NPA Velocity Study conducted 2005-2006

Making a Difference

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Methodology

Initial Velocity Study

Purpose: Track velocities from pitchers of various ages and skill levels, in two different positions, to find a correlation (if any) between velocity and hip/shoulder separation.

Study set up: Create a spreadsheet to record:

- Player name
- Age
- Height/weight
- Basic body type ("squatty body", tall and lean, long levers, etc.)
- Skill level
  - Youth 14 years and under
  - High School (9^{th} – 12^{th} grade)
  - College
  - Professional
- Two sets of velocities (10 throws in each position most cases)
  - Velocities from throws made from the knees
  - Velocities from throws made off the mound during a full speed bullpen session

Capturing the data:

- Setting included our indoor facility in addition to local baseball fields
- Data was gathered over the summer of 2005
- Pitchers warmed up their bodies either on their own or under the supervision of an NPA instructor; cardiovascular, "flexing", body work, etc.
- Players warmed up their throwing arms to their tolerance
  - Included flat ground throwing to their tolerance
  - Various drills with instructor or throwing partner to reinforce proper mechanics
- Pitchers, when ready, threw between 5 and 10 (10 most cases) throws from their knees at an approximate distance of sixty feet from their throwing partner. Each velocity was recorded.
- After a short break, pitchers threw a few pitches from the mound to get loose. When the pitcher said he was "ready", the next ten velocities from pitches on the mound were recorded.
- Data was entered onto spreadsheet for all pitchers that day participating in the study.

About recording the velocities:

- When throwing from the knees, pitchers were instructed to first start with a knee position near 45 degrees to the target
- Pitchers were encouraged to try increasing and/or decreasing the angle during practice throws to find an angle they were most comfortable with (see pictures on the following pages)
- If a pitcher felt at first he was "throwing across his body too much", he was encouraged to increase the angle of his knees (shoulders becoming more "square" to the target) until he felt more comfortable
- If a pitcher felt at first he was "too open" during his practice throws, he was encouraged to decrease the angle (glove side shoulder facing more toward the target) until he felt more comfortable or until he felt he was throwing harder
- Once we found the position the player was most comfortable in and throwing the hardest from, we noted the hip/knee angle with the use of a "knee mat" we created in order to measure angles of separation. The mat (basically a large protractor), also allowed us to measure how far each player brought his throwing shoulder back; the two measures of angles allowed us to measure each player's "degree of hip and shoulder separation"
    - From previous research done by various pitching coaches and performance analysts in recent years, and in some cases with the help of three dimensional motion analysis, we know that most elite pitchers get between 40 and 60 degrees of hip/shoulder separation
    - For example, in our study: We had a player whose optimal hip angle was 25 degrees. He brought his arm back only 5 degrees giving him a total of 30 degrees of hip and shoulder separation; we knew he "had more in the tank". Another player was most efficient at 45 degrees on his knees. He brought his arm back 15 degrees giving him a total of 60 degrees hip and shoulder separation.
- Pitchers were asked while in the knee position to slightly lean forward in order to maintain dynamic balance and to stabilize their posture. We also asked them to "sit down" a little bit in order to decrease the distance from their rear ends to their feet – basically lowering their center of gravity. They started with their hands in a relaxed manner (just as they would hold their hands together on the mound) and we encouraged them to take their arm back in the same manner, speed, and direction as they normally would when delivering a pitch from the mound; in other words, we asked them to throw with their regular pitching mechanics while they were in the knee drill position.
- We used the same "JUGS" model radar gun to record all velocities during the study
- After originally experimenting with the radar gun in different locations, we decided to position the gun directly behind (3 or 4 feet) the pitcher's throwing arm to capture the velocity at exit speed
- The same was done when recording pitch velocities for throws made off the pitching mound
- Other than the initial setup there was no instruction about mechanics when capturing velocities from flat ground/knees or from mound/full delivery
- Pitchers were encouraged to throw as hard as they could while maintaining what they understood to be proper mechanics in both positions
- After each pitcher finished throwing, data was reviewed in an effort to help them learn and improve. Discussions included coach/pitcher quantification of the most efficient hip angle for doing the knee drill as well as the proper level of hip and shoulder separation during the pitching motion (specific to that particular pitcher)

General findings for study

- Once velocities were recorded, we decided to analyze the data in the following fashion:
  - Calculate the average velocity for the set of throws made from the knee position
  - Calculate the average velocity for the set of throws made off the pitching mound
  - Note both the lowest and highest individual velocity from the throws made in each position
  - Calculate the speed differential between the average velocity from the knee position and the average velocity from the mound
  - Using the average velocity from the knee position and the average velocity from the pitching mound, we calculated what percent of their overall velocity (from the mound) was able to be derived from throws on the knees.
  - A quick illustration of the data collected for a pitcher is as follows:

A	B	C	D	E	F	G1-G5					H	I	J1-J10									K	L	M	N	O
8/23/05	Sample Player	R	15	HS	shorter w/ medium build	46	48	45	48	48	**47**	**48**	61	62	61	60	58	59	58	61	61	60	**60**	**62**	**13**	**78%**	**22%**

A: Date velocities were recorded
B: Player name
C: Right or left handed
D: Player age
E: Skill level
F: Brief description of body type
G1-G5: Individual velocities for throws in knee position (5 throws in this example)
H: Average velocity for throws in knee position
I: Top individual velocity from knee position
J1-J10: Individual velocities from pitches made off the mound (10 pitches in this example)
K: Average velocity for pitches thrown from the mound
L: Top individual velocity from pitches made from the mound
M: Speed differential between average knee velocity and average mound velocity
N: Percentage of overall velocity pitcher was able to generate from mechanics in knee position
O: Percentage of overall velocity pitcher had from the rest of the pitching mechanics. In this case regarding N and O:

- This player's average velocity from the mound on that day was 60 mph
- His average velocity from the knee position was 47 mph
- We can conclude that 78% of the total velocity he generated on the mound came from the separation/rotation he created on his knees. This player gained an average of 13 mph from extension, flexion/direction on the mound.

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Small Sample of Data Collected During the Initial Velocity Study

						Velocity from knees							Velocity from mound													
Date	Name	R/L	Age	Leve	Build	1	2	3	4	5	AVG	Top	1	2	3	4	5	6	7	8	9	10	AVG	Top	Differential	Knee %	mound %
8/21/05	A	R	13	Y	squatty body	39	40	42	42	43	41	43	50	50	50	49	51	51	49	50	51	49	50	51	9	82	18
8/21/05	B	R	13	Y	6'2" real tall, real skinny	50	51	51	54	51	51	54	70	65	65	63	63	69	67	67	66	66	66	70	15	78	22
8/21/05	C	R	10	Y	small squatty body	35	37	38	39	40	38	40	48	47	49	46	50	49	49	50	49	49	49	50	11	78	22
8/21/05	D	R	12	Y	1medium build	37	38	38	37	37	37	38	47	46	45	45	48	45	46	46	45	47	46	48	9	81	19
8/23/05	E	R	14	HS	Avg Body Growing	50	50	50	52	52	51	52	65	65	65	65	64	64	65	66	64	65	65	65	14	79	21
8/23/05	F	L	13	Y	skinny	48	48	46	48	50	48	50	62	63	63	62	61	63	61	63	64	64	63	64	15	77	23
8/23/05	G	R	13	Y	taller, skinny	53	54	52	54	52	53	54	66	64	64	65	65	65	65	63	65	65	65	66	12	82	18
8/23/05	H	R	13	Y	squatty body	49	49	49	49	50	49	50	61	62	58	63	61	61	62	62	63	62	62	63	12	80	20
8/23/05	I	R	15	HS	shorter w/ medium build	46	48	45	48	48	47	48	61	62	61	60	58	59	58	61	61	60	60	62	13	78	22
8/25/05	J	R	16	HS	6'5" good build	58	59	61	60	62	60	62	77	78	78	80	79	77	79	78	78	78	78	80	18	77	23
8/25/05	K	R	21	C	6'3" Functionally weak	60	61	61	62	60	61	62	71	71	71	71	71	71	71	71	71	71	71	71	10	86	14
8/25/05	L	R	17	C	6'5" Tall, long levers	61	61	62	59	62	61	62	78	79	76	76	78	77	80	78	81	78	78	81	17	78	22
8/25/05	M	R	17	HS	6'3" good build	68	68	68	68	68	68	68	80	79	80	77	78	79	80	78	79	79	79	80	11	86	14
8/25/05	N	R	17	HS	Skinny	65	64	63	63	65	64	65	79	79	78	77	78	78	76	79	78	79	78	79	14	82	18
8/25/05	O	R	17	HS	5'9"	60	59	59	60	60	60	60	75	75	75	75	75	75	75	75	75	75	75	75	15	79	21
8/25/05	P	R	18	C	6'1" Stocky Great Arm	72	73	70	72	74	72	74	90	88	90	90	90	89	97	90	91	90	91	91	18	80	20
8/26/05	Q	R	14	HS	Avg Body Growing	51	54	55	53	51	53	55	67	63	65	64	63	65	64	61	63	63	64	67	11	83	17
8/26/05	R	R	15	HS	taller, decent strength	60	61	61	61	60	61	61	78	77	77	77	76	77	77	77	77	77	77	78	16	79	21

Results from all players involved in study

The first number below (AVG) represents the overall speed differential (AVG fastball velocity from mound minus AVG velocity from knees) among all players in that age group. The MAX represents the highest differential in the age group and the MIN represents the smallest differential among the group. The MODE is the number representing the speed differential that showed up most often in that group. The 2nd AVG shown below represents the overall AVG velocity percentage that came from throwing from their knees. The MAX illustrates the highest percentage of velocity that came from the knees for the age group; MIN represents the least percentage of velocity that came from the movement represented by throwing from the knees. The 2nd MODE below represents the percentage that showed up most frequently for that age group.

Youth: Final Analysis of all players in this group (31 Pitchers)

- AVG 13.93 mph (The AVG speed differential for all players in this group; AVG mph from mound minus AVG mph from knees)
- MAX = 21 mph (Best fastball from mound minus worst velocity from knees from a player in this group)
- MIN = 9 mph (Best fastball from mound minus best velocity from knees from a player in this group)
- MODE = 12 mph (Differential between mound velocity and knee velocity that occurred most often for all players in this group)
- AVG = 77.19% (AVG % of velocity that came from throwing from the knees for all players in this group)
- MAX = 83% (Highest AVG % of velocity that came from throwing from the knees from a player in this group)
- MIN = 68% (Lowest AVG % of velocity that came from throwing from the knees from a player in this group)
- MODE = 82% (% that occurred most often in this age group)

High School: Final Analysis of all players in this group (69 Pitchers)

- AVG 14.65 mph
- MAX = 21 mph
- MIN = 11 mph
- MODE = 14 mph
- AVG = 79.84%
- MAX = 86%
- MIN = 72%
- MODE = 82%

College : Final Analysis of all players in this group (52 Pitchers)

- AVG 15.94 mph
- MAX = 23 mph
- MIN = 10 mph
- MODE = 17 mph
- AVG = 80%
- MAX = 86%
- MIN = 72%
- MODE = 80%

Professional: Final Analysis of all players in this group (48 Pitchers)

- AVG 16.67 mph
- MAX = 22 mph
- MIN = 17 mph
- MODE N/A
- AVG = 79.67%
- MAX = 84%
- MIN = 73%
- MODE = 81%

What the Numbers Mean to Us

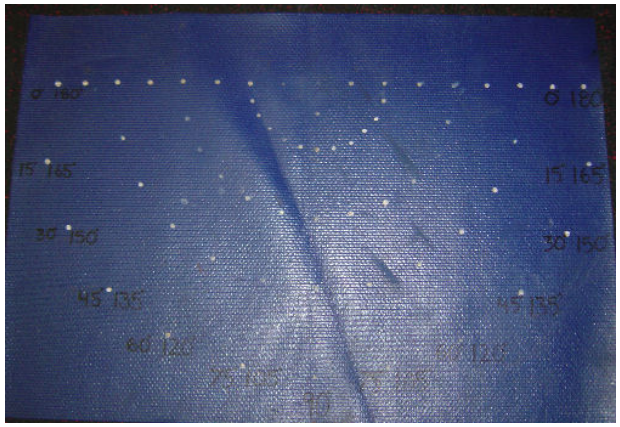
- Many pitching coaches have ideas about where velocity is generated from during the pitching motion. Some believe it comes from generating "torque" in the upper body, others by "scapular loading", while others believe in the more conventional wisdom – throwing hard comes from using the legs, having a very high leg lift, or from "pushing off the rubber"
- The results from our study indicate that just about 80% of a pitcher's real velocity comes from the torque of hip and shoulder separation; more specifically, the rotational, not linear, sequence of the pitching delivery. The averages from all ages and skill levels are very close to one another; too close in our opinion to be "coincidence"
- When the kids threw from their knees, they had no legs involved in the throwing motion, no slope from a mound to gain momentum from, and no leg lift to generate power and/or increase potential energy. We found the derived energy or potential to increase momentum from all these factors only contributed to roughly 20% of total velocity from pitches on the mound
- The MIN and MAX (speed differential) were similar across all age groups and skill levels. As a general rule, the least amount of velocity a pitcher was going to gain by going to the mound (after throwing from his knees) was 10 mph. The most velocity a player gained by doing the same was about 22 mph. The AVG came to 15 mph when considering all age groups and skill levels. Essentially, we can record the velocities from an athlete throwing from his knees, take the average, add 15 mph to it, and we can come extremely close to predicting what his overall velocity will be when he throws pitches from the mound
- The MIN and MAX (percentage of velocity that came from hip/shoulder separation alone) were also very similar. Across the board, the least amount of velocity the pitchers could generate from hip/shoulder separation was roughly 71%. The highest percentage for all age groups and skill levels was roughly 84%. In summary, we can safely say that 71-84% of the pitcher's velocity came from the rotational energy sequence; not the directional sequence. These were the extremes as the average for each group and all pitchers together was 80%.
- We believe that factors such as maximizing the efficiency of leg lift, maximizing momentum, and having a strong lower body are essential to maximizing velocity and linear momentum during the pitching delivery. However, we are now convinced that most of a pitcher's velocity does not come from these areas and that it comes from other sources – specifically hip/shoulder separation
- By finding the optimal level of torque and maximizing the hip and shoulder separation of a pitcher (while keeping balance and posture throughout the delivery), we believe we can increase a pitcher's velocity
- The way to do so includes:
    - Communicating new, objective information
    - Incorporating specific drills into their workouts that support the new information
    - Introducing a work out routine specific to the torso and core in order to improve rotational strength and flexibility. This will allow for better, more efficient hip and shoulder separation/rotation during the pitching delivery
- An understanding that hip and shoulder separation/rotation is where the majority of velocity really comes from, led us to learn how important *timing* is to an efficient delivery; the rotational part of a delivery demands perfect timing for maximizing velocity

Various Positions when Throwing on the Knees

Starting position: knees at 45 degrees

If a player was more comfortable more closed off…

If a player felt more comfortable more open…



Our “knee mat” to measure arm angle and knee angle

Noting a player’s knee angle and arm angle

Follow-up Actions

With our findings, we hypothesized that we could improve a pitcher's velocity with improved hip and shoulder separation.

We felt the best way to go about this was to design drills specifically to improve pitchers in this area, but more importantly, to design a strength and flexibility program for pitchers to get them stronger and more flexible in their core and torso. We believed doing so would get our pitchers to increase their hip/shoulder separation, getting it closer to a more efficient angle of 60 degrees, thus allowing them to throw harder…and our program worked. We created a pilot study called the SUV Program (Safe Usable Velocity Improvement Program) and we used the new information from our research during the summer to help a group of 23 local high school varsity players from the San Diego area. In addition to having the pitchers work out with our trainer on a weekly basis, the players also threw heavy/light baseballs (overloading/under loading with 6 oz and 4 oz) under our supervision on a weekly basis (number of weighted ball throwing days varied among players) to help build strength and increase arm speed. The entire program lasted 12 weeks. A brief description of the SUV Program is as follows:

- Players came in for an initial assessment where we recorded their velocities for the first time. We also measured each player's angle of hip/shoulder separation (from the knee position) to learn their efficiency at that particular point in time
- Players came in once a week to work out with our trainer. In addition to participating in the workouts that evolved and increased in workloads/repetitions/types of exercises over the twelve weeks, the players were given packets each week that demonstrated the exact exercises they were to do on their own throughout the week. Players did the individual workouts between 0 and 5 times a week on their own. We have records for each player indicating how many times they did the homework each week away from our supervision
- Players also came into the facility once a week to throw under the supervision of an NPA instructor
- Depending on the player's current game and practice schedule (throwing routine), the players either threw the weighted balls or participated in a normal bullpen session to focus on mechanics
- We tracked the velocities of every pitch thrown by each pitcher during each individual workout, most workouts consisted of:
    - 10 velocities with a 6 oz baseball
    - 10 velocities with a 4 oz baseball
    - 10 velocities with a standard Major League 5 oz baseball
- By keeping detailed velocity records for each pitcher, we were able to measure the progress/digress of each pitcher. A summary sheet after the study indicates:
    - The velocity of every pitch thrown with each baseball
    - Averages, modes, spreads, percentages, maximums, and minimums to track their progress/digress
    - Which week during the program (one through twelve) the players had the best/least improvement from their initial assessment
- Though not the central goal of our research, results of the SUV program indicated that the optimal number of individual workouts per athlete was approximately 3 workouts per week. Continued research of this subject will lead to a more accurate association between pitch velocity and workout frequency.

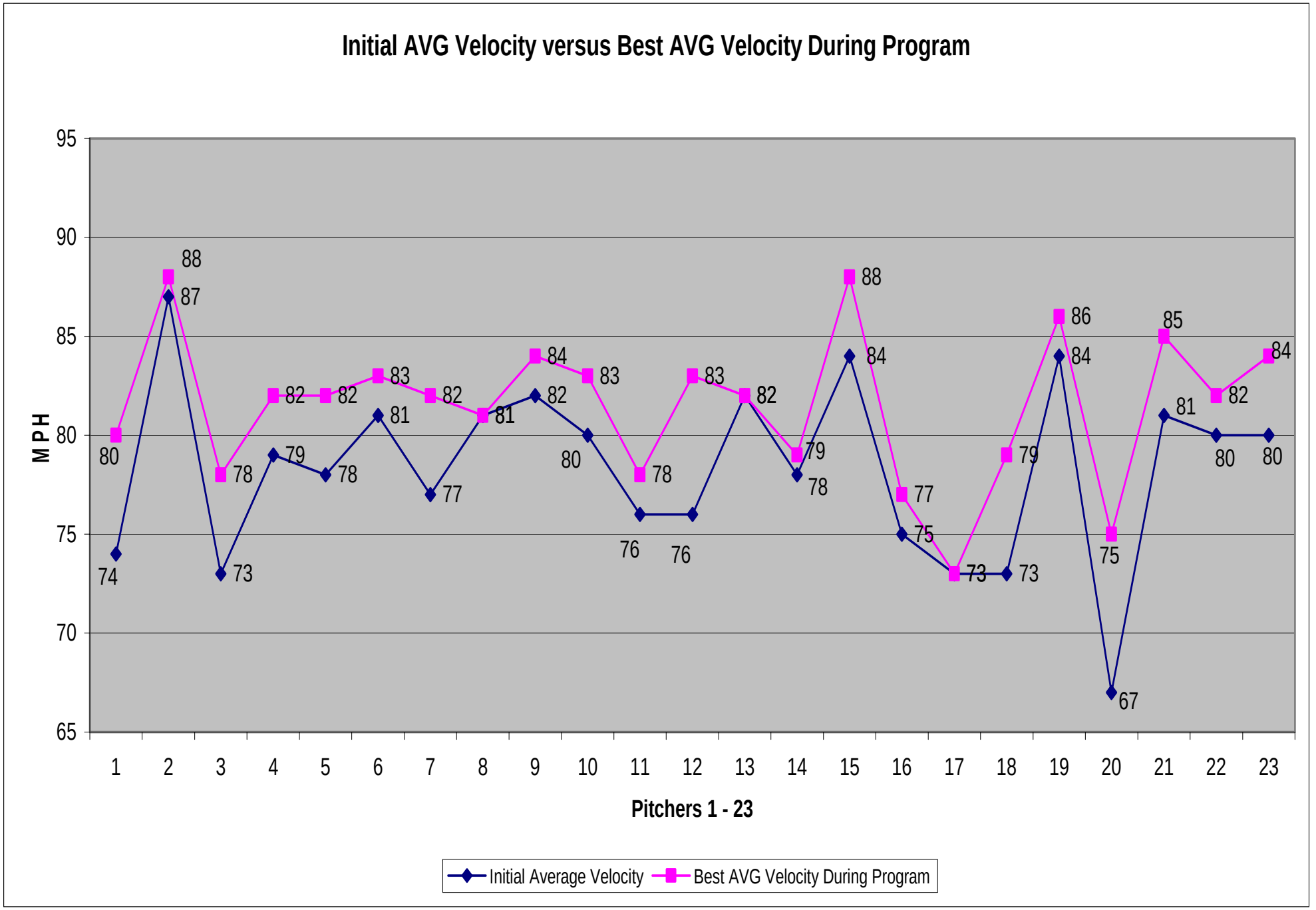
The following is an example of a Final Data Sheet for one of the twenty-three pitchers to participate in the program

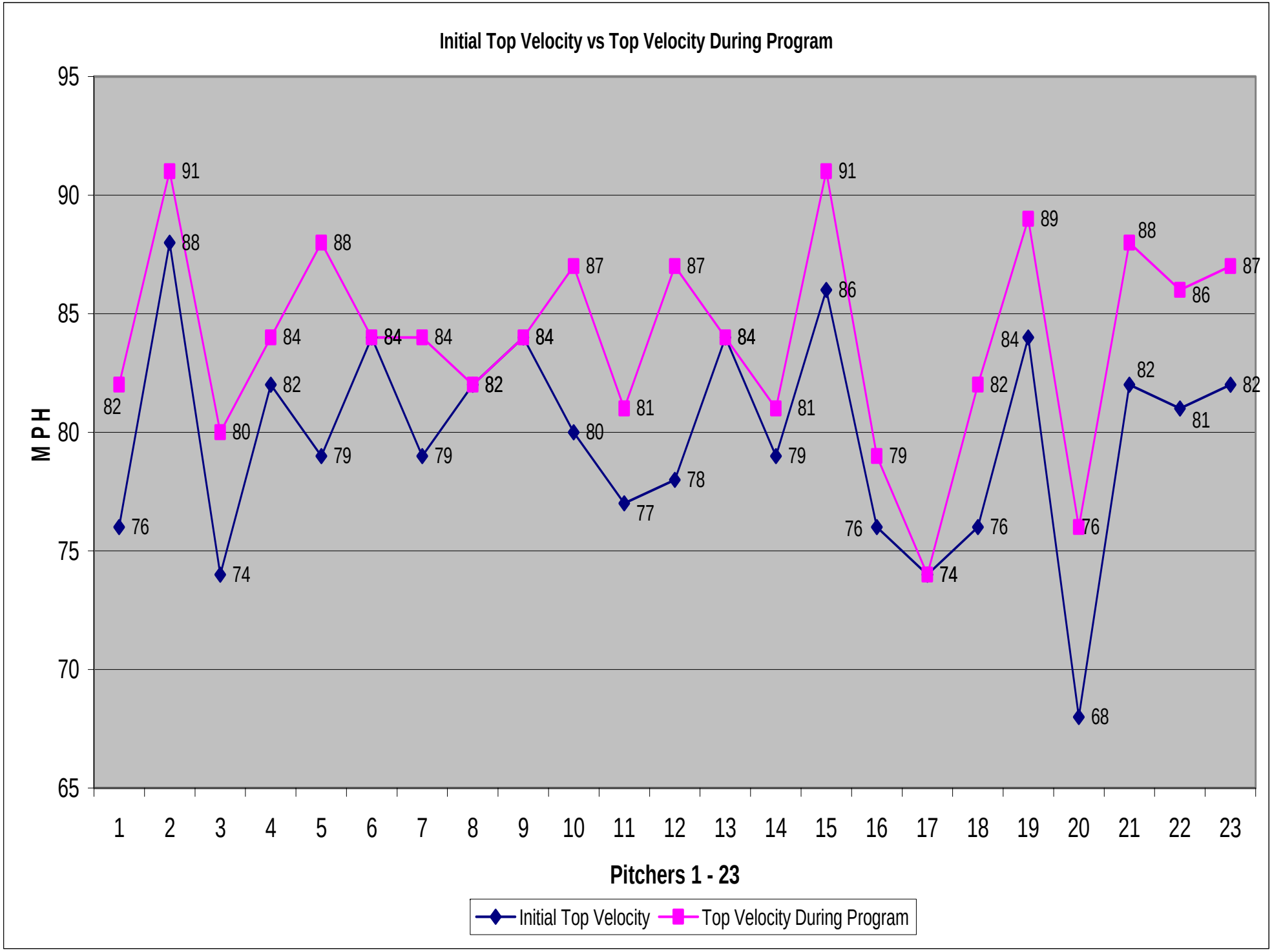
NPA SUV STUDY FINAL DATA

Name: **Pitcher # 1**

DATE	AGE	LEVEL	BUILD	Ball Weight	Velocity from Mound										Top	Average
					1	2	3	4	5	6	7	8	9	10		
11/15/05				6	69	69	71	70	70	69	70	70	69	70	71	70
				4	79	76	79	79	75	79	75	78	77	77	79	77
				5	74	74	74	74	72	75	76	76	75	74	76	74
11/21/05				6	68	70	68	71	71	70	72	71	70	71	72	70
				4	76	78	79	78	78	80	78	79	76	77	80	78
				5	75	76	72	73	74	74	73	75	74	75	76	74
12/6/05				6	71	71	71	72	71	71	72	71	71	73	73	71
				4	79	81	79	81	76	79	81	80	80	83	83	80
				5	78	75	78	70	79	78	73	77	73	80	80	76
12/12/05				6	72	73	72	72	71	72	72	72	72	72	73	72
				4	79	79	78	81	81	80	79	80	82	82	82	80
				5	79	77	79	79	77	77	78	78	78	80	80	78
12/19/05				6	69	70	70	70	70	69	70	72	71	70	72	70
				4	78	76	78	81	79	79	79	79	78	81	81	79
				5	72	77	73	76	73	75	76	73	72	71	76	74
12/26/05				6	70	70	70	71	71	72	72	71	72	72	72	71
				4	83	80	79	79	78	79	80	81	82	80	83	80
				5	78	77	76	76	76	76	75	77	77	76	78	76
1/9/06				6	69	68	69	68	68	68	67	67	70	70	70	68
				4	82	80	81	80	81	82	83	81	81	84	84	82
				5	77	78	76	79	77	79	78	80	79	79	80	78
1/16/06				6	71	72	74	71	72	72	72	74	73	73	74	72
				4	79	81	81	81	80	82	81	81	82	81	82	81
				5	75	79	80	77	77	78	78	78	81	81	81	78
1/23/06				6	71	73	71	71	71	71	72	71	73	72	73	72
				4	82	82	81	81	82	81	81	83	81	84	84	82
				5	78	77	77	76	78	75	78	76	77	77	78	77
2/14/06				6	71	72	72	74	71						74	72
				4	84	82	84	82	83						84	83
				5	79	82	82	78	80	80	81	81	81	80	82	80

# of weeks throwing	# of workouts attended	Best week avg/best top speed	Ball weight	First Weighted Ball Session (AVG)	Last Weighted Ball Session (AVG)	Best Weighted Ball (Top Speed)	Delta from first to last	Delta from first to best	Initial FB Average Velocity	Best Average Velocity during Program	Delta	Initial FB Top Velocity	Best Velocity during Program	Delta
10	12	10/10	6 oz	70	72	74	+2	+4						
			4 oz	77	83	84	+6	+7						
			5 oz	74	80	82	+6	+8	74	80	+6	76	82	+6


Initial AVG Velocity versus Best AVG Velocity During Program
MPH
95
90
85
80
75
70
65
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Pitchers 1 - 23
80 88 78 82 82 83 82 81 84 83 78 83 82 79 88 77 73 79 86 75 85 82 84
74 87 73 79 78 81 77 81 82 80 76 76 82 78 84 75 73 73 84 67 81 80 80
Initial Average Velocity
Best AVG Velocity During Program


Initial Top Velocity vs Top Velocity During Program
MPH
95
90
85
80
75
70
65
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Pitchers 1 - 23
Initial Top Velocity
Top Velocity During Program
82 91 80 84 88 84 84 82 87 81 87 84 81 91 79 74 82 89 76 88 86 87
76 88 74 82 79 84 79 80 77 78 79 86 76 74 76 84 68 82 81 82

Summary of Progress for Pitchers 1 - 23

Initial vs Best Average Velocity Improvement

0 - 1 mph	2 - 3 mph	4 - 5 mph	6 mph and up
4	**11**	**4**	**4**

(number of pitchers per category)

Initial vs Best Velocity Improvement (top speed)

0 - 1 mph	2 - 3 mph	4 - 5 mph	6 mph and up
4	**5**	**5**	**9**

(number of pitchers per category)

Conclusions and Recommendations

To recap the purpose of our research, remember, that it is a preliminary study that should, hopefully, generate enough "buzz" to motivate others to prove, disprove, and/or improve our real velocity findings. These are the study's conclusions and recommendations.

- 80% of a pitcher's real velocity comes from rotational momentum if his kinematic sequencing and energy translation are efficient.
- 20% of a pitcher's real velocity comes from directional momentum if his kinematic sequencing and energy translation are efficient.
- All pitchers have their unique interpretation of a universal biomechanical signature, but, they just look different doing the same things.
- It's easier to alter the timing of this signature than it is to change the signature. Timing is getting a pitcher to the right place at the right time with the right kinematic sequence.
- Biomechanical inefficiencies are minimized when there is less time in a pitcher's weight transfer. With less time, fewer things can go wrong.
- The less functional strength/flexibility a pitcher has, the less time a pitcher should take in his weight transfer. Less time requires less strength.
- Strength training scapular loading for rotational stability is necessary.
- Bio-mechanically training scapular loading is movement and strength recruitment out of sequence which alters kinematic sequencing and energy translation; sub-optimizes real velocity; and, increases risk of injury.
- Pitchers are only as strong as their weakest biomechanical/physical link.
- Fastball velocity is optimized when pitchers match mechanical efficiency with functional strength.

Finally, baseball should increase its effort to research and develop functional "rotational" strength, endurance, and flexibility training protocols for pitchers of all ages and skill levels.

Yours in baseball,

Tom House, PhD

The National Pitching Association