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Abstract

Since 2005, Major League Baseball (MLB) has suspended 258 players under its Drug Prevention and Treatment Program. Moreover, the Mitchell Report yielded the names of 89 alleged users of performance-enhancing drugs (PEDs). This documentation enables quantification of the impact of PEDs on player performance. Literature with this goal is limited, and has focused primarily on batters. Some authors have examined Roger Clemens, but there has been no previous work assessing the influence of PEDs on pitchers more generally. We gathered average fastball velocity from Fangraphs.com for all MLB pitchers who threw at least 10 innings in a month between 2002 and 2008 (11,860 player months). Pitchers were deemed to be PED users if they were named as such in the Mitchell Report or suspended by MLB for a positive PED test. Human growth hormone (HGH) usage was tracked separately. We modeled fastball velocity by PED and HGH usage, age, a Starter/Reliever indicator, and several control variables. Using PEDs significantly increased average fastball velocity by 1.074 MPH overall. When PED impact was allowed to vary by pitcher type (Starter/Reliever) and age, its benefits were most substantial later in a player's career. For example, at age 35, the effect of PEDs was 1.437 MPH for relievers and 0.988 MPH for starters. HGH use was significantly negatively correlated with fastball velocity. This suggests disproportional HGH use by injured players hoping to hasten their recoveries, and is consistent with frequent explanations provided in the Mitchell Report.

KEYWORDS: steroids, Major League Baseball, fastball velocity
1 Introduction

On August 30, 2002, Major League Baseball (MLB) team owners and the Major League Baseball Players Association (MLBPA), its players’ union, settled on a labor contract known as the Basic Agreement. This agreement averted a players’ strike by mere minutes, and marked the first time in thirty years that the two sides had arrived at a collective-bargaining agreement without a work stoppage. Added to the agreement very late in the negotiations was an addendum entitled *Drugs of Abuse and Steroids* (Commissioner, 2002), a radical departure from MLB’s previous stance on drug use which prohibited testing players without probable cause. In response to pressure from a meeting with a Senate Commerce Committee earlier in the year, the Basic Agreement called for anonymous testing to take place in 2003 for all professional players. If more than 5% of the players’ samples came up positive for performance-enhancing drugs (PEDs), mandatory testing would be enacted in 2004, without the courtesy of an announced testing date. MLB later confirmed that this threshold had indeed been exceeded: 71-101 players (≈ 5-7%) tested positive for PEDs during the announced round of survey tests in 2003 (MLB, 2003).

Mandatory testing began in July 2004, and positive tests dropped to 1-2% of the 1,183 samples (Bloom, 2005). Although Commissioner Bud Selig expressed confidence in the program and its policy of only releasing the names of players with two positive tests, a Congressional Committee threatened intervention if MLB did not bolster its drug policy. In April 2005, MLB began releasing the names of all players who tested positive for PEDs under its Joint Drug Prevention and Treatment Program. Through May 2009, over 250 major- and minor-leaguers have been suspended for positive PED tests.

The Mitchell Report, a 2007 MLB-commissioned examination of historical PED abuse in the sport, also yielded the names of 89 alleged users of performance-enhancers at the major-league level. The findings were fueled largely by the cooperation of Kirk Radomski, a former employee of the New York Mets who pled guilty to distribution of illegal PEDs in 2007, and seizures from a “raid by New York and Florida law enforcement officials on Signature Pharmacy and several rejuvenation centers” (Mitchell, 2007).

Research investigating the effect of PEDs on performance has been limited. Silver (2006) considered player performance immediately before and after a suspension during the 2005 season. Assuming that a player returning from suspension would not be using PEDs, this could provide an indication of the improvement afforded by using PEDs. Silver found, however, that the impact of suspensions on the conventional measures of walks, strikeouts, home-runs allowed, and earned run average (ERA), adjusted for age, “is tiny and would not be considered statistically significant by any standard test.” A plausible explanation for this result is a lasting
effect of the PEDs on the player for a period after he has stopped using them. A 2008 study produced by the agents of pitcher Roger Clemens addressed whether his late-career surge was unusual enough to support the accusations that he had used PEDs (Hendricks, Mann, and Larson-Hendricks, 2008). The report has been labeled as “not a compelling document” (Bradbury, 2008) and a conspicuous example of sampling bias (Bradlow, Jensen, Wolfers, and Wyner, 2008) for including in its control group only pitchers who also had atypical performances late in their careers. To the best of our knowledge, no other published work has assessed the impact of PEDs on pitching performance. Schmotzer, Switchenko, and Kilgo (2008) however, made “the first attempt to quantify the overall effect of PED abuse on offensive performance in baseball.” The authors examined age-adjusted runs created per 27 outs (ADJRC27) for the seasons of players listed as “PED-influenced” in the Mitchell Report. They found that steroid use for hitters mentioned in the report had a statistically significant effect on ADJRC27 across their model specifications.

We extend the literature which examines the influence of PEDs on pitching performance by analyzing an expanded pool of players: those mentioned in the Mitchell Report, as well as those suspended for positive tests by MLB. We adopt a classification rule for “PED-influenced” which is motivated by Silver (2006), but which improves upon both his method and that followed by Schmotzer et al. (2008). Moreover, we model a neglected variable to gauge pitching performance that we believe is more responsive to use of performance-enhancers than traditional measures such as ERA, winning percentage, or even walks plus hits per inning pitched (WHIP). Our inquiry is the first to examine the quantitative impact of PED use on pitching performance in MLB as measured by average fastball velocity.

The paper is organized as follows: In Section 2 we describe the pitching data used in our analysis and how PED users were identified from multiple sources. We also motivate the explanatory variables used to model average fastball velocity. Section 3 presents the results of several models and the estimated impact of PED use on average fastball velocity. Section 4 provides a discussion of our findings. In Section 5, we offer some concluding remarks.

2 Data and Methods

2.1 Pitching Performance Data

Fangraphs Baseball publishes game-level pitching data gathered by Baseball Info. Solutions on its website (FanGraphs, 2009). The website’s data on average fastball velocity (AFV), percentage of total pitches thrown that are fastballs (Fastball.Percent), innings pitched (IP), home-runs allowed (HR), walks allowed (BB),
and strikeouts (Ks) are available on a month-by-month basis, and are complete back to the 2002 season. We recorded whether the data came from a starting pitcher or relief pitcher; if a pitcher split time between the two roles, we labeled him a starter if at least half of his appearances in the month were listed as games started. We restricted our analysis to pitchers who threw at least 10 innings in a month between 2002 and 2008, inclusively, yielding a total of 11,860 player months.

We also created a “knuckleballer” variable to account for the aberrantly slow fastballs, and genuinely distinct approach to pitching, of two pitchers: Tim Wakefield and Steve Sparks (note that since neither Wakefield nor Sparks were ever found to be PED users, accounting for these knuckleball specialists lessened the estimated effect of PEDs on AFV). An alternative approach would have been to omit Wakefield and Sparks from the data altogether. We have verified that both approaches yield essentially identical results.

Building on work in The Bill James Baseball Abstract (James, 1982), baseball researchers have found that hitting performance as a function of age exhibits a concave-down parabolic shape, with maximum performance occurring, roughly, at age 26 or 27 (Silver, 2006). Preliminary work, from a sample of pitchers who threw at least 100 fastballs in both 2007 and 2008, has suggested that fastball velocity also follows a similar pattern (Kalk, 2008). To control for this performance indicator, we recorded age by following the approach of the Baseball Prospectus team, that is, using a player’s age on July 1 as their age for that season. All player birth dates were gathered from Baseball-Reference.com.

We included a “post Tommy John” variable to indicate all pitching months after an ulnar collateral ligament reconstruction surgery, also known as Tommy John surgery, had been performed. This procedure is almost always conducted in response to a torn labrum’s debilitating effect on fastball velocity, suggesting that a player who experiences damage to his labrum may exhibit unusual fastball-throwing tendencies. Anecdotal evidence also suggests that pitchers who return from Tommy John surgery immediately experience a positive bump in velocity. We thus felt that, in order to adequately model AFV, it was important to control for the potentially unusual career paths followed by pitchers who undergo this disruptive surgery, as their velocities may behave in an atypical way.

### 2.2 Drug Use Data

From the Mitchell Report we recorded the names of all players who were implicated for using PEDs by one or more of: their own confessions to investigators; the testimony of convicted supplier Kirk Radomski; statements from Gene Orazo, chief operating officer of the MLBPA; accounts from former trainer Brian McNamee;
physical evidence from pharmaceutical raids; and verified journalistic accounts in the wake of these raids. We then cross-referenced these names with those for whom 2002-2008 pitching data qualified them to be part of our analysis. This process yielded 23 pitchers. The Mitchell Report distinguished between PED use in the form of steroids and human growth hormones (HGH) for all pitchers in the data. We therefore also made this distinction, with the intention of tracking steroid use and HGH use separately. There were 12 pitchers classified as steroid users, 16 pitchers deemed to be HGH users, and there was evidence against 5 pitchers for using both HGH and steroids.

Furthermore, we gathered the names of all players suspended by MLB under its drug programs since 2005 (the first year the names were made public) from official MLB press releases and ESPN.com. In all, 16 pitchers with sufficient major-league experience were suspended for positive PED tests, including Ryan Franklin, who was also named in the Mitchell Report. We were able to omit positive tests for recreational drugs and stimulants, since they were deemed distinct from PEDs by the program. The Drug Treatment and Prevention Program in MLB contains a “non-exhaustive list” of 51 different steroids as well as HGH under its list of banned PEDs (MLBPA, 2005). Unfortunately, the specific substance within the performance-enhancers category for which each player tested positive was not officially disclosed with consistency until 2008. Thus, no player suspended before 2008 could be classified as either a distinct user of steroids or HGH.

In view of this, we created a steroids variable using the union of all players suspended by MLB for a positive PED test and those explicitly named in the Mitchell Report as steroid users (27 pitchers). This means that some players who used HGH exclusively, and were suspended by MLB, were unknowingly misclassified as steroid users for the purposes of this analysis. Liu, Bravata, Olkin, Friedlander, Liu, Roberts, Bendavid, Saynina, Salpeter, Garber, and Hoffman (2008) find, in a systematic review, that HGH “may not improve strength; in addition, it may worsen exercise capacity and increase adverse effects.” Moreover, the work on offensive performance by Schmotzer et al. (2008) suggested that “HGH has no effect on performance” in baseball. Hence, we believe that the only risk we run by potentially misclassifying some positive tests for HGH is a small attenuation of the impact of steroid use on AFV. We return to this point, and to other facets of our analysis which may render our estimation of the impact of steroids on AFV conservative, in Section 4. We also created an HGH variable using the 16 pitchers who were named only, explicitly, as HGH users in the Mitchell Report.

The 27 pitchers in the steroids group corresponded to 367 player months, whereas the 16 HGH pitchers comprised 246 player months. One approach might label all of these as steroid months and HGH months, respectively (Approach #1), with 58 months falling into both the steroids and HGH groups. Another approach,
analogous to the one adopted by Schmotzer et al. (2008), would only label as steroid/HGH months those within seasons specifically mentioned in the Mitchell Report, or in which a player was suspended by MLB (Approach #2). This much stricter classification rule resulted in 69 player months in the steroids group, 74 player months in the HGH group, with 31 player months in both groups.

There are flaws with both of these approaches. By essentially assuming that a PED user is caught in his only instance of abuse, Approach #2 strikes us as very optimistic, and inadequate. On the contrary, Approach #1 labels all months after a suspension as steroid months, disregarding the heavy incentive for a player to avoid a repeat positive test. We employ yet another approach (Approach #3), in which it was assumed that players identified as steroid users were so from their entrance into the data but, following Silver (2006), that after they have been suspended they ceased to use. We depart from Silver (2006) in that, if a player is suspended during a season, we continue to mark any subsequent months in that season as steroid-influenced. We feel that it is unwise to assume that the benefits of steroid use immediately end once abuse of the drug stops. For players who were not suspended by MLB, but were named in the Mitchell Report, we assume that they terminate their use of steroids and/or HGH at the time of the report’s release. In essence, we treated the Mitchell Report as a “suspension” which occurred in December 2007. With this classification rule, we obtained 309 observations in the steroids group and 226 observations in the HGH group, with 58 observations falling into both groups. Even Approach #3 risks misclassifying certain non-steroid months, but this could only have diminished the estimated effect of steroids on AFV. We feel that Approach #3 mitigates, as much as possible, the chance of misclassification.

2.3 Model Specifications

In all models, AFV was the response variable of interest. AFV is an accurate indicator of arm strength, as indicated by scientific findings that shoulder and elbow musculature contribute positively to pitching velocity (Stodden, Fleisig, McLean, and Andrews, 2005). We believe that AFV is a better gauge of PED use than traditional measures, such as ERA or winning percentage, which are more appropriate for describing broad contribution to a team rather than for changes in an individual’s level of physical strength. For example, it is well-known that ERA is affected by factors outside a pitcher’s ability, such as fielding, and that run support is crucial to a high winning percentage (Bradlow et al., 2008).

Of primary importance are the estimated effects of steroids and HGH on AFV obtained by using Approach #3, but for robustness, we also present the results assuming Approach #1 or Approach #2. Moreover, we investigated the hypothesis.
that the rate of change of fastball velocity associated with an increase in age has a different magnitude for steroid and non-steroid users. To do so, we specified models which included interaction between age and the steroids variable. Finally, we examined whether the impact of steroid use on AFV was different depending on whether the pitcher was a starter or a reliever.

We considered several control variables: Month was used since we expected velocity to gradually increase until the summer months, and then, perhaps, to decrease again as pitchers become fatigued later in the season. Year (2002, 2003, ..., 2008) was included to investigate whether there has been any drift in fastball velocity over this period. We incorporate the Fastball.Percent variable to account for the potential tendency of pitchers with strong fastballs to favor this pitch. Other controls included IP and the defense-independent pitching statistics (DIPS) Ks, HR, and BB, which are more uniquely determined by pitchers than, say, ERA, so they are subject to less variability across seasons (Woolner and Perry, 2006).

3 Results

The mean AFV was 90.19 miles per hour (MPH) with a standard deviation of 2.97 MPH. Starters threw significantly slower than relievers (89.54 vs. 90.90 MPH, p<2e-16). Pitchers threw significantly slower in April (89.79 MPH) compared to every other month (May: 90.07 MPH, p=0.0035; June: 90.25 MPH, p=1.75e-06; July: 90.29 MPH, p=1.33e-07; August: 90.33 MPH, p=6.62e-09; September: 90.37 MPH, p=9.10e-10). Pitchers also threw slower in the first year contained in the data (2002: 89.83 MPH) compared to every subsequent year, with the difference attaining statistical significance at the 5% level from 2004 onwards (2003: 89.96 MPH, p=0.18; 2004: 90.03 MPH, p=0.041; 2005: 90.16 MPH, p=0.0012; 2006: 90.45 MPH, p=8.02e-10; 2007: 90.21 MPH, p=0.00014; 2008: 90.66 MPH, p<2e-16). The differences associated with month of the season, year, and the Starter/Reliever indicator remained statistically significant after including various control variables, and in our final (interaction) model discussed below.

Boxplots of AFV as a function of age are presented in Figure 1. The velocity trend is decreasing, and it appears roughly linear over most of the age range. One can see some curvature in the graph at younger and older ages, and we found that a cubic term in age was significant (p=3.78e-06). We point out, however, that the distinction between a quadratic and cubic polynomial in age seemed small when graphed (see Figure 2). For the remainder of this paper we adopt a cubic polynomial in age, but our results are not sensitive to this choice and would be essentially unchanged by proceeding with a quadratic age polynomial instead.
Figure 1: Average monthly fastball velocity by age for pitchers in 2002-2008

Figure 2: Comparison of quadratic (dashed) and cubic (solid) polynomial in age.
We now turn to the results for the HGH and steroids variables. The HGH variable produced mixed results depending on the model specification and Approach (#1, #2, or #3) taken. In the unadjusted univariate model, pitchers indicated as HGH users threw significantly slower than non-HGH users using Approach #1 and #3, and insignificantly slower using Approach #2:

Approach #1: 90.21 MPH (non-HGH) vs. 89.30 MPH (HGH), p=2.2e-06
Approach #2: 90.19 MPH (non-HGH) vs. 90.11 MPH (HGH), p=0.82
Approach #3: 90.20 MPH (non-HGH) vs. 89.41 MPH (HGH), p=7.33e-05

Pitchers found to be HGH users were, however, 4.73-5.01 years older on average (depending on the approach) than non-HGH users. After adjusting for age with a cubic polynomial, HGH usage was still found to be negatively correlated with AFV using Approach #1 and #3, but now in an insignificant manner, while using Approach #2 led to a positive and significant result at the 5% level:

Approach #1: HGH coefficient = -0.063 MPH, p=0.74
Approach #2: HGH coefficient = 0.76 MPH, p=0.023
Approach #3: HGH coefficient = -0.0046 MPH, p=0.98

The results for the steroids variable were much more consistent. In the unadjusted univariate model, pitchers deemed to be on steroids threw significantly harder than non-steroid users when adopting Approach #1 and #3, and with Approach #2 the effect was marginally significant:

Approach #1: 90.16 MPH (non-steroid) vs. 90.94 MPH (steroid), p=8.54e-07
Approach #2: 90.18 MPH (non-steroid) vs. 90.87 MPH (steroid), p=0.054
Approach #3: 90.17 MPH (non-steroid) vs. 90.85 MPH (steroid), p=6.56e-05

After including a cubic polynomial in age, the effect of steroids increased, and was statistically significant, across all three approaches:

Approach #1: steroids coefficient = 1.27 MPH, p<2e-16
Approach #2: steroids coefficient = 1.06 MPH, p=0.0020
Approach #3: steroids coefficient = 1.21 MPH, p=1.82e-13

These steroids coefficients held roughly constant, and significant, across several model specifications. In our largest model without interactions, we modeled AFV by the steroids variable, the HGH variable, a cubic polynomial in age, a Starter/Reliever indicator, a knuckleballer indicator, a post Tommy John indicator,
month of the season, year, the Fastball.Percent variable, IP, HR, BB, and Ks. All control variables were significant at the 5% level. Once again, for this model, the results for HGH were not entirely in agreement, with Approach #1 and #3 giving significant negative coefficients, and Approach #2 showing an insignificant effect:

Approach #1: HGH coefficient = -0.45 MPH, p=0.0051
Approach #2: HGH coefficient = 0.26 MPH, p=0.42
Approach #3: HGH coefficient = -0.39 MPH, p=0.022

Using steroids, however, increased AFV in a significant way regardless of the approach used:

Approach #1: steroids coefficient = 1.07 MPH, p=3.91e-16
Approach #2: steroids coefficient = 0.85 MPH, p=0.0096
Approach #3: steroids coefficient = 1.07 MPH, p=1.02e-13

In our final model, we allowed the effect of the steroids variable to vary by pitcher type (Starter/Reliever) and age. Figure 3 displays a graphical representation of this model, using Approach #3, for a non-knuckleball specialist in July 2008, who is not on HGH, has not had Tommy John surgery, and assuming mean values for Fastball.Percent, IP, HR, BB, and Ks. The benefits of using steroids were most substantial later in a pitcher’s career. For example, at age 25, the effect of steroids, using all three approaches, was:

Approach #1: Relievers: 0.46 MPH, p=5.00e-07; Starters: -0.026 MPH, p=0.84
Approach #2: Relievers: 1.22 MPH, p=0.22; Starters: 0.039 MPH, p=0.98
Approach #3: Relievers: 0.48 MPH, p=5.13e-07; Starters: 0.30 MPH, p=0.052

At age 35, the effect of steroids was:

Approach #1: Relievers: 1.56 MPH, p<2e-16; Starters: 1.08 MPH, p<2e-16
Approach #2: Relievers: 1.77 MPH, p=1.64e-06; Starters: 0.59 MPH, p=0.029
Approach #3: Relievers: 1.26 MPH, p<2e-16; Starters: 1.08 MPH, p<2e-16

The widening of the gap between the steroids and non-steroids groups as age increases is also evident by examining Figure 3. We note that the interaction term between the steroids variable and the Starter/Reliever indicator was not significant at the 5% level in any of the approaches (p=0.11 in Approach #1, p=0.063 in Approach #2, and p=0.59 in Approach #3). This can be seen in Figure 3 as well, by comparing the discrepancy between steroid and non-steroid relievers to the discrep-
Figure 3: Interaction model between steroids and, both, age and Starter/Reliever.

ancy between steroid and non-steroid starters, and noticing that these two quantities are similar at any fixed age. Finally, as in the model with no interaction, HGH use was significantly negatively correlated with AFV using Approach #1 and #3, and insignificantly related to AFV using Approach #2:

Approach #1: HGH coefficient = -0.47 MPH , p=0.0045
Approach #2: HGH coefficient = 0.24 MPH , p=0.48
Approach #3: HGH coefficient = -0.41 MPH , p=0.017

4 Discussion

We have found that the behavior of fastball velocity with respect to age for pitchers in our sample did not exhibit a clear concave-down curvature as has been commonly observed for offensive performances and in the preliminary findings of Kalk (2008) on fastball speed. One might have expected to see a steady improvement in observed velocity for young pitchers, settling into a peak for pitchers in their late
20s before a steady decline into their final playing years. Instead, what our data show is an immediate downward slope from the highest values which are observed for the youngest pitchers in MLB. This is almost surely due to a selection bias: very young pitchers will only be called up to the majors if they are phenomenally talented. For example, consider Seattle’s Felix Hernandez, who entered MLB at age 19 and had an AFV of 95.19 MPH in our data. One might plausibly conjecture that a 19 year-old pitcher with a 90 MPH fastball is not very likely to enter MLB, whereas a 25 year-old with the same AFV is much more likely to be there. This may be due to increased experience or the development of a repertoire of pitches. Thus, our results do not necessarily contradict the concave down curvature for individual pitchers.

In any study of the effects of PEDs on performance, a major difficulty will be correctly classifying players into the “treatment” group or the “control” group. No method will ever achieve this perfectly, but we have described three possible approaches to doing so with the data used in this paper. In Section 3, we presented the results from all three approaches, but we feel that Approach #3 is the one which risks the least misclassification. We believe that it is reasonable to assume that a player will cease to use steroids after being suspended (or mentioned in the Mitchell Report) but that the effect of these steroids will be experienced beyond this point. We used the end of the season in which the player was suspended as a natural breaking point, although others might also be considered (e.g. a fixed number of months after the suspension). It is impossible to know for precisely how long in advance of a suspension the player in question abused steroids. We feel that, under any reasonable assumptions about the steroids and non-steroids groups, misclassification caused by assuming that all previous seasons were steroid-influenced would lead to our results underestimating the true effect of steroids on AFV. Indeed, we think that our results might further be conservative for the following three reasons:

1. All pitchers suspended by MLB were used to create our steroids variable, even though some of these pitchers might only have been using HGH (hypothesized, and shown, to have no positive impact on AFV).
2. Some steroid users might have successfully elevated their below-average fastball velocity to an adequate level in order to make it into MLB, and our data. Such pitchers would otherwise have gone unobserved, and will not throw any harder than an average non-steroid major league pitcher. They will thus dilute the true effect of steroids on AFV.
3. Some steroid users may not have been caught by MLB or exposed in the Mitchell Report. These individuals would have been included in the non-steroid group, presumably increasing its AFV, and thereby shrinking the disparity with the steroid group.
From Approach #3, the estimated overall impact of steroid use on AFV was an increase of 1.07 MPH, which carries considerable practical significance. To put the magnitude of this effect in perspective, a pitcher in the 35th percentile of AFV would be elevated to the median, and one at the median would be raised to the 65th percentile. The effect becomes even more dramatic with age, for relievers in particular, where a 35 year-old could have moved up an entire quartile by using steroids.

Approach #2 provided much smaller sample sizes for the steroids and HGH groups than the other two approaches. This generally led to much less significant results. Moreover, the magnitude of the effect of steroids on AFV were smaller using Approach #2 compared to the other approaches. For example, consider the model which accounts for age, where the steroids coefficients are 1.27, 1.06, and 1.21 for Approach #1, #2, and #3, respectively, or the largest model without interactions, which gives steroids coefficients of 1.07, 0.85, and 1.07 for Approach #1, #2, and #3, respectively. In our final model, it becomes clear that this disparity is especially large for older starters (for relievers, the magnitude is largest using Approach #2). At age 35, the effect of steroids for starters was estimated to be only 0.59 MPH using Approach #2, almost 0.5 MPH less than with the other approaches. Missing from the steroids group in Approach #2 are the 32 months of Roger Clemens’s career between 2002 and 2007, since no first-hand accounts of his steroid use after the year 2001 were given in the Mitchell Report. In these months, Clemens recorded an AFV of 91.89 MPH, more than 1.5 MPH above the overall mean AFV (placing him in the 72nd percentile), and this at the end of his career. Including these months in the control group is the main reason for the diminished effect of steroids using Approach #2, particularly for older starters. Nonetheless, estimates for the impact of steroids on AFV are significant and positive across all specifications, even under Approach #2.

The results of our study are less conclusive when it comes to the relationship between HGH use and AFV. Approach #1 and #3 found a statistically significant negative impact of HGH, while Approach #2 found a statistically insignificant positive relationship between HGH and AFV. The preponderance of evidence, however, seems to indicate a negative correlation between the two variables, that is, pitchers who used HGH tended to have less velocity on their fastballs. But this is not the whole story. Rather than suggesting that HGH negatively impacts AFV, we return to the Mitchell Report, which commonly cites a player’s desire to recover quickly from an injury as the reason for his decision to use the substance. For instance, when detailing the drug use of Kent Mercker, the Report states that “Mercker had recently undergone surgery and, according to Radomski, was seeking human growth hormone because he believed it might accelerate his recovery.” The Report also describes how, after injuring his elbow, six-time All Star Kevin Brown...
“called Radomski again and asked for human growth hormone.” Further, pitcher Andy Pettitte has publicly admitted that the accusations against him in the report were factual, saying “In 2002 I was injured. I had heard that human growth hormone could promote faster healing for my elbow. I felt an obligation to get back to my team as soon as possible.”

The perception of HGH as an expedient for injury recovery suggests that a pitcher who uses the drug is more likely to be suffering from a physical injury which negatively impacts his pitching effectiveness. These players, with or without the aid of HGH, are likely to experience a drop in fastball velocities, and there is simply no way at the moment to know whether this drop would be even greater without the use of HGH.

The findings that pitchers did not throw as hard in April as in other months, and that starters did not throw as hard as relievers were not surprising. The fact that AFV had increased by 0.83 MPH in the last 6 years, however, was surprising. Since 2002, AFV has only decreased once. We can only speculate as to what may have caused this occurrence (if, indeed, it is a real phenomenon), and it will be interesting to see whether the trend continues.

5 Concluding Remarks

In our investigation of PED use, we chose to model AFV instead of more commonly used statistics, like winning percentage, ERA, or WHIP. The difficulties associated with winning percentage and ERA are well documented. We feel that AFV is more responsive to steroid use than WHIP, since WHIP is often heavily dependent on the quality of a pitcher’s off-speed pitches and the location of all of his pitches, including his fastball.

We found a consistent positive impact of steroid use on AFV. The effect of steroids held under our preferred Approach #3, but also under alternative approaches for classifying observations as steroid-influenced. This seems to indicate that AFV shows a robust response to steroid use in professional baseball. Although not as clear as the findings for steroid use, HGH use seems to be negatively correlated with fastball velocity. We conjecture that this is due to a predominance of injured players using HGH to hasten their recoveries, which is consistent with frequent explanations provided in the Mitchell Report. Hence, we believe that a more detailed control variable for a player’s injury history would be very useful in determining the true impact of HGH on AFV. In addition to this, more detailed data on MLB suspensions will help correctly distinguish players suspended for steroid use from those only using HGH.
References