- 15 youth baseball pitchers (avg age 10 years) completed lower extremity strength testing immediately before and after throwing a submaximal number of pitches
- The MMT was repeated for the following 4 days to investigate the amount of rest time required for lower extremity strength to return to baseline

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2018

Lower Ex . Pilot

Table 4. Muscle strength before and after pitching session.

Muscle	Baseline	Post	t	*p*
Pivot Gluteus Maximus	131.133 ± 47.749	121.020 ± 36.374	1.687	.114
Stride Gluteus Medius	63.777 ± 21.236	57.390 ± 16.692	2.447	.028*
Pivot Quadriceps	184.017 ± 50.842	175.710 ± 50.077	1.697	.112
Stride Quadriceps	177.080 ± 48.089	169.393 ± 50.983	-8.483	.000*

Table 3. Mean required rest time.

Actual required rest days	Little League rest day requirement
2.641 ± 1.125	1.933 ± .798

p = .017

Other Possible Variables to Factor into Workload

- Pitch type?
  - Fastball % vs. breaking ball %; % fastballs in 1st vs. 6th inning?
- Average fastball velocity?
- Peak fastball velocity?
- Days of rest between outings?
- Warm up pitches?
  - Dry Humping

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Unaccounted Workload Factor

Game-Day Pitch Counts in High School Baseball Pitchers—An Observational Study

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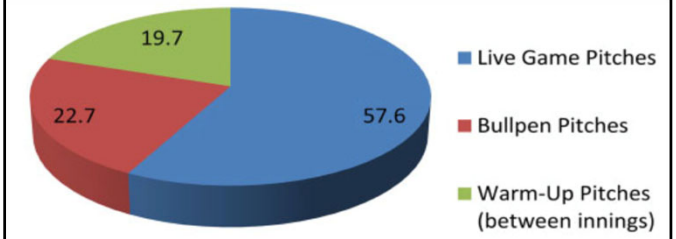
Orthopaedic Journal of Sports Medicine 2018



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Future Directions

- Re-evaluate workload
  - More weight to pitches later in games
  - Take fastballs, pitch speed, etc. into account
- Enhanced Recovery?
  - Phase Change Material (PCM) Cold therapy
  - Personalized recovery measurements
    - Muscle testing
- Serum markers of recovery?
  - Eliminate the guesswork and use and objective finding
    - CRP

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Thank You

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