All Stolen Bases Were Not Created Equal

by Ryan King

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Fielding percentage is often criticized for the selection bias introduced by a player's range (good defenders attempt more difficult plays, leading to more errors). A similar issue of selection bias is present in stolen bases. On any given pitch, it is at the sole discretion of the runner if he will steal a base or not. Naturally, the runner will only attempt a stolen base when he believes he has an advantage over the pitcher and catcher.

Ivan Rodriguez caught 46% of base-stealers throughout his career, topping out at a 60% caught stealing rate in his prime and leading the league in CS% in nine seasons. Knowing that stealing against Pudge is little more than a pipe dream for most, only the best baserunners would dare to attempt a steal. If this assumption holds, Rodriguez's CS% would in fact be far more impressive than initially reported due to the level of competition he faces relative to a typical catcher.

To adjust for selection bias in stolen-base attempts, I developed an ELO model. For those unfamiliar, ELO ratings are a method of calculating the relative skill levels of players in zero-sum games. You might recognize ELO from chess rankings or **FiveThirtyEight's sports prediction models**. These ratings can be used to directly estimate the probability of winning a match between two individuals or teams. The ratings change after each match, rewarding a win by an underdog more than a win by the favorite.

On a stolen-base attempt, the runner, pitcher, and catcher all play a major role in the outcome of the play. An argument could also be made for the importance of the fielder receiving the throw, especially when considering the select few who can make tags like this:

That being said, for the sake of this analysis, it is assumed that all tags are equal. Additionally, the ratings of the pitcher and catcher are combined into a single defense rating, leaving a two-sided match between the battery and the baserunner. The defense rating is a simple weighted average, taking 70% of the pitcher's rating and 30% of the catcher's rating. The 70–30 split comes from **Max Weinstein's findings** regarding the impact of pitchers and catchers on the battery's ability to control the running game.

The model uses 1978 as the base year, starting all players at a rating of 1000 and updating after each stolen base attempt. At the end of each season, ratings are mildly

regressed to the mean and then used as the starting value for the upcoming season. 1979 is the first full season, and by no coincidence, Rickey Henderson's rookie year.

	Best Runners by sbELO				
	Name	Year	SB	CS	ELO
1	Willie Wilson	1979	83	9	1178
2	Tim Raines	1983	90	10	1170
3	Willie Wilson	1980	79	6	1166
4	Rickey Henderson	1985	79	7	1157
5	Rickey Henderson	1988	93	12	1157
6	Tim Raines	1982	78	6	1157
7	Willie Wilson	1984	47	5	1155
8	Tim Raines	1986	68	8	1147
9	Willie Wilson	1983	59	6	1146
10	Jack Perconte	1985	31	1	1146
11	Tim Raines	1987	50	4	1144
12	Jacoby Ellsbury	2013	51	2	1143
13	Rudy Law	1983	77	8	1141
14	Ichiro Suzuki	2006	44	2	1140
15	Rickey Henderson	1993	52	8	1139

	Best Pitchers by sbELO				
	Name	Year	SB	CS	ELO
	Pat Rapp	1995	5	15	1224
	Jim Deshaies	1993	7	17	1190
	Rick Mahler	1987	9	15	1184
	Gaylord Perry	1981	2	11	1182
	Frank Castillo	1997	12	14	1178
	Eric Show	1985	15	16	1177
	Pete Redfern	1981	3	12	1172
	John Tudor	1986	7	14	1172
	Rick Reed	1998	7	14	1172
	Rick Langford	1982	5	13	1172
	Mike Witt	1982	2	11	1169
	Justin Verlander	2009	9	15	1169
	Zack Greinke	2017	5	8	1168
	Mike Mussina	2002	6	10	1168
	Hisashi Iwakuma	2014	0	8	1168

	Best Catchers by sbELO				
	Name	Year	SB	CS	ELO
	Ivan Rodriguez	1997	36	41	1242
	Henry Blanco	2000	27	38	1215
	Jason LaRue	2001	27	41	1215
	Ivan Rodriguez	1996	44	45	1203
	Ivan Rodriguez	1998	36	42	1200
	Jody Davis	1986	98	86	1196
	Yadier Molina	2007	22	23	1195
	Bob Boone	1982	46	60	1194
	Ivan Rodriguez	1999	33	38	1194
	Yadier Molina	2012	37	31	1193
	Ron Karkovice	1993	47	56	1191
	Gerald Laird	2007	58	39	1190
	Rich Gedman	1986	53	52	1185
	Tom Pagnozzi	1991	82	70	1184
	Ivan Rodriguez	1992	52	57	1181

Historical Analysis

Stolen bases have been on the decline recently, making it most interesting to look back to the glory days of stolen bases for this metric. Below are the most impressive player seasons dating back to 1979:

	Best Runners by sbELO					Best Pitchers by sbELO					Best Catchers by sbELO				
	Name	Year	SB	CS	ELO	Name	Year	SB	CS	ELO	Name	Year	SB	CS	ELO
1	Willie Wilson	1979	83	9	1178	Pat Rapp	1995	5	15	1224	Ivan Rodriguez	1997	36	41	1242
2	Tim Raines	1983	90	10	1170	Jim Deshaies	1993	7	17	1190	Henry Blanco	2000	27	38	1215
3	Willie Wilson	1980	79	6	1166	Rick Mahler	1987	9	15	1184	Jason LaRue	2001	27	41	1215
4	Rickey Henderson	1985	79	7	1157	Gaylord Perry	1981	2	11	1182	Ivan Rodriguez	1996	44	45	1203
5	Rickey Henderson	1988	93	12	1157	Frank Castillo	1997	12	14	1178	Ivan Rodriguez	1998	36	42	1200
6	Tim Raines	1982	78	6	1157	Eric Show	1985	15	16	1177	Jody Davis	1986	98	86	1196
7	Willie Wilson	1984	47	5	1155	Pete Redfern	1981	3	12	1172	Yadier Molina	2007	22	23	1195
8	Tim Raines	1986	68	8	1147	John Tudor	1986	7	14	1172	Bob Boone	1982	46	60	1194
9	Willie Wilson	1983	59	6	1146	Rick Reed	1998	7	14	1172	Ivan Rodriguez	1999	33	38	1194
10	Jack Perconte	1985	31	1	1146	Rick Langford	1982	5	13	1172	Yadier Molina	2012	37	31	1193
11	Tim Raines	1987	50	4	1144	Mike Witt	1982	2	11	1169	Ron Karkovice	1993	47	56	1191
12	Jacoby Ellsbury	2013	51	2	1143	Justin Verlander	2009	9	15	1169	Gerald Laird	2007	58	39	1190
13	Rudy Law	1983	77	8	1141	Zack Greinke	2017	5	8	1168	Rich Gedman	1986	53	52	1185
14	Ichiro Suzuki	2006	44	2	1140	Mike Mussina	2002	6	10	1168	Tom Pagnozzi	1991	82	70	1184
15	Rickey Henderson	1993	52	8	1139	Hisashi Iwakuma	2014	0	8	1168	Ivan Rodriguez	1992	52	57	1181

Legendary base-stealers Henderson, Tim Raines, and Willie Wilson dominate the list. These players played at the height of stolen bases and each had track-like speed.

The leaderboard for pitchers is more scattered, with no player repeating in the top 15. This is likely a function of the limited sample size in any given season for an elite starting pitcher. Few runners will attempt steals, leading to a larger influence of luck.

The top catcher seasons read like a tribute to Ivan Rodriguez as he appears five times in the top 15. As discussed at the beginning of this article, Rodriguez was truly excellent at throwing out even the best runners. **Yadier Molina** also takes two spots — the only active player on this list.

Flipping these leaderboards upside down, the following are the worst sbELO seasons:

	Worst Runners by sbELO				
	Name	Year	SB	CS	ELO
1	Will Clark	1987	5	17	850
2	Jose Vizcaino	1994	1	11	857
3	Greg Gagne	1994	10	14	863
4	Tony Johnson	1982	3	12	868
5	Ozzie Guillen	1990	12	17	868
6	Warren Morris	2000	6	10	876
7	Oscar Robles	2005	0	8	878
8	Elliott Maddox	1980	1	8	878
9	Jose Offerman	2000	0	7	879
10	Dave Parker	1985	4	11	880
11	Mike Marshall	1985	3	10	882
12	Chet Lemon	1983	0	6	884
13	Steve Garvey	1980	6	11	884
14	Tom Foley	1988	2	7	885
15	Vinny Castilla	1995	1	8	886

Worst Pitchers by sbELO				
Name	Year	SB	CS	ELO
Mark Clear	1984	23	0	821
Chris Young	2007	43	0	833
Bobby Witt	1987	44	2	836
Joe Niekro	1986	23	1	841
Bobby Witt	1986	44	4	844
Mark Clear	1983	33	1	847
Noah Syndergaard	2019	41	3	849
Ted Lilly	2011	34	1	850
Jimmy Anderson	2001	29	0	852
Mike Parrott	1979	34	4	854
A.J. Burnett	2012	38	0	854
Ted Lilly	2003	21	0	862
Jimmy Anderson	2002	19	1	864
Jeff Juden	1998	45	6	864
Mike Scott	1989	37	1	865

Worst Catchers by sbELO				
Name	Year	SB	CS	ELO
Scott Hatteberg	2001	109	10	816
Mike Piazza	2000	105	16	851
Rod Barajas	2012	91	4	858
Tyler Flowers	2016	56	1	860
Mike Piazza	2002	121	21	863
Miguel Montero	2017	56	3	864
Darrin Fletcher	1996	103	14	867
Robert Fick	2001	58	7	871
Mike Stanley	1996	89	11	872
Josh Bard	2007	116	9	875
Ryan Doumit	2010	77	7	881
Hank Conger	2015	41	1	882
Ed Taubensee	1999	93	15	883
Mike Piazza	2006	94	13	883
Jason Varitek	2009	103	11	884

Similar to pitchers, we see no repeat names on the worst runners list. Presumably, anyone having this poor of a season stealing bases would stop getting the steal sign from the manager. Ozzie Guillen's 1990 campaign stands out, in which he was caught 17 times on 29 attempts. It's shocking it took 29 attempts to realize he was better off staying put. Notably, it is not the slowest players who are the worst thieves, but rather the players who are overly aggressive given their talent at stealing bases. Guillen would certainly beat **David Ortiz** in a footrace, though Ortiz knows he has no business stealing second base. Picking your battles is a key component of stealing bases and is heavily rewarded by sbELO.

Unlike the best pitching seasons, the worst pitching seasons begin to see some repeat names: Mark Clear, Bobby Witt, Ted Lilly, and Jimmy Anderson. These pitchers are the most vulnerable to stolen bases and therefore see a much higher volume of attempts. This aligns well with the prior hypothesis that the best seasons were a function of small samples, as we see the effect of sample size on consistency here.

Looking at the catchers, Mike Piazza's name immediately catches the eye, appearing three times on this list. The Hall of Famer was remarkable at the plate but much less so behind it. In his 16 seasons, Piazza compiled just 1.5 WAR on defense, led the league in passed balls twice, and allowed 1400 stolen bases in his career (the second-most in the modern era behind Gary Carter).

It is also of note that no players appear on the lists of both best and worst seasons. This can be viewed as a sign that sbELO is consistent from year-to-year and that players exhibit a true, definable skill in stealing bases or preventing stolen bases.

Many of these top performers for a single season carried this success throughout their careers. The metric sbELO Above Average (EAA) is used to measure sbELO across a player's career. EAA is very simply the total ELO a player has collected over his career less league average for each season he played. That is:

> sbELO Above Average = Career ELO – (1000*Seasons Played)

Below are the players who excelled the most across their careers in sbELO:

	Best Runners by sbELO Above Average				Best Pitchers by sbELO Above Average				Best Catchers by sbELO Above Average			
	Name	Years	ELO	EAA	Name	Years	ELO	EAA	Name	Years	ELO	EAA
1	Rickey Henderson	25	27161	2161	Zack Greinke	14	15380	1380	Ivan Rodriguez	20	22603	2603
2	Tim Raines	22	23846	1846	Chris Carpenter	12	13281	1281	Lance Parrish	17	18539	1539
3	Willie Wilson	16	17504	1504	Mike Mussina	17	18258	1258	Yadier Molina	15	16531	1531
4	Paul Molitor	20	21234	1234	Tim Belcher	14	15240	1240	Bob Boone	12	13417	1417
5	Roberto Alomar	16	17156	1156	Frank Viola	15	16140	1140	Henry Blanco	14	15281	1281
6	Ozzie Smith	18	19027	1027	Tom Glavine	21	22131	1131	Ron Karkovice	12	13006	1006
7	Kenny Lofton	16	16870	870	John Candelaria	15	16097	1097	Tom Pagnozzi	12	12899	899
8	Eric Davis	17	17866	866	Dave Stieb	16	17019	1019	Jim Sundberg	11	11894	894
9	Jimmy Rollins	16	16866	866	Bob Welch	16	17007	1007	Charles Johnson	11	11886	886
10	Barry Larkin	17	17859	859	Jon Garland	12	12933	933	Terry Steinbach	14	14885	885
11	Barry Bonds	20	20857	857	Bret Saberhagen	16	16915	915	Benito Santiago	19	19848	848
12	Stan Javier	16	16793	793	Kirk McCaskill	12	12887	887	Charlie O'Brien	14	14835	835
13	Devon White	17	17787	787	Curt Schilling	18	18883	883	Rick Dempsey	14	14833	833
14	Lance Johnson	14	14777	777	Geoff Zahn	7	7853	853	Steve Lake	11	11817	817
15	Carlos Beltran	17	17775	775	Rick Reuschel	10	10848	848	Jose Molina	14	14777	777

The names topping the list should come at no surprise. Henderson was dominant on the basepaths throughout his 25-season career, claiming the record for the most stolen bases. Meanwhile, Rodriguez is widely regarded as the most difficult catcher to steal on. He is light years ahead of the competition, with 1064 EAA separating him from Lance Parrish in second place. The pitchers on this list may not be as well-known for preventing stolen bases, although looking at career stats, it is readily apparent why they top this list. For example, **Zack Greinke** has allowed just 81

stolen bases in 161 career attempts — a tremendous weapon for an already elite pitcher.

Looking farther down the list, Barry Bonds, The Home Run King*, may seem a bit out of place coming in at 11th. Then again, the combination of a long career, near elite base stealing in his younger years, and savvy base-running as a veteran make for a tremendous career on the base paths. Following a similar trajectory, **Alex Rodriguez** ranks 18th in sbELO Above Average.

sbELO Today: Analyzing the 2019 Season

Focusing in on the 2019 season, the following players excelled in stealing bases or preventing stolen bases:

Best Runners by sbELO

	Name	SB	CS	ELO
1	Adalberto Mondesi	40	3	1098
2	Christian Yelich	28	2	1088
3	Tim Locastro	17	0	1088
4	Jonathan Villar	40	6	1079
5	Mallex Smith	46	6	1073
6	Trea Turner	32	4	1072
7	Jarrod Dyson	30	3	1068
8	Trevor Story	23	3	1065
9	Tommy Pham	25	3	1065
10	Ramon Laureano	13	1	1062
11	Brett Gardner	10	1	1057
12	Shin-Soo Choo	14	1	1056
13	Jose Ramirez	24	4	1055
14	Terrance Gore	13	2	1054
15	Billy Hamilton	21	3	1054

Best Pitchers by sbELO

Name	SB	CS	ELO
Mike Leake	5	7	1127
Andrew Cashner	2	5	1117
Mike Montgomery	7	6	1101
Trevor Richards	3	5	1097
Zack Greinke	2	2	1092
Yonny Chirinos	4	5	1090
Hector Velazquez	0	3	1088
Marcus Stroman	11	8	1086
Glenn Sparkman	1	4	1084
Eduardo Rodriguez	4	4	1084
Masahiro Tanaka	2	5	1081
Ross Stripling	2	3	1080
Jesse Chavez	2	3	1070
Oliver Drake	1	3	1070
Zach Davies	10	6	1069

Best Catchers by sbELO

Name	SB	CS	ELO
J.T. Realmuto	47	38	1162
Roberto Perez	28	18	1075
James McCann	35	14	1074
Christian Vazquez	35	18	1072
Tony Wolters	41	20	1068
Alex Avila	10	10	1066
Tom Murphy	20	12	1056
Mike Zunino	27	15	1056
Caleb Joseph	2	3	1051
Josh Phegley	47	18	1050
Buster Posey	47	16	1047
Manny Pina	19	7	1044
Francisco Cervelli	16	6	1044
Matt Wieters	11	8	1041
Gary Sanchez	33	11	1038

Looking at the best base-stealers, **Jonathan Villar** comes in one spot ahead of **Mallex Smith** despite having fewer stolen bases and the same number of times caught. The logic behind this is that Villar took his 46 attempts against more difficult competition than Smith did in his 52 attempts.

The pitcher leaderboard is again scattered with seasons of low volume of stolen base attempts. **Marcus Stroman** comes in at eighth-best, and faced 19 stolen base attempts, substantially more than any pitcher with a better sbELO. Baserunners' aggressiveness against Stroman was likely caused by his stint in New York with **Wilson Ramos**, a far below average defender, enticing runners to steal.

At catcher, **J.T. Realmuto** earned his Gold Glove award, leading the league in CS% and recording the highest sbELO of any catcher this season by a whopping 87 points.

As for the players who are having nightmares about stolen bases following their 2019 seasons:

	Worst Runners by sbELO					Worst Pitchers by sbELO					Worst Catchers by sbELO			
	Name	SB	CS	ELO		Name	SB	CS	ELO		Name	SB	CS	ELO
1	Rafael Devers	8	7	925		Noah Syndergaard	41	3	849		Kevan Smith	29	1	904
2	Max Kepler	1	4	931		Yu Darvish	24	1	879		Kurt Suzuki	44	4	913
3	Tim Beckham	1	3	931		Kenley Jansen	12	0	896		Mitch Garver	28	3	927
4	Luis Rengifo	2	4	943		Adam Ottavino	14	1	906		Wilson Ramos	94	15	946
5	Charlie Blackmon	2	4	946		Wade Davis	13	0	909		Stephen Vogt	28	3	947
6	Kyle Schwarber	2	3	948		Cory Gearrin	11	0	918		Omar Narvaez	56	9	952
7	Paul DeJong	7	5	949		Reyes Moronta	8	0	924		Chris Iannetta	19	3	952
8	Mike Yastrzemski	2	4	950		Madison Bumgarner	13	1	925		Tomas Nido	32	3	953
9	Daniel Robertson	0	2	951		Miguel Castro	17	1	932		Tyler Flowers	37	9	955
10	Jeff McNeil	4	6	952		Chaz Roe	10	0	935		Grayson Greiner	35	7	958
11	Orlando Arcia	7	5	952		Anibal Sanchez	15	0	935		Austin Barnes	17	3	959
12	Dexter Fowler	6	5	954		Cole Hamels	8	0	936		Russell Martin	22	3	963
13	Jake Bauers	3	3	955		Edwin Diaz	11	0	937		Robinson Chirinos	44	12	963
14	Brian Dozier	3	4	955		Steven Matz	9	2	937		Carson Kelly	28	6	965
15	Steven Duggar	1	3	955		Cal Quantrill	10	0	941		Brian McCann	34	6	969

The battery of Ramos and **Noah Syndergaard** had tremendous difficulty catching runners. Citing framing issues, Syndergaard began to use Tomás Nido as his personal catcher midway through the season. Undoubtedly, the inability to control the running game was a notable issue for the pair. Syndergaard was by far the worst pitcher at controlling the running game in 2019 while Ramos ranked fourth to last in sbELO. Unfortunately for the Mets (as most things are), Nido's far-below-average 953 sbELO doesn't represent much of an upgrade at the position.

Molina is another interesting case. For much of his career, Molina was consistently rated as one of the best catchers at controlling the running game. In fact, he holds two of the top 10 best seasons by a catcher according to sbELO (2007 and 2012).

However, it appears age has maybe finally caught up to him as he ranked just 31st in 2019 with an sbELO of 1019, not too far removed from league average.

Rafael Devers had a breakout season at the plate, but unfortunately for the Red Sox, he didn't like to stay on base. He was caught on seven of his 15 attempts, especially painful when big bats like **J.D. Martinez** or **Xander Bogaerts** would have had the opportunity to drive him in.

Notes and Acknowledgements

- The data for this project was downloaded from Retrosheet. Stolen base and caught stealing values may not align with official statistics as Retrosheet may categorize some of these events differently.

- If you're interested in playing with the data, a basic shiny app can be found **here**.

- This project was inspired by playerELO, an article published here on FanGraphs Community in August of 2019 by Jacob Richey. playerELO takes into account strength of schedule in batter vs. pitcher matchups. His article can be found **here**.

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