Short Communication

# The relationship between measures of lower body power and pitching velocity in professional baseball pitchers

Paul T. Donahue, Erik Beiser, Sam J. Wilson, Christopher M. Hill, John C. Garner

***Objectives***: The purpose of this study was to examine the relationship between lower-body power output and pitching velocity in professional baseball pitchers.

***Design and Methods***: A cross-sectional design was used to assess twenty-seven minor league baseball pitchers were for lower body power output using two methods. Countermovement vertical jump (CMVJ) and a 30 second sprint cycling test (Cycle) were used to calculate peak and mean power, as well as normalized peak and mean power respectively. Additionally, peak velocity, and mean velocity was assessed during the CMVJ with the use of a linear position transducer attached to a wooden dowel. Pitching velocity was measured as the greatest fastball pitch velocity for each subject recorded during a minor league spring training game. Mean velocity was that of all fastballs thrown. Pearson product-moment correlation coefficients were used to analyze the relationship between all variables with alpha levels set at $p < 0.05$.

***Results***: Mean power during Cycle showed a significant positive relationship to both peak and mean throwing velocities ($r = 0.441$ and 0.428, respectively).

***Conclusions***: Sprint cycling performance and more specifically the mean output over the duration of the sprint has a significant linear relationship with both peak and mean throwing velocity in professional baseball pitchers.

**(*Journal of Trainology* 2018;7:24-27)**

Key words: countermovement Jump ■ cycling Power ■ throwing Velocity

## INTRODUCTION

It is highly desirable in the game of baseball for pitchers to throw the ball with the greatest velocity. Throwing the ball with a greater velocity is beneficial as it decreases the time that a hitter has to react to the pitch and make contact.[1] The pitching motion is commonly described as the segments of the body working in a kinetic sequence from the ground up, beginning with the foot and ending with the hand. This in turn accelerates the baseball to a maximum velocity.[2] Though the previous description of the pitching motion is common, the actual contribution of the lower extremity in regard to throwing velocity is inconclusive. Spaniol[3] has suggested that throwing requires a summation of forces from the ground up and that leg power has a positive relationship with throwing velocity in high school and collegiate baseball players. Additionally, it has been shown that both lower body strength and power have a relationship with throwing velocity in other overhand throwing sports such as cricket[4] and handball athletes[5]. It has been shown that a similar relationship is present in adolescent baseball athletes.[6] Moreover, it has been shown that improvement of lower body strength/power through various training methods has been shown to improve throwing velocities.[7]

The assessment and training of lower body power amongst Major League Baseball (MLB) strength and conditioning coaches can be seen in a survey which found that a third of organizations tested muscular power of the lower extremity in their athletes.[8] Both the "vertical jump" and "wingate" were specified as the test used to measure muscular power in those athletes. Additionally, it has been suggested that the use of the power clean and its variations might enhance performance as the game of baseball requires lower-body strength and power in order to be successful.[9] The vertical jump, as well as throwing velocities and body composition have been suggested as a method in measuring fatigue over the course of a season.[10] Furthermore, lower body power assessed through the vertical jump has been shown to have a positive relationship on offense[11] and fielding[12] performance over the course of a season in professional baseball players. Based on the body of research, there is an expectation that lower body power and force production is significantly associated with pitching velocity in professional pitchers. Thus, the purpose of this investigation was to examine the relationship between countermovement vertical jump (CMVJ) and sprint cycling (Cycle) performance and pitching velocity in elite professional baseball pitchers.

## METHODS

### Participants

Twenty-seven professional baseball pitchers (age 23.31 ± 2.41 years old, height 189.63 ± 4.27 cm, body mass 97.10 ±

Received August 23, 2018; accepted October 6, 2018
From the Department of Health, Exercise Science, and Recreation Management, The University of Mississippi, University, MS 38677 USA (P.T.D., C.M.H.), Minnesota Twins Baseball Club, Minneapolis, MN 55403, USA (E.B.), Department of Health Sciences and Kinesiology, Georgia Southern University, Statesboro, GA 30460 USA (S.J.W.) and Department of Kinesiology and Health Promotion, Troy University, Troy, AL 36082, USA (J.C.G.)
Communicated by Takashi Abe, PhD
Correspondence to Paul T. Donahue, Department of Health, Exercise Science, and Recreation Management, The University of Mississippi, PO Box 1848, University, MS 38677 USA. Email: ptdonahu@olemiss.edu
***Journal of Trainology*** **2018;7:24-27 ©2012 The Active Aging Research Center http://trainology.org/**

10.36 kg) were examined. All players belonged to one professional organization (Rookie ball through AAA). Subjects had at least one season of professional pitching experience (3.00 ± 2.21 years). All assessments took place during scheduled conditioning sessions during spring training. Informed consent approved from the University Institutional Review Board was obtained.

### Procedures

Countermovement vertical jump and 30 second cycle sprint testing was conducted during spring training as part of a normal training sessions and as part of the physical fitness assessment of spring training. Cycle testing was performed first; a minimum of 48 hours followed the cycle testing before throwing velocity was recorded during a spring training game. CMVJ testing occurred on the first day after the player had pitched in a game. All subjects had completed their individual throwing and long toss programs before coming in and taking part in cycle and jump testing. A minimum of 30 minutes was given from the time the subject had finished throwing to the time they arrived to take part in the testing session. Subjects were familiar with all testing procedures as both CMVJ and sprint cycling were part of the regular training program.

### Countermovement Vertical Jump

Countermovement vertical jumps were performed using a wooden dowel (1.0 kg) placed across the shoulders in a high bar squat position. Participants performed a general warm up routine, which included hip mobility drills and dynamic stretching. Participants completed one set of three jumps at a self-selected foot position and to a self-selected countermovement depth. They were instructed to jump as explosively as possible to achieve maximal height.[13] Participants were also instructed to maintain contact with wooden dowel at times throughout the movement. A minimum of 10 seconds rest was given between CMVJ attempts. CMVJ performance was assessed with the use of a linear position transducer (LPT) (Gymaware™; Kinetic Performance Technology, Canberra Australia). The LPT transmitted information to a handheld device via Bluetooth communication. The displacement data is time stamped at a 1000 Hz then down sampled to 50Hz for analysis. Velocity is then calculated as the change in displacement over the change in time. Acceleration is then calculated as a change in velocity over a change in time. This acceleration data is then used to calculate force as mass of the system (body mass and the dowel) multiplied by the acceleration. Power is then calculated as the force multiplied by the velocity.[14] Variables of interest in the CMVJ included, peak power (CMVJPP), mean power (CMVJMP), normalized peak power (CMVJPP/kg), normalized mean power (CMVJMP/kg), peak velocity (CMVJPV), and mean velocity (CMVJMV). The of mean values of the three jumps was used in the analysis.

### 30 Second Sprint Cycling Test

All cycle testing was performed on an air-braked cycle ergometer (Wattbike Pro, Nottingham, UK). Each subject performed a warm up that consisted of cycling at a self-selected pace for three minutes, followed by a 60 second rest period. At that time participants were instructed to remain seated during the duration of the test. Elapsed time was available for participants and were required to perform the greatest amount of work possible during that time period. Verbal encouragement was provided throughout the duration of the test. Peak (CyclePP) and mean (CycleMP) power as well as normalized peak (CyclePP/kg) and mean (CycleMP/kg) power were used in the analysis.

### Pitching Velocity

Pitching velocity was measured during minor league spring training games. Pitching data was analyzed from four spring training games in which each subject pitched in one of the four games. The peak and mean fastball velocities for the first inning pitched each of the subjects was measured in this analysis. Subjects threw between 11 and 15 pitches (12.59 ± 1.76). Subjects went through their self-determined pre-competition warm up routine. Pitching velocities were measured by a handheld radar gun (Stalker Pro II, Richardson, TX).

### Statistical Analysis

SPSS 24 (SPSS Inc, IBM, Chicago, IL) was used for all statistical analyses. Data was assessed for normality using Shaprio-Wilk test. Linear relationships between CMVJ and Cycle performance and peak and mean pitching velocities were assessed using Pearson product – moment correlations. Intraclass correlation coefficients (ICC) and coefficient of variation (CV%) of the CMVJ variables were also calculated. Significance was set a $p < 0.05$ for all analysis.

## RESULTS

All variables showed normal distribution. ICC and CV% for CMVJ are presented in Table 1. Mean and standard deviations for all variables are presented in Table 2. Pearson correlation coefficients for all variables are presented in Table 2. No significant relationships were found between measures obtained

**Table 1** Intraclass correlation coefficients and coefficient of variation of countermovement vertical jump

| | ICC | CV% |
|---|---|---|
| CMVJPP (w) | 0.95 | 7.8 |
| CMVJPP/kg (w/kg) | 0.93 | 8.1 |
| CMVJMP (w) | 0.87 | 7.8 |
| CMVJMP/kg (w/kg) | 0.87 | 7.8 |
| CMVJPV (m/s) | 0.81 | 4.6 |
| CMVJMV(m/s) | 0.89 | 5.9 |

ICC = Intraclass correlation coefficient; CV% = coefficient of variation; CMVJPP = countermovement vertical jump peak power; CMVJPP/kg = countermovement vertical jump peak power per kilogram; CMVJMP = countermovement vertical jump mean power; CMVJMP/kg = countermovement vertical jump mean power per kilogram; CMVJPV = countermovement vertical jump peak velocity; CMVJMV = countermovement vertical jump mean velocity

**Table 2** Mean and standard deviation (SD) of all variable, and correlation coefficients for peak and mean velocity

| | Mean | SD | Correlation Coefficients | |
|---|---|---|---|---|
| | | | Peak Velocity | Mean Velocity |
| CMVJPP (w) | 6515.90 | 1531.93 | 0.284 | 0.266 |
| CMVJPP/kg (w/kg) | 67.08 | 13.49 | 0.171 | 0.169 |
| CMVJMP (w) | 3775.44 | 522.49 | 0.106 | 0.112 |
| CMVJMP/kg (w/kg) | 39.00 | 4.70 | -0.093 | -0.062 |
| CMVJPV (m/s) | 3.30 | 0.25 | -0.052 | -0.029 |
| CMVJMV(m/s) | 2.11 | 0.15 | 0.170 | 0.217 |
| CyclePP (w) | 1316.60 | 202.85 | 0.212 | 0.243 |
| CyclePP/kg (w/kg) | 13.89 | 2.53 | 0.014 | 0.089 |
| CycleMP (w)* | 820.11 | 86.47 | 0.441 | 0.428 |
| CycleMP/kg (w/kg) | 8.57 | 0.86 | 0.159 | 0.217 |
| Peak Pitching Velocity (m/s) | 41.32 | 0.88 | | |
| Mean Pitching Velocity (m/s) | 40.47 | 0.97 | | |

CMVJPP = countermovement vertical jump peak power; CMVJPP/kg = countermovement vertical jump peak power per kilogram; CMVJMP = countermovement vertical jump mean power; CMVJMP/kg = countermovement vertical jump mean power per kilogram; CMVJPV = countermovement vertical jump peak velocity; CMVJMV = countermovement vertical jump mean velocity; CyclePP = sprint cycling peak power; CyclePP/kg = sprint cycling peak power per kilogram; CycleMP = sprint cycling mean power; CycleMP/kg = sprint cycling mean power per kilogram
* $p < 0.05$

during the CMVJ and either peak and mean pitching velocity. There was a moderate positive relationship between mean cycling power and both peak and mean pitching velocities. No other significant relationships were found between cycling performance and peak and mean pitching velocities.

## DISCUSSION

Becoming a stronger and more powerful baseball player is desired by both athletes and coaches as it has been shown to differentiate between levels of play in professional baseball.[15] The use of training techniques such as plyometrics, Olympic lifting variations, and traditional resistance training have been advocated as a means for helping increase and maintain throwing velocities by increasing the power generating capacities of baseball pitchers both during the offseason as well as during the competitive season.[8,9] Results from the current study show that lower body power output has varying relationships to throwing velocity depending on the variable of interest and the movement used to assess a power.

Lehman et al.[16] investigated the use of lower body field test in the predication of the throwing velocity in college baseball players. The authors suggest that the use of the lateral to medial jump distance is highly correlated to throwing velocity and can be used as a predication method of throwing velocity because of the principle of specificity. While neither measure of the power production of the lower body in the current study is specific to the throwing motion we can see that a relationship can exist between power and throwing. Both investigations found that the vertical jumping task did not have a significant relationship to throwing velocity. Additionally, it is important to note that while both the studies used baseball athletes there were differences in throwing styles (flat ground vs pitching mound) and positions (position players vs pitchers).

Similar findings with the use of cycle ergometers have been shown in other overhand throwing athletes. Handball athletes were shown to have a positive relationship between lower body power and throwing velocities to a similar degree ($r = 0.56$) as the current study.[5] It is important to note that in the present investigation mean power was the variable that showed a relationship with throwing velocities rather than peak power which was seen in the previous investigation. This could again be methodological differences in throwing style (three step approach vs throwing from a mound) as well as difference in the cycle ergometer used. Both throwing velocities and peak power in the present study were greater than those seen in with the handball players (Peak power 898 ± 220 vs 1316.60 ± 202.85 W and throwing velocity 23.0 ± 1.8 vs 41.32 ± 0.88 m/s). In the present investigation a small range of throwing velocity was seen (38.98 – 42.57 m/s) with large ranges of peak power output in both the CMVJ and Cycle. This provides evidence that subjects were able to throw at similar speeds with differing power production thus lower body power output may contribute less than previously thought. This is similar to findings of Szymanski[17] that demonstrated increases in lower body power as measured by vertical jump height, did not translate into increases in throwing velocity.

Throwing velocities in cricket athletes has also been shown to be significantly correlated to the vertical jump height.[4] Though the vertical jumping test was used in both the current investigation and in the previous investigation by Freeston[4] variables of interest differed. Power was used over vertical jump height as a variable of interest due to the potential lack of sensitivity of vertical jump height as a variable of assessing jumping performance.[18] Moreover, power derived from the vertical jump has been used in examining the relationship between lower leg power and baseball fielding and offense performance.

The present investigation has contrasting findings to other studies investigating lower-body power output and on field performance in baseball athletes.[11] While the correlation coefficients investigations are similar (low to moderate), the present study did not reach statistical significance, unlike the previous investigations. This can be a result of the difference in the variables used as those of previous studies involved offensive statistics (home runs, runs batted in, batting average, etc) over the course of the season, whereas this investigation looked at pitching velocity using a cross-sectional design.

It is important to note that while the present study has differing results from other studies the finding that mean cycling power showed a moderate relationship to both peak and mean throwing velocities is important. While peak power is commonly sought as a variable of interest it, the value is for only one instantaneous moment in time, thus only representing a very small portion of the sprint duration. Mean power during sprint cycling however has been shown to representative of anaerobic capacity.[19] This is important to the present investigation as it may explain the relationship between mean pitching velocity and sprint cycling. As mean pitching velocity is taken over a number of maximal effort throws having a greater anaerobic capacity would allow you to maintain the maximal effort for a greater period of time, thus increasing mean throwing velocity. In the sample used the peak and mean pitching velocities are high correlated ($r = .954$), explaining the relationship seen between peak throwing and mean power.

Further investigations should examine the relationship between anthropometrics and performance measures and pitching statistics similar to those of previous investigations. Additionally, future investigations should examine how peak power may respond to a competitive season and thus pitching velocity. As well as peak power and anthropometric differences between levels and positions (starters and relievers) of professional baseball pitchers.

## CONCLUSION

This investigation showed that CMVJ performance and pitching velocity do not have the statically significant relationship that is seen between CMVJ and other athletic performance measures. These results may not be generalizable to pitchers at all levels, but only those in the professional ranks. This investigation does show however that sprint cycling performance does have a moderate relationship with pitching velocity and may be a better tool in the assessment of professional baseball pitchers. Thus, if performing a battery of test on baseball athletes sprint cycling should be included as it was the only variable to show a significant relationship with throwing velocities in professional baseball pitchers.

### Conflicts of Interest

There is no conflict of funding source to disclose.

## REFERENCES

1. Hay JG. The Biomechanics of Sports Techniques. 2nd ed. Prentice-Hall, Inc, Englewood Cliffs, NJ; 1978. pp.186-210.
2. Pappas AM, Zawacki RM, Sullivan TJ. Biomechanics of baseball pitching. A preliminary report. *Am J Sports Med* 1985;13:216-222.
3. Spaniol FJ. Baseball athletic test: A baseball-specific test battery. *Strength Cond J* 2009;31:26-29.
4. Freeston JL, Carter T, Whitaker G, et al. Strength and power correlates of throwing velocity on subelite male cricket players. *J Strength Cond Res* 2016;30:1646-1651.
5. Chelly MS, Hermassi S, Shephard RJ. Relationships between power and strength of the upper and lower limb muscles and throwing velocity in male handball players. *J Strength Cond Res* 2010;24:1480-1487.
6. Spaniol F. Phyisological predictors of bat speed and throwing velocity in adolescent baseball players. *J Strength Cond Res* 2002;16:16.
7. Derenne C, Ho KW, Murphy JC. Effects of general, special, and specific resistance training on throwing velocity in baseball: A brief review. J Strength Cond Res 2001;15:148-156.
8. Ebben WP, Hintz MJ, Simenz CJ. Strength and conditioning practices of major league baseball strength and conditioning coaches. *J Strength Cond Res* 2005;19:538-546.
9. Suchomel TJ, Sato K. Baseball resistance training: Should power clean variations be incorporated? *J Athl Enhanc* 2013;2:2-5.
10. Suchomel TJ, Bailey C. Monitoring and managing fatigue in baseball players. *Strength Cond J* 2014;36:39-45.
11. Hoffman JR, Vazquez J, Pichardo N, et al. Anthopometric and performance comparisons in professional baseball players. *J Strength Cond Res* 2009;23:2713-2178.
12. Mangine GT, Hoffman JR, Vazquez J, et al. Predictors of fielding performance in professional baseball players. *Int J Sports Physiol Perform* 2013;8:510-516.
13. Argus CK, Gill N, Keogh J, et al. Assesing lower-body peak power in elite rugby-union players. *J Strength Cond Res* 2011;25:1616-1621.
14. Crewther BT, Kilduff LP, Cunningham DJ, et al. Validating two systems for estimating force and power. *Int J Sports Med* 2011;32:254-258.
15. Guido JA Jr. Werner SL. Lower-extremity ground reaction forces in collegiate baseball pitchers. *J Strength Cond Res* 2012;26:1782-1785.
16. Lehman G, Drinkwater EJ, Behm DG. Correlation of throwing velocity to the results of lower-body field tests in male college baseball players. *J Strength Cond* Res 2013;27:902-908.
17. Szymanski D, Szymanski JM, Albert JM, et al. Physiological and anthropometric characteristics of college baseball players over an entire year. *J Strength Cond Res* 2010;24(Suppl 1):1.
18. Coutts A, Reaburn P, Piva TJ, et al. Changes in selected biochemical, muscular strength, power, and endurance measures during deliberate overreaching and tapering in rugby league players. *Int J Sports Med* 2007;28:116-124.
19. Zupan MF, Arata AW, Dawson LH, et al. Wingate anaerobic test peak power and anaerobic capacity classifications for men and women intercollegiate athletes. *J Strength Cond Res* 2009;23;2598-2604