Training With Lighter Baseballs Increases Velocity Without Increasing the Injury Risk

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Background: Pitch velocity has become an increasingly popular metric by which pitchers are graded and compared. Training programs that utilize weighted balls have been effective in increasing velocity but at the cost of an increased injury risk. No studies have evaluated training with lighter baseballs with regard to increasing pitch velocity and the injury risk.

Purpose/Hypothesis: The purpose of this study was to determine whether a training program utilizing lighter baseballs could increase fastball velocity without increasing the injury risk to participants. We hypothesized that a training program with lighter baseballs would increase fastball velocity but not increase the injury risk.

Study Design: Case series; Level of evidence, 4.

Methods: All baseball pitchers who participated in a 15-week program at a single location, with the same coaches, and aimed to improve pitching mechanics and increase velocity were included. The training program was broken down into 3 phases, and each participant went through the same program. Lighter baseballs (3 and 4 oz) and standard baseballs (5 oz) were utilized as part of the training program. Weighted (heavier) balls were not used. Velocity was measured at 4 time points throughout the program with the pitcher throwing 5 fastballs using a standard 5-oz ball at maximum velocity (sessions 3, 10, 17, and 25). Injuries for all players were recorded throughout the entire program.

Results: A total of 44 male pitchers aged 10 to 17 years (mean age, 14.7 ± 1.8 years) completed the training program and were available for analysis. No pitcher sustained a shoulder or elbow injury during the course of the training program. Fastball velocity increased by a mean of 4.8 mph (95% CI, 4.0-5.6 mph) ($P < .001$). Overall, 43 of 44 players (98%) had an increase in fastball velocity over the course of the program.

Conclusion: A 15-week pitching training program with lighter baseballs significantly improved pitching velocity without causing any injuries, specifically to the shoulder or elbow. Lighter baseballs should be considered as an alternative to weighted baseballs when attempting to increase a pitcher's velocity.

Keywords: velocity; baseball; shoulder injury; elbow injury; weighted balls; lighter balls

Injury rates in baseball players of all levels have been on the rise in recent years.[2,4-6,8,14] Many injury prevention programs focused on modifiable risk factors have been implemented in an effort to quell this rise in injury rates and include an emphasis on pitch count limits, minimum number of days of rest between starts, and many other factors.[4,7,13] Unfortunately, one of the most significant risk factors for an injury in baseball players is also a metric that is used to measure and evaluate a pitcher. This risk factor is pitch velocity.[3]

Pitch velocity is one of the most commonly measured and valued pitching performance metrics in all of baseball. Since the introduction of the radar gun to baseball in the 1960s, pitch velocity has become an integral part of evaluating pitching talent. As such, many pitchers strive to continually increase their fastball velocity in an attempt to pitch more effectively. There are many ways that pitchers attempt to increase their velocity. One of the most common methods that pitchers have used to increase their velocity in recent years is the use of weighted (heavier) baseballs.[1,10,12] A standard, regulation baseball weighs 5 oz, and many velocity enhancement programs have utilized weighted (heavier) baseballs up to 32 oz in an attempt to increase fastball velocity.[1,11] Heavier baseballs are theoretically thought to enhance throwing mechanics, as well as arm strength and speed, thereby leading to enhanced pitch velocity. While pitch velocity is a kinetic chain phenomenon that begins from the ground up, enhancing upper extremity mechanics may have a significant role in increasing velocity. While many of these weighted baseball programs have been effective in increasing fastball velocity, some have also caused a significant number of injuries to the pitchers participating in the programs.[12] Interestingly, none of these programs have critically evaluated the use of

lighter baseballs in regard to the injury risk and as a means of increasing pitching velocity. Velocity is determined by the distance that an object travels, divided by the time that it takes to progress through that distance. Theoretically, if training can focus on increasing the speed of the arm and not be affected by a small increase in the weight of the ball from 3 or 4 oz to the standard 5 oz, the velocity of the ball can be increased.

Therefore, the purpose of this study was to determine if a pitching training program utilizing lighter baseballs could increase fastball velocity without increasing the injury risk. We hypothesized that a training program with lighter baseballs would increase fastball velocity without causing injuries to the participants.

METHODS

Male baseball pitchers aged between 10 and 17 years were eligible to participate in the velocity training program. Players and parents were asked about injury history, current injury status, and prior surgery by the coach running the program (T.R.A.). They also underwent a brief screening examination by 1 author (B.J.E.) before participation. Players were excluded if they were currently injured or had undergone recent surgery and were not cleared to return to throwing at the start of the program. An injury that was resolved at the time that the program began did not exclude pitchers from taking part in the program. All players (and their legal guardians) signed an assent/consent form to participate in the program and to have their data analyzed. All data were collected by the facility where the program was run as standard of care and were deidentified before sharing for analysis. The study was considered exempt from institutional review board approval. The velocity-based training program was designed and monitored by one of the authors (T.R.A.), who is a former professional baseball pitcher.

The program was divided into 3 phases (a total of 25 training sessions, which will be referred to as "sessions") and was run out of a single facility, with all players going through the same scheduled sessions. The program is detailed in Appendices 1 to 6. The training sessions took place in the winter months. Players were asked after each session if they had sustained any injury to any body part. An injury was defined as any issue that caused the player to

miss time participating in the program (to leave a session early or miss a session). The total duration of the training program was 15 weeks. All participants were divided into 3 groups based on age: group 1, 10-12 years; group 2, 13-14 years; and group 3, 15-17 years. Only 1 group trained on a given day, such that players in an age group trained together. Group 1 trained on Mondays and Fridays, group 2 trained on Tuesdays and Saturdays, and group 3 trained on Wednesdays and Sundays. Hence, coaches who were training the athletes were able to give each group the same amount of attention and put each group through the same exact routine. No group had more than 2 sessions per week during the program. All groups went through the same routine at each session.

Pitch velocity was tested at 4 time points during the program using a radar gun (JUGS Sports): sessions 3, 10, 17, and 25. Pitchers were instructed to throw 5 fastballs at maximum effort after having warmed up. Pitch velocity was recorded for each pitch.

Statistical Analysis

For each time point, mean velocity was calculated using the 5 velocity measurements obtained. Data normality was evaluated using the Kolmogorov-Smirnov test, and parametric and nonparametric tests were used as appropriate depending on data normality. Velocity data for each time point were compared with baseline using the paired Student t test and related-samples Wilcoxon signed rank test. All analyses were performed with Excel 16 (Microsoft) and SPSS 25 (IBM).

RESULTS

In total, 48 players were involved in the program. There were 4 players who were excluded from the analysis: 1 because no baseline velocity data were available, as he did not attend the initial session; 1 because he did not complete the program, as he sustained a broken ankle while playing basketball at home; 1 because he moved before completion of the program; and 1 because he experienced biceps tendon soreness after participating in back-to-back showcases before the training program was completed against recommendations. Hence, 44 male pitchers aged 10 to 17 years (mean age, 14.7 ± 1.8 years) completed the training

TABLE 1
Change in Velocity Over the Course of the
Training Program[a]

Time Point	Velocity, Mean ± SD, mph	Velocity Change from Baseline, Mean (95% CI), mph	P Value
Baseline (session 3)	65.4 ± 8.2	NA	NA
Session 10	66.3 ± 8.0	0.9 (0.0-1.7)	**.045**
Session 17	66.9 ± 8.3	1.5 (0.4-2.6)	**.007**
Session 25	70.2 ± 8.5	4.8 (4.0-5.6)	**<.001**

[a]Bold values indicate statistically significant changes in velocity. NA, not applicable.
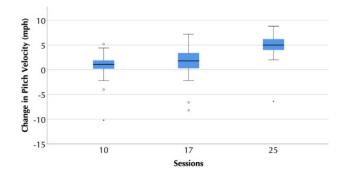

Figure 1. This boxplot shows the change in velocity (in mph) after 10, 17, and 25 sessions. Boxes represent the interquartile range, with the central line representing the median. Whiskers represent the furthest nonoutlier, nonextreme value. Outliers, those values between 1.5 and 3 box lengths from either end of the box, are denoted with circles. Extreme values, those values more than 3 box lengths from either end of the box, are denoted with asterisks.

program and were available for analysis. No player sustained a baseball-related injury during the training program.

Velocity significantly and sequentially increased over baseline at all time points (Table 1). The mean change in velocity by the end of the program was 4.8 mph (95% CI, 4.0-5.6 mph) (P < .001). By the end of the program, velocity was increased for all but 1 player; that is, velocity increased for 43 of 44 or 98% of players (Figure 1).

DISCUSSION

Fastball velocity is an important metric used by many to evaluate and grade baseball pitchers. While velocity itself is a risk factor for injuries, velocity enhancement programs have also been implicated in injuries because of the use of weighted (heavier) baseballs. Our hypotheses were confirmed, as the use of lighter baseballs (3 and 4 oz) was effective in increasing fastball velocity but did not cause any injuries in the pitchers who participated in the program.

The use of weighted (heavier) baseballs to enhance pitching velocity has become a subject of debate in the baseball community among players, coaches, training staff, and team physicians.[1,9] Some authors have found a significant increase in pitching velocity when using weighted (heavier) baseballs to train their pitchers, while others have seen no change in velocity.[10,12] Fleisig et al[9] conducted a study to evaluate the kinetics and kinematics of weighted baseball exercises. The authors included 25 high school and college-level pitchers and had the participants use 4-, 5-, 6-, and 7-oz baseballs that they threw off a mound and with a flat-ground crow hop. The participants also performed flat-ground hold exercises with 14- and 32-oz balls. The authors found no difference in arm and trunk velocities between throwing a standard 5-oz baseball and a lighter 4-oz baseball. However, arm and trunk velocities steadily decreased as the ball's weight increased from 5 to 32 oz. Furthermore, while arm torque and forces decreased as the ball's weight increased, elbow flexion torque increased as the ball's weight increased. The increase in elbow flexion torque is concerning for the use of weighted balls, as this could increase the risk of injury to the elbow.

Okoroha et al[11] conducted a study to evaluate medial elbow torque with the use of weighted baseballs in 19 youth baseball pitchers with an average age of 11.8 years (range, 9-14 years). The authors found that, for every 1-oz increase in the ball's weight, velocity decreased an average of 2.0 mph (P < .001), medial elbow torque increased 0.92 N·m (P = .02), and arm speed decreased 8.52 rpm (P = .02). This biomechanical analysis adds to the data that weighted baseballs may increase the injury risk by placing increased loads on the medial elbow.

Interestingly, the authors asked pitchers which ball (based on weight of 3, 4, 5, and 6 oz) they preferred the most and then asked a separate question of which ball they disliked the most. The majority of pitchers preferred the 3-oz ball the most, and a majority of pitchers disliked the 6-oz ball the most. Given the results of these studies, it may be that lighter baseballs train the arm to move faster by allowing for higher shoulder and elbow angular velocities. This in turn can lead to an increase in arm speed and ultimately an increase in ball velocity.

While previous studies have demonstrated an increase in torque placed on the elbow with weighted baseballs, these studies did not evaluate the injury risk or ball velocity. Caldwell et al[1] performed a systematic review of the literature to determine if weighted baseballs increased a pitcher's velocity and increased the risk of injuries. The authors included 10 articles in their analysis but unfortunately noted that the majority of studies were heterogeneous and found it difficult to draw significant conclusions. It did appear that weighted balls were effective and increased velocity, although the types of weighted balls varied greatly between studies (6-32 oz). Reinold et al[12] randomized 38 youth male baseball pitchers (average age, 15.3 years) into a control group (only using standard 5-oz baseballs) and an experimental group, which participated in a 6-week weighted ball program 3 times per week using balls ranging from 2 to 32 oz. Both groups participated in a strength training program. The authors found a 24% injury rate in

the experimental group (all were elbow injuries) compared with a 0% injury rate in the control group. Reinold et al did not randomize pitchers to a lighter ball training program. The current available literature suggests a potential increase in ball velocity with weighted baseball training programs but at the cost of an increased risk of sustaining an elbow injury. The lighter ball training program in this study achieved the goal of increasing velocity but without causing any injuries during the training program. Theoretically, a light ball allows the pitcher to focus on training for increased speed of his arm movement, which can then be used to increase the velocity of the arm when throwing the regulation-sized 5-oz ball. Consideration should be given to a training program utilizing lighter baseballs to enhance pitching velocity in an effort to mitigate the injury risk while at the same time increasing velocity.

One additional difference between this program and others is that this training program was longer (more weeks) than some training programs in previous studies.[12] The pitchers in this study did not begin throwing on a rope until after the 10th session. Hence, this delay in throwing while working on mechanics may be a good way to ready a player's arm for more intensive throwing. To date, the ideal duration of a velocity training program has not been defined. As none of the players who participated in this throwing program were injured, consideration may be given to a longer training program with more days of rest to potentially decrease the injury risk. Future studies randomizing pitchers to velocity programs of varying durations will help elucidate the ideal training program duration.

Limitations

While this study is the first to critically evaluate a training program with lighter baseballs, it is not without limitations. The pitchers included in this study ranged in age from 10 to 17 years. Therefore, it is unclear if these results, either in the velocity increase or injury risk, are translatable to pitchers who are younger or older. This study did not have a control group of pitchers who used weighted balls, as we do not believe that these programs should be used based on current evidence showing significant increases in injury rates for players. This study included a relatively small group of pitchers, which will be expanded to include more pitchers in future studies. Finally, this study did not determine a "ceiling effect" in which the pitchers reached a certain velocity and neither additional training nor time to train led to further increases in velocity. While there were no injuries during the course of the training program, there was no control group of pitchers who did not participate in the training program for comparison. When this program is instituted in following years, the goal will be to follow the participants throughout the subsequent season to determine if their injury risk is the same, lower, or higher than their peers who did not participate in the training program.

CONCLUSION

A 15-week pitching training program with lighter baseballs significantly improved pitching velocity without causing any injuries, specifically to the shoulder or elbow. Lighter baseballs should be considered as an alternative to weighted baseballs when attempting to increase a pitcher's velocity.

REFERENCES

1. Caldwell JE, Alexander FJ, Ahmad CS. Weighted-ball velocity enhancement programs for baseball pitchers: a systematic review. *Orthop J Sports Med*. 2019;7(2):2325967118825469.
2. Camp CL, Dines JS, van der List JP, et al. Summative report on time out of play for Major and Minor League Baseball: an analysis of 49,955 injuries from 2011 through 2016. *Am J Sports Med*. 2018;46(7):1727-1732.
3. Chalmers PN, Erickson BJ, Ball B, Romeo AA, Verma NN. Fastball pitch velocity helps predict ulnar collateral ligament reconstruction in Major League Baseball pitchers. *Am J Sports Med*. 2016;44(8):2130-2135.
4. Erickson BJ, Chalmers PN, Axe MJ, Romeo AA. Exceeding pitch count recommendations in Little League baseball increases the chance of requiring Tommy John surgery as a professional baseball pitcher. *Orthop J Sports Med*. 2017;5(3):2325967117695085.
5. Erickson BJ, Gupta AK, Harris JD, et al. Rate of return to pitching and performance after Tommy John surgery in Major League Baseball pitchers. *Am J Sports Med*. 2014;42(3):536-543.
6. Erickson BJ, Nwachukwu BU, Rosas S, et al. Trends in medial ulnar collateral ligament reconstruction in the United States: a retrospective review of a large private-payer database from 2007 to 2011. *Am J Sports Med*. 2015;43(7):1770-1774.
7. Fleisig GS, Andrews JR. Prevention of elbow injuries in youth baseball pitchers. *Sports Health*. 2012;4(5):419-424.
8. Fleisig GS, Andrews JR, Cutter GR, et al. Risk of serious injury for young baseball pitchers: a 10-year prospective study. *Am J Sports Med*. 2011;39(2):253-257.
9. Fleisig GS, Diffendaffer AZ, Aune KT, Ivey B, Laughlin WA. Biomechanical analysis of weighted-ball exercises for baseball pitchers. *Sports Health*. 2017;9(3):210-215.
10. Marsh JA, Wagshol MI, Boddy KJ, et al. Effects of a six-week weighted-implement throwing program on baseball pitching velocity, kinematics, arm stress, and arm range of motion. *PeerJ*. 2018;6:e6003.
11. Okoroha KR, Meldau JE, Jildeh TR, Stephens JP, Moutzouros V, Makhni EC. Impact of ball weight on medial elbow torque in youth baseball pitchers. *J Shoulder Elbow Surg*. 2019;28(8):1484-1489.
12. Reinold MM, Macrina LC, Fleisig GS, Aune K, Andrews JR. Effect of a 6-week weighted baseball throwing program on pitch velocity, pitching arm biomechanics, passive range of motion, and injury rates. *Sports Health*. 2018;10(4):327-333.
13. Smart MP. Guidelines for youth and adolescent pitchers. http://m.mlb.com/pitchsmart/pitching-guidelines/. Accessed January 3, 2016.
14. Wilk KE, Macrina LC, Fleisig GS, et al. Deficits in glenohumeral passive range of motion increase risk of shoulder injury in professional baseball pitchers: a prospective study. *Am J Sports Med*. 2015;43(10):2379-2385.

APPENDIX 1

Phase 1 of Throwing Velocity Program: Sessions 1-10

This phase focuses on core strengthening and throwing mechanics to build a strong foundation for the rest of the program.

Session 1
1. Active warm-up + stretching routine
   a. Before your group starts
2. Velocity program medicine ball routines
   a. Heavy medicine ball routine
   b. Light medicine ball routine
3. Recovery routine

Session 2
4. Active warm-up + stretching routine
   a. Before your group starts
5. Velocity program medicine ball routines
   a. Heavy medicine ball routine
   b. Light medicine ball routine

Session 3
6. Active warm-up + stretching routine
   a. Before your group starts
7. First pitching evaluation: 5 fastballs at maximum effort
8. Velocity program medicine ball routines
   a. Heavy medicine ball routine
   b. Light medicine ball routine

Session 4
9. Active warm-up + stretching routine
   a. Before your group starts
10. Velocity program medicine ball routines
    a. Heavy medicine ball routine
    b. Light medicine ball routine

Session 5
11. Active warm-up + stretching routine
    a. Before your group starts
12. Velocity program medicine ball routines
    a. Heavy medicine ball routine
    b. Light medicine ball routine

Session 6
13. Active warm-up + stretching routine
    a. Before your group starts
14. Velocity program medicine ball routines
    a. Heavy medicine ball routine
    b. Light medicine ball routine

15. Velocity program throwing routines
    a. Precatch routine: 5 repetitions per exercise

Session 7
16. Active warm-up + stretching routine
    a. Before your group starts
17. Velocity program medicine ball routines
    a. Heavy medicine ball routine
    b. Light medicine ball routine
18. Velocity program throwing routines
    a. Precatch routine: 5 repetitions per exercise

Session 8
19. Active warm-up + stretching routine
    a. Before your group starts
20. Velocity program medicine ball routines
    a. Heavy medicine ball routine
    b. Light medicine ball routine
21. Velocity program throwing routines
    a. Precatch routine: 5 repetitions per exercise
    b. Long toss: feet moving (lengthen it out)
       i. 10 throws

Session 9
22. Active warm-up + stretching routine
    a. Before your group starts
23. Velocity program medicine ball routines
    a. Heavy medicine ball routine
    b. Light medicine ball routine
24. Velocity program throwing routines
    a. Precatch routine: 5 repetitions per exercise
    b. Long toss: feet moving (lengthen it out)
       i. 10 throws

Session 10
25. Active warm-up + stretching routine
    a. Before your group starts
26. Velocity program medicine ball routines
    a. Heavy medicine ball routine
    b. Light medicine ball routine
27. Velocity program throwing routines
    a. Precatch routine: 5 repetitions per exercise
28. Second pitching evaluation: 5 fastballs at maximum effort

APPENDIX 2

Phase 2 of Throwing Velocity Program: Sessions 11-17

This phase focuses on continued core strengthening and mechanics but adds in quick twitch movements. Lighter balls are introduced during this phase of the program. The pull-downs are the throws during the session in which the lighter balls are used. These throws are the highest effort throws of the session, designed to increase velocity by increasing momentum before the throw and then translating that momentum from the ground up the kinetic chain during the throw.

Session 11

29. Active warm-up + stretching routine
   a. Before your group starts
30. Velocity program medicine ball routines
   a. Heavy medicine ball routine
   b. Light medicine ball routine
31. Velocity program throwing routines
   a. Precatch routine: 5 repetitions per exercise
32. Pitching routines
   a. Feel work
      i. Cool down (flat ground): 5 primary + 5 change-ups + 5 fastballs (not primary)

Session 12

33. Active warm-up + stretching routine
   a. Before your group starts
34. Velocity program medicine ball routines
   a. Heavy medicine ball routine
   b. Light medicine ball routine
35. Velocity program throwing routines
   a. Precatch routine: 5 repetitions per exercise
   b. Long toss: increase distance of throws with medium/high effort
      i. 20 throws
   c. Pull-downs
      i. 5 (5 oz) + 5 (4 oz) + 5 (3 oz) + 5 (5 oz)
36. Pitching routines
   a. Feel work: low effort
      i. Cool down (flat ground): 5 primary + 5 change-ups + 5 fastballs (not primary)

Session 13

37. Active warm-up + stretching routine
   a. Before your group starts
38. Velocity program medicine ball routines
   a. Heavy medicine ball routine
   b. Light medicine ball routine
39. Velocity program throwing routines
   a. Precatch routine: 5 repetitions per exercise
   b. Long toss: increase distance of throws with medium/high effort
      i. 20 throws
   c. Pull-downs: on mound with regular motion
      i. 5 (5 oz) + 5 (4 oz) + 5 (3 oz) + 5 (5 oz)
40. Pitching routines
   a. Feel work: low effort
      i. 30 pitches

Session 14

41. Active warm-up + stretching routine
   a. Before your group starts
42. Velocity program medicine ball routines
   a. Heavy medicine ball routine
   b. Light medicine ball routine
43. Velocity program throwing routines
   a. Precatch routine: 5 repetitions per exercise
   b. Long toss: increase distance of throws with medium/high effort
      i. 20 throws
   c. Pull-downs
      i. 5 (5 oz) + 5 (4 oz) + 5 (3 oz) + 5 (5 oz)
44. Pitching routines
   a. Feel work: low effort
      i. 30 pitches

Session 15

45. Active warm-up + stretching routine
   a. Before your group starts
46. Velocity program medicine ball routines
   a. Heavy medicine ball routine
   b. Light medicine ball routine
47. Velocity program throwing routines
   a. Precatch routine: 5 repetitions per exercise
   b. Long toss: increase distance of throws with medium/high effort
      i. 20 throws
   c. Pull-downs: on mound with regular motion
      i. 5 (5 oz) + 5 (4 oz) + 5 (3 oz) + 5 (5 oz)
48. Pitching routines: 25 minutes
   a. Feel work: low effort
      i. 35 pitches

Session 16

49. Active warm-up + stretching routine
   a. Before your group starts
50. Velocity program throwing routines
   a. Precatch routine: 5 repetitions per exercise
   b. Long toss: increase distance of throws with medium/high effort and slight elevation
      i. 20 throws
   c. Pull-downs
      i. 5 (5 oz) + 5 (4 oz) + 5 (3 oz) + 5 (5 oz)
51. Pitching routines
   a. Feel work
      i. 35 pitches

Session 17

52. Active warm-up + stretching routine
    a. Before your group starts
53. Velocity program medicine ball routines
    a. Light medicine ball routine
54. Velocity program throwing routines
    a. Precatch routine: 5 repetitions per exercise

    b. Long toss: feet moving
       i. 10 throws
55. Third pitching evaluation: 5 fastballs at maximum effort
56. Pitching routines
    a. Feel work
       i. Cool down (flat ground): low-effort work on spin/action/command with 20 throws

APPENDIX 3

Phase 3 of Throwing Velocity Program: Sessions 18-25

This phase focuses on getting ready for game situations in addition to maintaining what was learned in phases 1 to 2.

Session 18

57. Active warm-up + stretching routine
    a. Before your group starts
58. Velocity program throwing routines
    a. Precatch routine: 5 repetitions per exercise
    b. Long toss: increase distance of throws by adding effort throughout each phase
       i. Walking with step behind (90 ft): 5 throws
       ii. Walking with step behind + hop (120 ft): 5 throws
       iii. Jog with step behind + hop (150 ft): 5 throws
    c. Pull-downs
       i. 5 (5 oz) + 5 (4 oz) + 5 (3 oz) + 5 (5 oz)
59. Pitching routines: game-day preparation

    a. Feel work
       i. Drills with focus on mechanical issues and/or any pitch that you are struggling with (action/feel/command): 20 pitches maximum (pitcher's choice)
       ii. Bullpen: 20 pitches

Session 19

60. Active warm-up + stretching routine
    a. Before your group starts
61. Velocity program throwing routines
    a. Precatch routine: 5 repetitions per exercise
    b. Long toss: increase distance of throws by adding effort throughout each phase
       i. Walking with step behind (90 ft): 5 throws
       ii. Walking with step behind + hop (120 ft): 5 throws
       iii. Jog with step behind + hop (150 ft): 5 throws
    c. Pull-downs
       i. 5 (5 oz)
62. Pitching routines (game day): bullpen routine + making adjustments against hitters

    a. Bullpen: 20 pitches
    b. Execution: pitchers will simulate first inning of a start by facing first 3 hitters in a lineup, and coaches will describe typical tendencies for first 3 hitters in most lineups
       i. 3 hitters (No. 1: lefty; No. 2: righty; No. 3: righty)

Session 20

63. Active warm-up + stretching routine
    a. Before your group starts
64. Velocity program throwing routines
    a. Precatch routine: 5 repetitions per exercise
       i. Hip hinge routine
    b. Long toss: increase distance of throws by adding effort throughout each phase
       i. Walking with step behind (90 ft): 5 throws
       ii. Walking with step behind + hop (120 ft): 5 throws
       iii. Jog with step behind + hop (150 ft): 5 throws
    c. Pull-downs
       i. 5 (5 oz) + 5 (4 oz) + 5 (3 oz) + 5 (5 oz)
65. Pitching routines: midweek preparation day
    a. Feel work: work on any/all pitches
       i. 40 pitches

Session 21

66. Active warm-up + stretching routine
    a. Before your group starts
67. Velocity program throwing routines
    a. Precatch routine: 5 repetitions per exercise
       i. Hip hinge routine
    b. Long toss: increase distance of throws by adding effort throughout each phase
       i. Walking with step behind (90 ft): 5 throws
       ii. Walking with step behind + hop (120 ft): 5 throws
       iii. Jog with step behind + hop (150 ft): 5 throws
    c. Pull-downs
       i. 5 (5 oz)
68. Pitching routines (game day): pitcher's role as starter + reading hitters
    a. Feel work
       i. 15 pitches
    b. Bullpen: 20 pitches
    c. Execution: simulated 2 innings of work
       i. 30 pitches

Session 22

69. Active warm-up + stretching routine
    a. Before your group starts
70. Velocity program throwing routines
    a. Precatch routine: 5 repetitions per exercise
       i. Hip hinge routine
    b. Long toss: increase distance of throws by adding effort throughout each phase
       i. Walking with step behind (90 ft): 5 throws
       ii. Walking with step behind + hop (120 ft): 5 throws
       iii. Jog with step behind + hop (150 ft): 5 throws
    c. Pull-downs
       i. 5 (5 oz) + 5 (4 oz) + 5 (3 oz) + 5 (5 oz)
71. Pitching routines
    a. Feel work
       i. 40 pitches

Session 23

72. Active warm-up + stretching routine
    a. Before your group starts
73. Velocity program throwing routines
    a. Precatch routine: 5 repetitions per exercise
    b. Long toss
       i. 15 throws
    c. Pull-downs
       i. 5 (5 oz)
74. Pitching routines (game day): facing heart of a lineup multiple times during a game
    a. Bullpen: 20 pitches
    b. Execution: 30 pitches (6 simulated hitters)

Session 24

75. Active warm-up + stretching routine
    a. Before your group starts
76. Velocity program throwing routines
    a. Precatch routine: 5 repetitions per exercise
       i. Hip hinge routine: 20 repetitions
    b. Long toss
       i. 10 throws
77. Final pull-down evaluation: will be using data from this evaluation to calculate overall improvement with these drills
    a. 5 (5 oz) + 5 (4 oz) + 5 (3 oz) + 5 (5 oz)
78. Pitching routines
    a. Feel work
       i. 40 pitches

Session 25

79. Active warm-up + stretching routine
    a. Before your group starts
80. Velocity program throwing routines
    a. Precatch routine: 5 repetitions per exercise
    b. Long toss
       i. 20 throws
81. Final (fourth) pitching evaluation: 5 fastballs at maximum effort
82. Pitching routines
    a. Feel work
       i. 30 pitches maximum
83. Program wrap-up

APPENDIX 4

Warm-up Routine Completed by All Players Before Each Session

1. Lunges/twists: 5 per side
2. Standing knee hugs: 5 per side
3. Alternating high kicks with toe touch: 5 per side
4. Alternating hip turnouts: 5 per side
5. High knees (quick): 10-second count
6. Butt kicks (quick): 10-second count
7. Squat jumps: 5 repetitions
8. Trunk twists: 10 per side
9. Back slaps: 10-second count
10. Arm circles (forward/palm down): 10-second count
11. Arm circles (backward/palm up): 10-second count
12. Sleeper stretches: 3 sets for 10-second count
13. Stretch anything else that needs attention before we start

APPENDIX 5

Description of Light Medicine Ball Routine

This routine uses 2- and 4-lb medicine balls to execute "over-the-head" throws with both arms. These drills are great for building velocity because the arm is not carrying the workload, whereas most velocity programs place all the stress on the arm, which leads to overuse and a higher potential for injuries. The drills in this routine involve the feel of the concepts from the heavy medicine ball routine and the strength gained with each concept in those drills, with an emphasis on acceleration instead of power. The lighter ball combined with the power development from the heavy medicine ball routine will be used to teach the body to be the primary accelerator for motion while the arm remains in a healthier position for a longer period of time and does less work.

Trunk Throw

Start on your knees with your body square to the target (feet, hips, shoulders), checking to make sure that you have a straight line from your knees to your shoulders. The ball should be sitting slightly above and behind your head with the elbows bent and arms loose. This is not a high-effort throw. The torso will generate the movement forward to start the throw with your arms following. Your elbow should follow your chest, allowing your throwing arm to rotate externally. Your hands will come through last, and as you release, you need to focus on feeling your throwing hand pronate (hand rotates thumb in and down). This is not a high-effort throw, and the torso is still what you are using to get the arms moving.

Back Leg Drive + Front Foot Stabilization + Trunk Throw: With Stop

Start with both feet pointing forward (feet, hips, and chest facing forward toward your target), with the plant foot slightly in front of the drive foot and both arms above your head with elbows bent and the ball sitting slightly above and behind your head. Starting from the drive foot, you will drive your hips forward with your plant foot extending. Once your drive foot drags, you will plant and stabilize your front foot/leg and hold this position. Your plant foot should be ahead of your knee with your leg almost straight, and your torso should be chest up and sitting slightly behind your belt buckle with your arms in the same position as when you started. If your positioning is off, then you will fix it. Once you are in a good stable position, you will drive with the back foot and extend your trunk to initiate the throw as you "push the earth down" with your lead leg. You want to try and create an explosive move with your torso on this drill, with increasing intensity as you improve with the drill. Do not worry about finishing in a "perfect position" with this drill; simply allow your body to react to the momentum of your torso, generating power with a strong front leg.

Back Leg Drive + Front Foot Strike + Trunk Throw: One Motion

The starting position and the details from the previous drill are the same for this drill. The only difference is that you will not stop motion at front foot strike. The goal here is to delay the throw until your drive foot drags and you feel front foot strike. Do not worry about finishing in a perfect position with this drill; simply allow your body to react to the momentum of your torso, generating power with a strong front leg.

Hip/Shoulder Separation Throw: With Stop

Start with both feet pointing forward (feet and hips facing forward toward your target), with the plant foot slightly in front of the drive foot. Your shoulders should be perpendicular to your hips (starting with hip/shoulder separation) and the ball sitting above your throwing shoulder and behind the ear with both hands on the ball and elbows bent with arms loose. Starting from the drive foot, you will drive your hips forward with your plant foot extending and your torso "riding the back leg" and maintaining hip/shoulder separation. Once your drive foot drags, you will plant and stabilize your front foot/leg and hold this position. Check to see that you are maximizing hip/shoulder separation before you start the throw. You will initiate the throw by driving with your back leg and leading your front shoulder forward and down as you push the earth down with your lead leg. Your trunk should rotate to extension with your arms following into the throw. You want to create velocity with your trunk and legs and will again add intensity as you improve with this drill. Do not worry about finishing in a perfect position with this drill; simply allow your body to react to the momentum of your torso, generating power with a strong front leg.

Hip/Shoulder Separation Throw: One Motion

The starting position and the details from the previous drill are the same for this drill. The only difference is that you will not stop motion at front foot strike. The goal here is to delay the throw until your drive foot drags and you feel front foot strike. Do not worry about finishing in a perfect position with this drill; simply allow your body to react to the momentum of your torso, generating power with a strong front leg.

Squat Throw: With Contralateral Trunk Rotation

Start with your body (feet, hips, shoulders) perpendicular to your target. Your feet should be about shoulder width apart, and you want to feel like you are sitting on your heels with a slight bend in both knees (similar to being halfway into a squat in the gym); the ball should be in the same position that your glove would be. You will initiate drive, trying to keep your back heel and back knee from rotating immediately. As you drive forward and extend your lead foot, you will load your hands and ball to the same loaded position as the previous drills. During motion, your hips will start to release into the front leg as you force the shoulders to rotate slightly closed (contralateral trunk rotation) while keeping your body loaded over your back hip (ride your back leg). The goal is to delay the throw until your front leg stabilizes, increasing hip/shoulder separation. Again, the throw and the velocity are coming from the legs and your trunk as it extends over a strong front leg. Allow your momentum to lead you into your finish.

Plyometric Throw: 3 Hops for Momentum With Throw on Third Hop

Start your stretch in your set position with the ball sitting above your throwing shoulder and behind the ear

with both hands on the ball and elbows bent with arms loose. You will hold your balance; then, you will start by sitting slightly onto your heel (hips back, knee steady, heel connected to the ground) and then hopping laterally in a controlled way. When you land, make sure that your back heel gets down and your knee is not rolled in toward flexion as you cushion the landing by sitting slightly onto your heal (repeat). You will initiate the throw by driving and extending your lead foot with your head staying behind your belt buckle and shoulders staying locked onto the target. Again, you are delaying the throw until front foot strike, and the throw should start with your lead shoulder going forward and rotating down as the trunk extends into the throw. Allow your momentum from the throw to carry you into your finish.

APPENDIX 6

Description of Heavy Medicine Ball Routine

This routine uses 8-lb medicine balls to execute "chest pass" throws using both arms. The routine involves several progressive drills with work on connection to the ground with the drive foot, the position of the back knee before drive, increasing the output of force and momentum from the drive leg, hip loading and release, front foot strike, front leg stabilization, and hip/shoulder separation. Improvements to these concepts will increase power from the ground through the hips and into the torso.

Back Leg Drive + Front Leg Stabilization + Trunk Extension: With Stop

Start with both feet pointing forward (feet, hips, and chest facing forward toward your target), with the plant foot slightly in front of the drive foot and both arms above your head with elbows bent and the ball sitting slightly above and behind your head. Starting from the drive foot, you will drive your hips forward with your plant foot extending. Once your drive foot drags, you will plant and stabilize your front foot/leg and hold this position. Your plant foot should be ahead of your knee with your leg almost straight, and your torso should be chest up and sitting slightly behind your belt buckle with your arms in the same position as when you started. If your positioning is off, then you will fix it. Once you are in a good stable position, you will drive with your back leg, extending your trunk over your stabilized lead leg, and the arms will follow into the throw. Do not worry about your finish looking like you were pitching. If your body falls back because of the lead leg being straight/strong, that is fine.

Back Leg Drive + Front Foot Strike + Trunk Extension: One Motion

The starting position and the details from the previous drill are the same for this drill. The only difference is that you will not stop motion at front foot strike. The goal here is to delay the throw until your drive foot drags and you feel front foot strike. Again, do not worry about your finish looking like you were pitching. If your body falls back because of the lead leg being straight/strong, that is fine.

Squat Throw: With Stop

Start with your body (feet, hips, shoulders) perpendicular to your target. Your feet should be about shoulder width apart, and you want to feel like you are sitting on your heels with a slight bend in both knees (similar to being halfway into a squat in the gym); the ball should be in the middle of your chest. You will initiate drive, trying to keep your back heel and back knee from rotating immediately. As you drive forward, extend your lead foot while keeping your body loaded over your back hip and preventing your torso from rotating (shoulders are to stay in line with your target). Front foot strike and lead leg stabilization should occur after your back foot rotates and drags. You will hold this position and check to make sure that your front foot is facing the target, your lead leg is stabilized, and you have good hip/shoulder separation. Once positioning is correct, you will initiate the throw by driving and leading your front shoulder forward with the chest rotating to extension and the throw following. You are trying to use your trunk as the power behind the throw. Allow the momentum from the throw to carry you into your finish.

Squat Throw: One Motion

The starting position and the details from the previous drill are the same for this drill. The only difference is that you will not stop motion at front foot strike. The goal is to focus on the details from Appendix 3 while trying to keep your shoulders and trunk loaded during drive and front foot strike so that when you throw, you will be doing so from a position of maximized hip/shoulder separation. The key is to delay the throw for as long as you can and to feel front foot strike before throwing. Allow the momentum from the throw to carry you into your finish.

Plyometric Throw: 3 Hops for Momentum With Throw on Third Hop

Start your stretch in your set position with the ball in the same position that your glove would be. You will hold your balance; then, you will start by sitting

slightly onto your heel (hips back, knee steady, heel connected to the ground) and then hopping laterally in a controlled way. When you land, make sure that your back heel gets down and your knee is not rolled in toward flexion as you cushion the landing by sitting slightly onto your heal (repeat). You will initiate the throw by driving and extending your lead foot with your head staying behind your belt buckle and shoulders staying locked onto the target. Again, you are delaying the throw until front foot strike, and the throw should start with your lead shoulder going forward and rotating down as the trunk extends into the throw. Allow your momentum from the throw to carry you into your finish.