RELATIONSHIPS BETWEEN LOWER EXTREMITY POWER AND BAT VELOCITY AND EXIT VELOCITY IN COLLEGIATE SOFTBALL PLAYERS

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INTRODUCTION

For a softball and baseball hitter, benefits of increased bat velocity are increased decision time, decreased swing time, and increased exit velocity (9). Among these benefits, increased exit velocity has been shown to be a distinguishing performance variable between various levels of baseball and softball players (9). To positively influence exit velocity and performance, softball players need to generate, absorb, and transfer forces from the proximal to distal segments (3). During hitting, force is initially generated in the legs and transferred to the hips, spine, trunk, and upper extremities, and ultimately out to the bat and ball (2).

Tests of lower extremity power have been shown to be correlated to hitting and throwing performance in baseball and softball players (4,5,10,11). Countermovement jump testing is a useful physical performance functional test of the lower extremity (5, 6). The ground reaction forces measured from jump testing using force plates provides valuable information on power production capabilities, and how efficiently and fast a player can generate and absorb forces in the lower extremity (6,11).

The purpose of this study was to examine the relationship between lower extremity power and bat velocity and exit velocity in collegiate softball players. The secondary purpose was to examine the relationship between the forces produced while hitting and bat and exit velocities. We hypothesized that collegiate softball players with greater lower extremity power would possess greater bat velocity and greater exit velocity while hitting. A better understanding of these relationships may provide coaches and clinicians advanced knowledge for the implementation of evaluating talent, developing hitting skills, and training programs to improve performance.

METHODS

Nineteen Division I collegiate softball players (age = 20.2 ± 1.6 years; height = 167.7 ± 5.9 cm; body mass = 69.4 ± 7.5 kg; lean body mass = 51.2 ± 4.7 kg; percent body fat = 26.0 ± 5.0%) volunteered for this study. Lower extremity power was assessed while completing jump performance testing on force plates. Maximum effort jump tests included bilateral countermovement jump (BCMJ) (Figure 1), unilateral countermovement jump (UCMJ) (Figure 2), lateral to medial jump (LMJ) (Figure 3), and standing long jump (SLJ) (Figure 4). Peak power, relative peak power, and maximum jump height or distance was recorded and used for data analysis.

In the hitting trials for this study, athletes completed five swings with a ball placed on a batting tee positioned at the middle of the femur. Bat velocity was recorded using a Blast Motion sensor (1) placed on the knob of the bat (Figure 5). Exit velocity was recorded using a Stalker Pro radar gun positioned behind a screen directly in front of the batted ball (Figure 6). Force plate measurements were captured with AMTI force plates for drive and stride foot (Figure 7). Recorded measurements included mean bat velocity (MBV), best bat velocity (BBV), mean exit velocity (MEV), and best exit velocity (BEV). Peak forces were also recorded for the drive (back) and stride (front) foot in the vertical direction (HitDrive-Fz; HitStride-Fz), the anteroposterior force in the sagittal plane (HitDrive-Fy; HitStride-Fy), and the lateral force in the frontal plane (HitDrive-Fx; HitStride-Fx).

Separate simple regression analyses were conducted. Independent variables consisted of BCMJ, UCMJ, LMJ, and SLJ. The dependent variables consisted of MBV, BBV, MEV, and BEV. Interpretation of correlation coefficient is based on the suggestion of Safrit and Wood (8). Correlations were listed as high (± 0.800 - 1.00), moderately high (± 0.600 - 0.799), or moderate (± 0.456 - 0.599). Statistical significance was set at an alpha level of $p \le 0.05$.

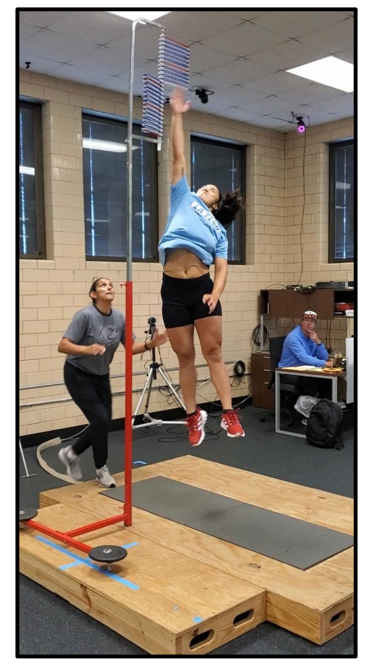

Figure 1. Bilateral countermovement jump with Vertec from Bertec force plates.

Figure 2. Unilateral countermovement jump with Vertec from Bertec force plate.

Figure 3. Lateral to medial jump from AMTI portable force plate.

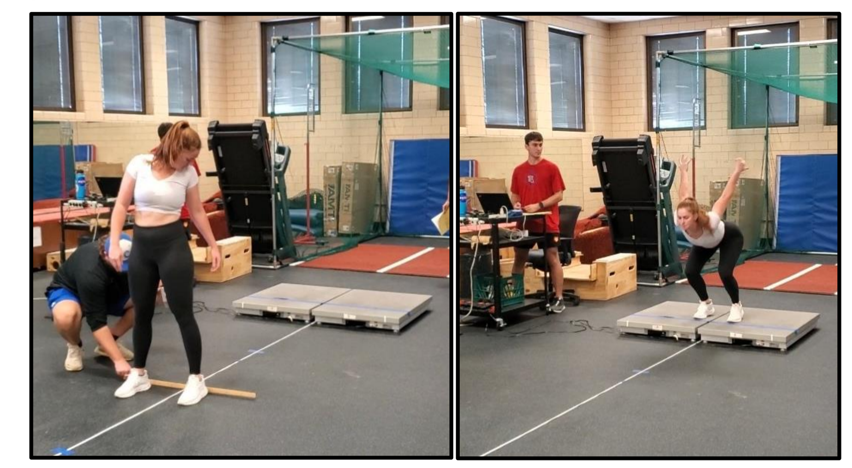

Figure 4. Standing long jump from AMTI portable force plates.

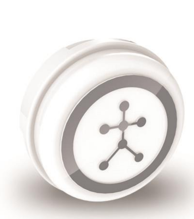

Figure 5. Blast Motion sensor used to measure bat velocity.

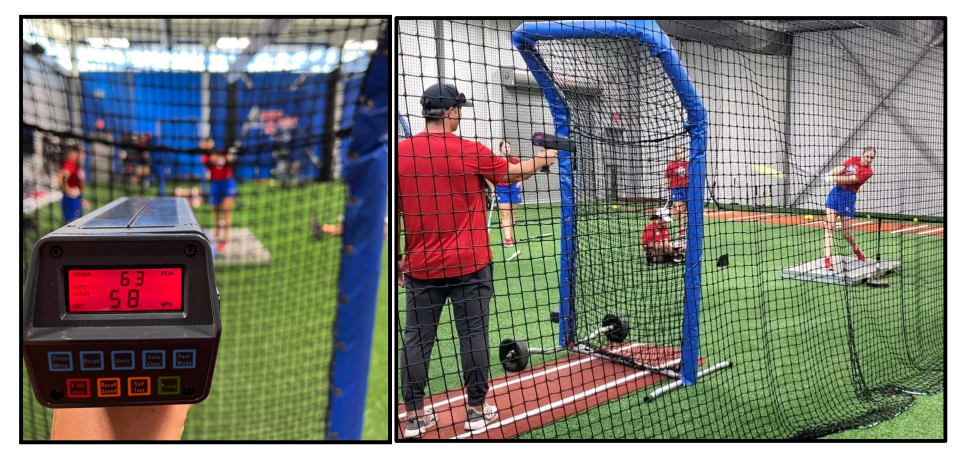

Figure 6. Stalker Pro radar gun used to measure exit velocity from behind screen.

Figure 7. Hitting from AMTI portable force plates.

RESULTS

Table 1. Descriptive Statistics of Exit Velocity, Bat Velocity, and Bilateral Countermovement Jump Variables.

Variable	Mean	SD	Min	Max
Mean Exit Velocity (m/s)	29.55	1.54	27.1	33.0
Best Exit Velocity (m/s)	30.40	1.53	27.7	33.5
Mean Bat Velocity (m/s)	28.37	1.45	25.9	31.3
Best Bat Velocity (m/s)	29.68	1.65	26.0	32.2
Bilateral Countermovement Jump Height (cm)	45.05	6.76	34.29	58.42
Bilateral Countermovement Jump Peak Power (W)	3350.26	481.58	2670.51	4268.70
Bilateral Countermovement Jump Peak Power/ Lean Body Mass (W/ kg)	65.41	6.92	57.64	80.85
Hitting Stride Leg Lateral Force in Frontal Plane (N)	258.90	255.64	12.95	689.65

Table 2. Correlations Between Bat Velocity and Exit Velocity and Lower Extremity Power Variables.

Lower Extremity Power and Hitting Performance Variables	*r*	R^2	F	B	*p*
BCMJ-Ht and BBV	0.458	0.210	4.518	0.112	0.048*
HitStride-Fx and BBV	0.569	0.324	8.155	0.004	0.011*
BCMJ-PP and MEV	0.502	0.252	5.739	0.002	0.028*
BCMJ-Ht and MEV	0.474	0.225	4.927	0.108	0.040*
BCMJ-PP/ LBM and MEV	0.648	0.420	11.602	0.147	0.004*
BCMJ-PP and BEV	0.484	0.234	5.199	0.002	0.036*
BCMJ-PP/ LBM and BEV	0.495	0.245	5.184	0.110	0.037*

High	0.800-1.00
Moderately High	0.600-0.799
Moderate	0.456-0.599

CONCLUSIONS

This study showed significant relationships between lower body power and increased bat and exit velocity in collegiate softball players. It also affirmed previous research indicating that stride foot forces have a relationship to hitting performance in baseball and softball athletes (7). Bilateral countermovement jump height (BCMJ-Ht) was significantly related to BBV and MEV. Bilateral countermovement jump peak power (BCMJ-PP) was significantly related to MEV and BEV. Bilateral countermovement jump peak power normalized for lean body mass (BCMJ-PP/ LBM) was significantly related to MEV and BEV. While hitting, lateral force of the stride foot in the frontal plane (HitStride-Fx) was significantly related to BBV. There were no significant relationships between UCMJ, LMJ, or SLJ with bat velocity (BV) and exit velocity (EV) metrics.

PRACTICAL APPLICATIONS

A collegiate softball player who has greater lower extremity power capabilities has the potential to produce increased BV and EV. Higher power output during countermovement jump testing can be a useful, predictive, and evaluative tool to identify athletes who have the potential to hit with either greater BV or EV. Strength and conditioning coaches and sport coaches should consider this information to integrate appropriate training programs designed to improve lower body power of collegiate softball players to improve hitting velocities. Those that recruit college softball players may want to look for more powerful individuals, especially relative to their lean body mass, since there was a relationship between lower body power relative to lean body mass and greater BV and EV. If applicable, a coach should look at stride foot force production when hitting as it may identify a greater ability to transfer force from the ground into the bat and ball. For many programs, a countermovement jump performed with a Vertec (jump height measuring device) that estimates peak power could be a more cost-effective option in player evaluation since force plates may be cost prohibitive.

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