RELATIONSHIP BETWEEN JUMP VARIABLES AND SPRINT ABILITY IN NCAA DIVISION III BASEBALL ATHLETES

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INTRODUCTION: Performance in baseball athletes is based upon high rates of force development that can influence swing velocity, throw velocity, and sprint speed. (Szymanski, Beiser, Bassett, Till, & Szymanski, 2011). Specifically, baseball athletes from more elite competition levels exhibit greater amounts of lean tissue, faster sprint speeds, and increased strength. (Hoffman, Vazquez, Pichardo & Tenenbaum, 2009; Spaniol, 2011). Maximal strength and power are related to baseball specific demands such as increased swing velocity, throw velocity and base running (Symanski, Derenne & Spaniol, 2008; Spaniol, 2011). Therefore, resistance training is critical to performance enhancement in baseball athletes. Among the most popular submaximal assessments with strength and conditioning professionals are two measures of neuromuscular performance: the countermovement jump (CMJ) and the squat jump (SJ) (Williams, Chapman, Jones, & Ball, 2018). Further, a common assessment of stretch shortening cycle (SSC) performance using the quotient between the CMJ and SJ is known as the eccentric utilization ratio (Mcguigan, Doyle, Newton, Edwards, Nimphius, Newton, 2006). Performance in the context of the SSC depends upon musculotendinous stiffness and is a critical component to jumping and sprinting (Brazier, Maloney, Bishop, Read, Turner, 2019). Linear speed is typically assessed via the 60-yd dash in baseball athletes although the specificity of this assessment for baseball has come into question, since baseball athletes rarely run this distance in competition (Spaniol, 2011). While there is support for the benefits of resistance training on baseball performance (Symanski, Derenne & Spaniol, 2008; Spaniol, 2011), additional research that addresses neuromuscular performance in collegiate baseball athletes throughout off-season training is of interest. Therefore, the purpose of this study was to assess relationships among measurements of vertical jump and sprint performance in National Collegiate Athletic Association (NCAA) Division III baseball athletes across a 10-week periodized resistance training program.

METHODS: Twenty-four NCAA Division III baseball athletes participated (Table 1). A 10-week periodized strength and conditioning program was implemented. For each testing session, the athletes performed a supervised standardized dynamic warm-up. Three familiarization trials were performed prior to jump testing and two for sprint testing. Subjects were assigned to one of two contact jump mats for all jumps. Estimated one-repetition max back squat (1RM-BS) data were collected only during post- assessments. *Squat Jump:* Subjects completed one trial at a time and then returned to the back of the line to recover. Each subject completed two trials and a third if the first two were not within ±0.1 in. To complete a trial, a static squat would begin the movement followed by maximal effort jump and a controlled landing. A 90° knee angle was visually estimated by the tester. The subject was instructed to jump straight out of the squat position with no countermovement keeping hands on the hips. All trials were counted with "3,2,1, JUMP!" and the athlete was instructed to initiate movement on "JUMP!". If the athlete did not land in a controlled manner or performed a tuck jump, an additional trial was given. The subjects were instructed to push as hard and as fast as possible and to jump as high as they could for each trial. *Countermovement Jump:* The trial began in a tall standing position with hands on hips followed by a rapid countermovement to a self-selected depth. Instructions for test administration were identical to those of the SJ. Again, two maximal effort jumps were recorded. If the second was not within ±0.1 in of the first, a third was recorded. The average of all administered trials was taken. *60-yard Dash:* All subjects were allowed 2 maximal effort attempts with the fastest time being recorded for the data collection. Timing gates were placed 60 yards away from each other. The subjects were instructed to stand behind a line ~2cm from the beam. Verbal encouragement was provided for each subject. *One-Repetition Max Back Squat:* During post testing only, maximal strength was assessed using estimated 1RM back squat. At the start of the data collection, the testers did not feel the athletes were ready to safely execute a proper maximal effort strength test. The athletes would go through a standard supervised warm-up followed by warm up sets beginning with a 20 kg barbell. Under supervision, the athletes progressed to a 3RM set. The 1RM was estimated from the 3RM value.

Data Collection and Analysis: Peak power (PP) was derived from jumps using the equation: PP (watts) = 60.7 * (jump height [cm]) + 45.3 * (body weight [kg]) – 2055. Eccentric utilization ratio (EUR) was calculated by dividing CMJ by SJ for both jump height (EUR_{JH}) and peak power (EUR_{PP}). Means and standard deviations are reported for all anthropometrics, pre- and post-measurements as well as changes over time (Table 1). Paired samples t-test was used to compare pre- and post-test values. Pearson Correlation Coefficients were used to evaluate each assessment for each time point and changes over time (Table 2). Data were analyzed using IBM SPSS Statistics v. 26.

TABLE 1. Physical characteristics and performance assessments

Subjects (n=24)		Assessment	PRE	POST	CHANGE
Age (years)	20.2 ± 1.35	Bodyweight (kg)	84.6 ± 11.78	86.08 ± 10.44	1.48 ± 5.12**
Height (cm)	182.35 ± 7.41	CMJ (in)	22.30 ± 2.77	22.64 ± 2.88	0.35 ± 1.34
Weight (kg)	84.6 ± 11.78	SJ (in)	21.34 ± 2.63	21.9 ± 2.73	0.55 ± 1.43
POST Absolute 1RM-BS	152.41 ± 26.27	EUR_{JH}	1.05 ± .06	1.03 ± .04	-0.01 ± .68
		CMJ_{PP} (W)	5213.81 ± 588.15	5335.28 ± 561.12	121.47 ± 214.57*
POST Relative 1RM-BS	1.81 ± .29	SJ_{PP} (W)	5068.31 ± 470.98	5220.83 ± 531.75	152.52 ± 210.58**
		EUR_{PP}	1.03 ± .04	1.02 ± .02	-0.01 ± .04
		60-Yd Dash (s)	7.24 ± .37	7.08 ± .35	-0.16 ± .11*

Notes: ** = significant at p<.01; * = significant at p<.05 CMJ = Countermovement Jump; SJ = Squat Jump; EUR = Eccentric Utilization Ratio; JH = Jump Height; PP = Peak Power; 1RM-BS = 1 repetition max back squat

RESULTS: Significant increases were found in body weight, CMJ_{PP} and SJ_{PP} and a significant decrease in 60-yd dash time (Table 1). Significant relationships were found between jump variables but not with 60-yd dash (Table 2). 1RM-BS performance displayed positive relationships with CMJ and SJ and a negative relationship with 60-yd dash.

TABLE 2. Relationships Between Performance Measurements

Assessment	BW	CMJ (in)	SJ (in)	EUR_{JH}	CMJ_{PP} (W)	SJ_{PP} (W)	EUR_{PP}	60-yd dash (s)
BW	1							
CMJ (in)	-0.171	1						
SJ (in)	-0.334	.518**	1					
EUR_{JH}	0.208	0.377	-.592**	1				
CMJ_{PP} (W)	0.327	.875**	0.333	.463*	1			
SJ_{PP} (W)	0.149	.457*	.882**	-.518**	.512*	1		
EUR_{PP}	0.131	.440*	-.531**	.980**	.486*	-.492*	1	
60-Yd Dash (s)	0.268	0.045	-0.096	0.171	0.175	.034	0.122	1

Notes: ** - indicates correlation with significance at α = .01 (99%) * - indicates correlation with significance at α = .05 (95%) CMJ = Countermovement Jump; SJ = Squat Jump; EUR = Eccentric Utilization Ratio; JH = Jump Height; PP = Peak Power

DISCUSSION: The purpose was to assess relationships among measurements of vertical jump and sprint performance in NCAA Division III baseball athletes across a 10-week periodized resistance training program. The primary findings indicate increased lower extremity neuromuscular performance as is demonstrated by an improved vertical jump and faster sprint time. There were no significant relationships between 60-yd dash and other performance tests. However, baseball athletes rely primarily on acceleration which occurs in the first 10m of a sprint (Coleman & Amonette, 2012; Delecluse, 1997) and will rarely reach maximum velocity as in the case of the 60-yd dash. Bodyweight increased along with an increase in vertical jump performance and peak power, indicating that performance likely increased through increased neuromuscular capacity rather than changes in body weight. As expected, the eccentric utilization ratio was significantly related to vertical jump performance. Interestingly, changes in eccentric utilization ratio demonstrated a strong negative relationship with SJ performance but did not relate to CMJ performance. This indicates that changes in eccentric utilization ratio may be more sensitive to changes in SJ than CMJ, which provides implications for interpretation and monitoring SSC in this population. Musculotendinous stiffness has been shown to influence force production and absorption (Brazier, Maloney, Bishop, Read, Turner, 2019). Adaptations within the muscle and/or tendon can influence vertical jump performance and vary from one test to another (i.e. CMJ vs. SJ). Some limitations to the current study include the time of day that jump testing was performed and the use of contact mats vs force platforms prevented the ability to account for any low amplitude countermovement that may have occurred during SJ testing.

CONCLUSION AND PRACTICAL APPLICATION: Analyzing stretch shortening cycle function can differentiate adaptations acquired through training based upon the phase of training and the desired outcome (Mcguigan, et al. 2008). The appropriate assessment of sport specific demands is integral to program design and implementation. The 60-yd dash may not be an accurate assessment of performance in baseball athletes. Therefore, it is recommended that baseball practitioners include sport-specific testing to monitor the training process specific to the demands of their sport. Additionally, eccentric utilization ratio may provide insight into training adaptations that can influence force production in explosive movements such as jumping and sprinting (Brazier, Maloney, Bishop, Read, Turner, 2019); therefore, consistent monitoring of the eccentric utilization ratio in collegiate baseball athletes may assist the practitioner with individual athlete goal setting.

REFERENCES

Brazier, J., Maloney, S., Bishop, C., Read, P.J., & Turner, A.N. (2019). Lower Extremity Stiffness: Considerations for Testing, Performance Enhancement, and Injury Risk. *Journal of Strength and Conditioning Research, 33(4), 1156-1166.*

Coleman, E., Amonette, W.E. (2012). Pure Acceleration is the Primary Determinant of Speed to First-base in Major-League Baseball Game Situations. *Journal of Strength and Conditioning Research, 26*(6), 1455-60.

Delecluse, C. (1997) Influence of strength training on sprint running performance. *Sports Med. 24,147–156.*

Hoffman, J. R., Vazquez, J., Pichardo, N., & Tenenbaum, G. (2009). Anthropometric and performance comparisons in professional baseball players. *Journal of strength and conditioning research*, 23(8), 2173-2178.

Inkster, A., Murphy, A., Bower, R., & Watsford, M. (2011). Differences in the Kinematics of the Baseball Swing between Hitters of Varying Skill. *Medicine & Science in Sports Exercise, 43*(6), 1050–1054.

Mcguigan, M. R., Doyle, T. L. A., Newton, M., Edwards, D. J., Nimphius, S., & Newton, R. U. (2006). Eccentric utilization ratio: effect of sport and phase of training. *Journal of Strength and Conditioning Research, 20.*

Spaniol F.J. (2009) Baseball athletic test: a baseball-specific test battery. *Strength Cond Journal*, 31(2), 26–29.

Szymanski, D. J., Beiser, E. J., Bassett, K. E., Till, M. E., & Szymanski, J. M. (2011). Relationships Between Sports Performance Variables and Bat Swing Velocity of Collegiate Baseball Players. *Journal of Strength and Conditioning Research, 25*, S122.

Szymanski, D. J., Derenne, C., & Spaniol, F. J. (2009). Contributing factors for increased bat swing velocity. *Journal of Strength and Conditioning Research*, *23*(4), 1338–1352.

Williams, K. J., Chapman, D. W., Jones, J. V, & Ball, N. (2018). Current Practices in Monitoring and Maximising Explosive Power in Strength and Conditioning. *Journal of Australian Strength & Conditioning, 26(2)*, 35–41.