Chinese Journal of Sports Biomechanics, 5(S1): 448-451, 2013

PREDICTING OFFENSIVE PERFORMANCE IN COLLEGIATE BASEBALL PLAYERS USING ISOMETRIC FORCE PRODUCTION CHARACTERISTICS

Christopher A. Bailey, Kimitake Sato and William G. Hornsby

Department of Exercise and Sport Sciences, East Tennessee State University, Johnson City, Tennessee, USA[1]

This study assessed the predictability of offensive performance in collegiate baseball players using isometric force production variables. Baseball players (n=31) performed isometric mid-thigh pull strength testing to assess kinetic variables from force plate data. Bivariate correlations were calculated between kinetic data and baseball performance variables (batting avg, slugging % (SLG), doubles and HRs). Linear regression was used to calculate multiple correlations and to generate prediction equations with kinetic data and offensive performance. Moderate to large statistically significant correlations were observed between HRs and SLG with all kinetic variables. A moderate correlation is seen between doubles and rate of force development (RFD). Resistance exercises that will increase the hitter's ability to develop large forces as well as increase RFD may be necessary for better performance.

KEY WORDS: RATE OF FORCE DEVELOPMENT, ISOMETRIC, MID THIGH PULL

INTRODUCTION: Strength and conditioning procedures of baseball players are not well documented from an evidence-based setting, but it appears that there is trend toward very conservative strength and conditioning methods (Potteiger et al 1992b). Baseball as a whole is quite unresponsive to change, making it difficult to break the traditional conservative approach to training for baseball. It is not uncommon for players to only train during the season or to only perform rehabilitation exercises. As late as the 1980s it was common place for most players to "play themselves into shape," which may have been one of the secondary purposes of spring training (Moore 1983). In the past few decades the idea of strength training for baseball players does seem to be much more main stream (Parker 1985, Moore 1983). This may be further evidenced by the increasing number of players willing to risk suspension and fines by taking performance ehancing drugs which are banned in Major League Baseball (Mitchell 2007).
Baseball is an explosive and ballistic natured sport, and success in the sport is dependent on many biomechanical, physiological, and even psychological variables (Coleman et al. 1982). Evaluating the relationships between strength testing variables and baseball performance can aid strength and conditioning professionals in the program design process. For example, the ability to produce force rapidly has been shown to be a significant factor in the sport performance of strength-power athletes, but this was not evaluated in baseball players (Stone 2003). Previouisly, Hoffman and colleagues (2009) established a moderate correlation between measures of grip strength and home runs in professional baseball players (r=.317). Unfortunately, the relationship with multi-joint force production and actual baseball performance was not evaluated. Thus, there is a need for specifically analyzing the linkage between strength profile and baseball performance characteristics. Therefore, the purpose of this study was to assess the relationships and predictability of offensive performance and multi-joint isometric force production characteristics in collegiate baseball players. The study hypothesized that moderate to strong relationships between baseball offensive performance variables and the various force production characteristics would be observed.

METHODS: Data from 31 NCAA Division I baseball players from the spring baseball seasons of 2009, 2010, 2011, and 2012 was analyzed for the current investigation. A minimum requirement of 100 at bats across a respective season was set for study inclusion.

Testing sessions began with a standardized warm-up consisting of 25 jumping jacks, a set of five repetitions of dynamic pulls from the mid-thigh position with 20 kg, and three sets of five repetitions with 60 kg. Multi-joint isometric force production was measured using an isometric mid-thigh pull (IMTP), which was performed on a 0.91m x 0.91m force plate (RoughDeck HP, Rice Lake, WI; sampling rate of 1,000 Hz) in a custom-designed power rack. The standardized position has been established based upon previous publications Haff et al. (1997) and Kraska et al. (2009). Bar heights were set specific to the individual, corresponding to a knee angle of 125º±5º and a hip angle of 175º±5º (see Figure 1). Athletes' hands were fixed to the bar using weightlifting straps and athletic tape to prevent their hand movement and to ensure a maximum effort could be given without the limitation of hand grip strength. Each athlete performed two warm up trials at 50 and 75% of perceived effort, followed by two maximal voluntary isometric contractions with 1 minute rest between each pull. The athlete was verbally instructed to "pull as fast and as hard as possible". Averages of each variable were determined to better indicate the athlete's typical performance level (Henry 1967).

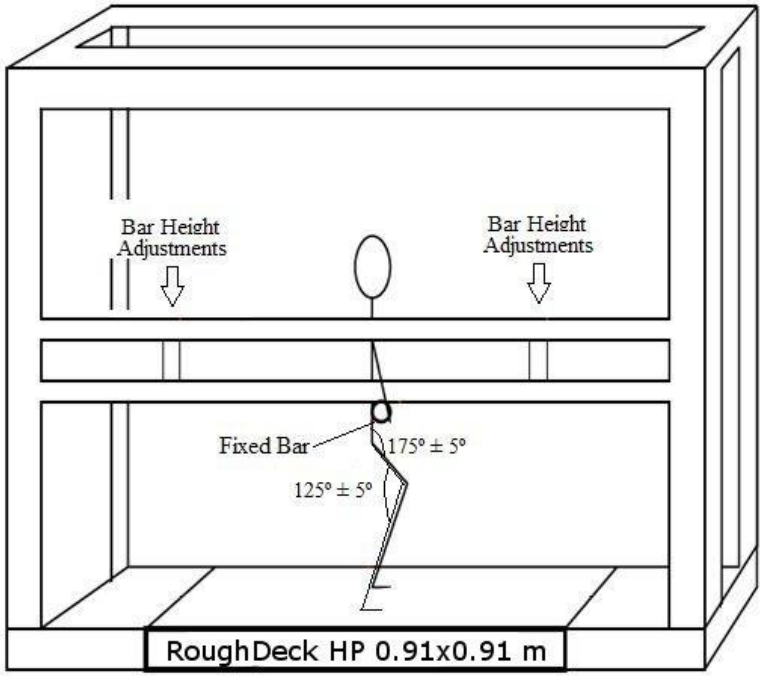

Figure 1: Position of isometric mid-thigh pull test

Labview software (National Instruments Co., Austin, TX) was used to determine peak force (IPF), allometrically scaled isometric peak force (IPFa), rate of force development (RFD), and instantaneous forces at 50, 90, and 250 ms (F@50, F@90, F@250). IPFa ($N/kg^{(2/3)}$) in an effort to take each player's body mass into account.

Statistical analysis was performed with PASW software (SPSS version 19.0: An IBM company, New York, NY). Bivariate Pearson Product Correlation coefficients were assessed between all variables. Linear regression was used to assess multiple correlations and to generate prediction equations with isometric force characteristics as independent variables and offensive performance as the dependent variables. Two prediction equations were used with the only difference being whether or not peak force was scaled. Offensive statistics used for this study

were batting average (Ba avg), doubles (2B), slugging percentage (SLG=total bases/at bats), and home runs (HR).

RESULTS: Results from bivariate correlations are shown in Table 1. Moderate to large statistically significant correlations were observed between HRs and SLG with all force production characteristics. A statistically significant moderate correlation is seen between doubles and RFD. Doubles also produced moderate correlations with instantaneous forces at 90 and 250 ms, although they did not reach statistical significance. The relationship between Ba avg and force production characteristics seems to be minimal. Results from linear regression can be seen in Table 2. Multiple correlation values for SLG and HRs were larger than those found in both Ba avg and doubles. The model using allometrically scaled peak force (Table 2B) appears to account for more variance than the model using raw peak force (Table 2A).

Table 1
Bivariate Pearson Correlation Matrix

	IPF	IPFa	RFD	F@50	F@90	F@250
Ba Avg	-.056	-.023	.040	-.346	-.192	-.073
2B	.220	.140	.464**	.144	.302	.347
SLG	.386*	.212	.603**	.405*	.516**	.539**
HRs	.421*	.235	.633**	.489**	.573**	.577**

*** correlation is significant at the 0.05 level**
**** correlation is significant at the 0.01 level.**

Table 2
Regression model results
Model A predictors: (Constant), IPF, F@50 ms, F@90 ms, F@250 ms, RFD
Model B predictors: (Constant), IPFa, F@50 ms, F@90 ms, F@250 ms, RFD

Regression model A

DV	R	R^2	Adj R^2
Ba Avg	0.499	0.249	0.99
Doubles	0.54	0.291	0.149
SLG	0.625	0.391	0.269
HRs	0.671	0.451	0.341

Regression model B

DV	R	R^2	Adj R^2
Ba Avg	0.499	0.249	0.098
Doubles	0.559	0.313	0.175
SLG	0.665	0.443	0.331
HRs	0.705	0.497	0.397

DISCUSSION: The results from the bivariate correlations suggest that a few strong statistically significant relationships occur between isometric force production characteristics and baseball offensive performance, partially supporting the hypothesis. Specifically, RFD seems to produce the strongest relationship with doubles, SLG and HRs. Instantaneous high forces at the early time periods (90 and 250 ms) also produce strong relationships with SLG and HRs. A moderate relationship is seen between SLG and HRs and the earliest instantaneous force measured (50ms) as well as IPF. These relationships indicate those who can produce high forces and produce them quickly are more likely to perform better offensively. This is further evidenced by previous research showing the highest vertical ground reaction forces produced in the lead foot occur just 93 ms prior to contact with the ball. Thus, a higher RFD may also have an influence on a player's ability to adjust to different pitch types and locations (Fortenbaugh 2011).
Batting average does not seem to be related to any of the force characteristics measured. This may simply be indicative of the skill component in hitting a baseball. Batting average, possibly more so than the other statistics used, is illustrative of poor performance as well as positive

performance. For example, a power hitter may hit many homeruns and doubles, but could also strike out a great deal. His SLG will be high due to the large number of total bases covered, but his batting average could still be low.

Two prediction equations were used for each dependent variable with IPFa being substituted for IPF in the second equation. As suggested by Tabachnik and Fidell (2001), the adjusted R^2 value is used for interpretation. Both models produced the best predictions when HRs was the dependent variable followed by SLG. Accounting for the variance in doubles was weaker and the predictability for Ba avg was very low, similarly to the bivariate correlations.

It is interesting that the equation using IPFa produced higher predictability than the equation IPF. The regression equation using IPFa could account for 39.7% of the variance in HRs and 33.1% of the variance in SLG, while the first equation accounted for 34.1% and 26.9%. The bivariate correlations indicate a stronger relationship between peak force and HRs and SLG than when peak force is scaled to account for body mass. However for the multiple correlation analysis, the opposite was true. This may indicate that allometrically scaled force values are more appropriate in assessing the relationship when a multivariate approach is utilized.

CONCLUSION: The results of the current investigation indicate a strong relationship exists between force production characteristics and some offensive performance variables. Strength and conditioning coaches may wish to focus on exercises that will increase the athlete's ability to develop large forces along with increasing RFD. This data also suggests that increases in strength may be associated with better hitting performance. Strength coaches may be benefitted by investing in instruments that monitor variables such as RFD.

REFERENCES:

Coleman, E. (1982). Physiological characteristics of major league baseball players. *Physician Sports medicine, 10*, 51-57.

Fortenbaugh, D. M. (2011). *The biomechanics of the baseball swing. Open Access Dissertations, 540*, 1-235.

Haff, G., Stone, M., O'Bryant, H., Harman, E., Dinan, C., Johnson, R., & Ki-Hoon, H. (1997). Force-time dependent characteristics of dynamic and isometric muscle actions. *Journal of Strength and Conditioning Research, 11*(4), 269-272.

Henry, F. (1967). "Best" versus "Average" individual scores. *The Research Quarterly, 38*, 317-320.

Hoffman, J. R., Vazquez, J., Pichardo, N., & Tenenbaum, G. (2009). Anthropometric and performance comparison in professional baseball players. *Journal of Strength and Conditioning Research, 23*(8), 2173-2178.

Kraska, J. M., Ramsey, M. W., Haff, G. G., Fethke, N., Sands, W. A., Stone, M. E., & Stone, M. H. (2009). Relationship between strength characteristics and unweighted and weighted vertical jump height. *International Journal of Sports Physiology and Performance, 4*(4), 461-473.

Mitchell, G. J. (2007). *Report to the commissioner of baseball of an independent investigation into the illegal use of steroids and other performance enhancing substances by players in major league baseball,* Major League Baseball.

Moore, M. (1983). You can't play yourself into shape for baseball these days. *Physician Sports medicine, 11*(4), 167-174.

Parker, R. (1985). In-season strength training for baseball. *NSCA Journal, 7*(5), 64-65.

Potteiger, J. A., Williford, H. N., Blessing, D. L., & Smidt, J. (1992). Effect of two training methods on improving baseball performance variables. *Journal of Applied Sport Science Research, 6*(1), 2-6.

Stone, M. H., Sanborn, K., O'Bryant, H., Hartman, M., Stone, M. E., Proulx, C., et al. (2003). Maximum strength-power-performance relationships in collegiate throwers. *Journal of Strength and Conditioning Research, 17*(4), 739-745.

Tabachnick, B. G., & Fidell, L. S. (2001). *Using multivariate statistics* (4th ed.). Needham Heights, MA: Allyn and Bacon.