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Relationships Between Isokinetic Core Strength and Field Based Athletic Performance Tests in Male Collegiate Baseball Players

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ABSTRACT

Clayton MA, Trudo, CE, Laubach LL, Linderman JK, De Marco GM, Barr S. Relationships Between Isokinetic Core Strength and Athletic Performance Tests in Male Collegiate Baseball Players. **JEPonline** 2011;15(5):20-30. Core strength and its relation to sport performance is a focal point of athletic training programs. The purpose of this study was to determine the relationships between isokinetic core strength and multiple measures of athletic performance in male collegiate baseball athletes. Subjects included 29 male collegiate baseball players (20.4 ± 1.6 yrs). All subjects participated in 5 data collection sessions, including 2 familiarization meetings. Data collection included measures of body composition, athletic performance tests, and isokinetic core strength. The primary finding of this research was that the Backwards Overhead Medicine Ball (BOMB) throw consistently produced significant correlations with all measures of isokinetic core strength, with the highest correlation observed between the BOMB throw and trunk flexion ($r = .680$; $P=0.05$). Statistically significant relationships were also found between trunk flexion and body weight, BMI, BodPod percent body fat, fat weight, and body weight. The complexity of core musculature must be considered when selecting assessments of core strength, with special attention to their impact on sport specific movements.

Key Words: Trunk, Torso, Flexion, BOMB Throw

INTRODUCTION

Presently, the relationship between core strength and athletic performance is a focal point of many training paradigms. It is a common misconception that an individual's "core" consists of the anterior abdominal musculature (i.e., the rectus abdominis muscles). Core strength is more accurately defined to include muscles of the upper thigh, gluteals, and lower back. It is generally accepted by fitness professionals (1,2) that core strength and stability are related to peak sport performance.

Due to the complexity of core strength, there are a variety of measures that can be used. Many researchers often use the McGill standardized testing battery to measure core strength (6,11-13,20). The McGill test protocol is a series of tests that measures four static trunk holds: (a) the back extensor test; (b) the abdominal fatigue test; and (c) the two lateral bridge tests. Although the testing battery is commonly used to measure core stability and endurance, for many athletes it is not specific to sport movements. Other professionals (4,8,9) suggest using alternative methods of measuring core strength through sports specific performance tests.

According to Okada et al. (13), to improve functional movement of sport related skills, athletes should perform training exercises that are similar to the movements and motions used during competition. Peak athletic performance requires high levels of stability, strength, and power. Power, the product of force and velocity, is achieved when the optimal combination of these variables is used throughout a muscle contraction (10). Current literature indicates that the Backward Overhead Medicine Ball (BOMB) test is a valid method of evaluating lower body and trunk power.

Stockbrugger and Haennel (16) reported significant correlations between vertical jump height and medicine ball throwing distance. Therefore, they proposed that the BOMB test is a valid field test of athletic performance. Other health and sport science experts suggest that Olympic lifts (e.g., power clean) would be efficacious for training or as a measure of both core strength and power. Hoffman and colleagues (7) reported a statistically significant improvement in vertical jump height with Olympic weight training. According to Stockbrugger and Haennel (16) and Hoffman et al. (7), the vertical jump and Olympic lifts such as the hang clean highlight the importance of core strength/power in athletics.

Seeking to determine the effects of functional core exercise interventions on athletic performance (3,13,15), investigators have provided a focus for strength and conditioning research. Stanton et al. (15) examined the effects of a Swiss ball training intervention on core stability and running economy. Although there were no statistically significant changes between oxygen consumption (VO_2) or running economy, they reported a statistically significant difference in pre- to post-test scores in core stability and the Swiss ball prone stabilization time to failure test.

While the preponderance of related research has focused on the effects of core strengthening interventions, few studies have examined the relationships between core strength and athletic performance. Nesser and Lee (12) examined the relationship between core strength and performance in Division I soccer players. They found no significant correlations between core strength/stability and performance measures. Additionally, in an earlier paper, Nesser et al. (11) examined the relationship between core strength/stability and performance tests in Division I football players and found weak to moderate correlations. The findings of these studies could be results of either the tests used to measure core strength are not specific to athletic strength and power and/or the possibility that core strength plays a minor role in athletic strength and performance.

The current literature focusing on the relationship between core strength and athletic performance is limited. Additionally, at present time, neither the McGill Test Battery nor any of the other methods

have been compared with measures of isokinetic core strength. Thus, the primary purpose of this study is to investigate the relationship between isokinetic core strength and multiple measures of field based core strength and power. Specifically, this investigation will develop correlations between isokinetic trunk flexion, trunk extension, and trunk rotation with the McGill Test Battery, vertical jump, BOMB throw, and the hang clean. A secondary purpose of this research is to explore relationships between body composition and measures of isokinetic trunk strength and athletic performance.

METHODS

Subjects

The subjects in this study consisted of 29 male college baseball players from the University of Dayton, OH. The subjects were moderate to highly trained, as defined by their current involvement in collegiate athletics. Participation was voluntary and individual performance data were not shared with the coaches. Prior to participation, all subjects signed informed consent forms approved by the University of Dayton Institutional Review Board.

Procedures

Each subject included in the final analysis completed 5 sessions of data collection and 2 sessions of familiarization. As outlined below, data collection included measures of body composition, isokinetic core strength, and athletic performance.

Body Composition

Subject's height and weight were measured with an anthropometer and calibrated digital scale, respectively. Body mass index was calculated for each subject. Percent body fat was measured and assessed via BodPod techniques following the BodPod Body Composition Tracking System protocol (5) of air displacement and whole body densitometry. Percent body fat, lean mass, and fat mass were recorded for BodPod measurements.

Athletic Performance Tests

Athletic performance assessments included the vertical jump, hang clean, Backward Overhead Medicine Ball (BOMB) throw, and McGill plank battery. Each subject completed a familiarization session of all performance tests in order to prepare mentally and physically for the testing session. During the familiarization session, the researchers made sure that the subjects demonstrated proper form and technique for each of the tests. Familiarization session and testing session were separated by at least 24 hr. After completing a familiarization session, subjects performed the athletic tests to the best of his ability. Only the testing data were recorded for each subject.

To maximize performance across multiple testing trials, the order of the athletic tests were completed as suggested by the National Strength and Conditioning Association: (a) vertical jump; (b) hang clean; (c) BOMB throw; and (d) McGill plank battery.

A. Vertical Jump

Vertical jump was measured using a standing Vertec measuring instrument. The subject's standing reach height was obtained by standing below the Vertec and extending one arm straight above his head attempting to reach as high as possible. Next, the subject's jump height was obtained by completing 3 no-step vertical jumps. The best of the 3 jump attempts was recorded. Vertical jump was calculated by subtracting standing reach height from vertical jump height.

B. Hang Clean

All subjects were previously familiarized with the hang clean movement since it was part of their team strength training program. Subjects followed Nesser and Lee (12) repetition max protocol to find hang clean max. They started each lift with 50% of their approximate 1 repetition maximum (RM) and increased 10-20 kg until 1RM was determined. Starting weight was pre-determined based on hang clean weight lifted in previous team training sessions. All subjects were instructed to achieve their maximum hang clean within 5 total lifts. Subjects started in a standing athletic position with knees slightly bent while holding an Olympic bar at knee height. Once the starting position was achieved, using a full body motion, subjects launched the bar upward to shoulder height in a quick, controlled manner. The lift was finished in a standing, controlled position with the bar resting on the subject's chest and shoulders.

C. BOMB (Backward Overhead Medicine Ball) Throw

Each subject started in an athletic position with the heels of their feet behind a pre-determined starting point. Then, the subject launched a 20-lb medicine ball backwards over their head as far as possible. Subjects performed the movement 3 times with each throw measured to the closest inch. The best of 3 throws was recorded for each subject.

D. McGill Battery

The McGill Battery was conducted following the procedures of Tse and colleagues (20) to test the subjects' muscular endurance and strength of the core. Each subject completed a series of 4 static plank holds including: (a) abdominal fatigue; (b) back extensor; (c) right side bridge; and (d) left side bridge. Each subject was instructed to hold each static plank until he chose to stop or proper form was broken.

Isokinetic Core Strength

Core strength was assessed using Cybex isokinetic equipment that measured torque produced against different speeds. Two isokinetic machines were used; one to measure torso rotation and one for torso extension-flexion. Similar to the athletic performance tests, the subjects completed a familiarization session on both machines prior to testing. Prior to core strength tests, the subjects rode a bicycle at low resistance for approximately 10 min for warm-up purposes. Measures of trunk extension-flexion and rotation were obtained following the procedures of Smith et al. (14). Verbal support was provided to encourage maximal effort by the subjects. Any report of symptoms of pain, shortness of breath, and/or dizziness during the testing session was recorded.

A. Extension-Flexion

Each subject was securely positioned in the Cybex trunk extension-flexion stabilization unit where he stood on an adjustable foot frame facing forward with scapulae and lower back resting on adjustable support frames. A popliteal pad was adjusted to support the back of the knee and to maintain an approximate 15° flexion at the knee. An adjustable posterior scapulae pad was positioned at approximately the level of inferior angle of the scapulae. Stabilization pads were secured above and below the knees, across the chest just below the sternal notch, and a fabric belt was strapped across the waist. The padded chest bar had a handle in which the subjects were instructed to grasp. Subjects' upper and lower body were secured and stabilized to isolate muscles of the trunk. Flexion and extension ranged from approximately 0° to 80° as positioned on the Cybex.

A series of 5 trunk extension-flexion sets were completed in a consecutive pattern following 60°, 90°, 120°, 90°, and 60° per sec, accomplishing 5 repetitions per set. Prior to each set requiring maximal performance, each subject completed 3 trial submaximal repetitions to be accustomed to the speed setting. After the trial set, all subjects had a 20-sec rest before performing maximal effort at the

respective speed. There was another 20-sec rest before advancing to the next trial and set. For flexion and extension individually, the mean peak torque generated in foot/pounds was computer recorded for the subject at each speed.

B. Torso Rotation

Each subject was securely positioned in the Cybex torso rotation stabilization unit. Subjects sat on a padded, adjustable seat with hips and knees flexed at a 90° angle with the feet flat on an adjustable support frame. Seat height was adjusted so shoulders rested against a posterior shoulder pad and spine maintained neutral position. An over-head unit stabilized the subject's upper body with a ventral chest pad that connected to the shoulder pad. Stabilization pads were secured at the hips and knees, and a fabric belt was strapped across the waist. Subjects' upper and lower body were secured and stabilized to isolate muscles of the trunk. Left and right rotation ranged from approximately 45° to 45° on each side for a total of 90° rotation. Subjects were instructed to maintain the head and neck in neutral face-forward position while holding handles on the front of the chest pad of the over-head unit.

A series of 5 torso rotation sets were completed in a consecutive speed pattern of 60°, 120°, 180°, 120° and 60° per sec. Subjects completed 5 repetitions per set at 60° and 120° per sec and 18 repetitions at 180° per sec. Prior to each set requiring maximal performance, subjects completed 3 trial submaximal repetitions to be accustomed to the speed setting. After the trial set, subjects had a 20-sec rest before performing maximal effort at the respective speed. There was another 20-sec rest before advancing to the next trial and set. For both left and right rotation individually, the mean peak torque generated in foot/pounds was computer recorded for the subject at each speed.

Statistical Analyses

Statistical analyses were conducted using SPSS (Statistical Package for Social Science, Version 17.0) software. Descriptive statistics were calculated separately for subjects' anthropometrics, field-based athletic performance tests, and torque measures of isokinetic core strength, as described in Tables 1, 2, and 3 respectively. Data analysis consisted of Pearson Product Moment Correlations (r) between measures of anthropometrics, field based athletic performance tests, and isokinetic core strength. Statistically significant correlations were at $P=0.05$ level of probability.

Each unit measure of flexion, extension, left rotation, and right rotation contained 3 individual variables obtained from the different speed settings used in testing, resulting in a total of 12 values of isokinetic core strength. To minimize the number of isokinetic core strength variables, a multicollinearity matrix was developed. Since the correlations among each individual measure of flexion, extension, left rotation, and right rotation were statistically significant at or beyond $r = .70$, the mean of the three measures for each unit was derived. This technique created four average measures of isokinetic core strength, being trunk flexion, trunk extension, left torso rotation, and right torso rotation, which were used as standard measures for analysis. Independent samples t-tests were calculated to examine statistical differences between trunk flexion-extension and left-right trunk rotation.

RESULTS

Tables 1, 2, and 3 present the descriptive statistics for subject characteristics, field based athletic performance tests, and isokinetic core strength.

Table 1. Descriptive characteristics of the 29 subjects.

Variable	Mean \pm SD	Range
Age (yrs)	20.43 \pm 1.55	18-23
Height (cm)	182.56 \pm 5.99	171.40-195.70
Weight (kg)	86.97 \pm 11.53	63.98-119.52
BMI (kg/m ²)	26.08 \pm 3.00	18.8-31.9
BodPod (% Fat)	14.18 \pm 4.84	5.8-27.0
Fat Weight (kg)	12.75 \pm 5.85	3.7-28.6
Lean Weight (kg)	74.23 \pm 6.92	60.3-94.0

Table 2. Descriptive characteristics of the field based athletic performance tests.

Variable	Mean \pm SD	Range
Vertical Jump (in)	24.71 \pm 3.25	19.0-31.5
Hang Clean (lbs)	193.16 \pm 32.89	130.0-260.0
BOMB (ft)	31.25 \pm 3.92	22.17-38.42
Back Extension (min)	1.57 \pm 0.36	1.07-2.38
Abdominal Fatigue (min)	1.74 \pm 0.81	0.43-4.57
Left Plank (min)	1.66 \pm 0.58	0.90-3.03
Right Plank (min)	1.45 \pm 0.44	0.85-2.47

Table 3. Descriptive characteristics of isokinetic core strength.

Variable	Mean \pm SD	Range
Trunk Flexion Avg (ft•lb)	174.67 \pm 24.65	130.67-233.67
Trunk Extension Avg (ft•lb)	209.76 \pm 42.04	114.33-280.00
Left Trunk Rotation Avg (ft•lb)	99.98 \pm 20.21	60.00-142.00
Right Trunk Rotation Avg (ft•lb)	99.26 \pm 20.81	61.00-161.33

Anthropometrics and Isokinetic Core Strength

There were no statistically significant relationships between anthropometrics and isokinetic core strength measures of trunk extension, trunk left rotation, or trunk right rotation (Table 4). Trunk flexion showed statistically significant relationships with measures of anthropometrics and body composition (Table 4). Statistically significant relationships were observed between trunk flexion and body weight ($r = .681$), BMI ($r = .614$), percent body fat ($r = .555$), fat weight ($r = .597$), and lean weight ($r = .630$).

Table 4. Pearson correlations between anthropometrics and isokinetic core strength.

Variable	Trunk Flexion	Trunk Extension	Left Trunk Rotation	Right Trunk Rotation
Height (cm)	.298	.302	-.069	.055
Weight (kg)	.681*	.285	.118	.210
BMI (kg/m²)	.614*	.175	.181	.212
BodPod (% Fat)	.555*	.215	.034	.112
Fat Weight (kg)	.597*	.212	.020	.106
Lean Weight (kg)	.630*	.295	.178	.261

*statistically significant at P=0.05 level of probability

Anthropometrics and Field Based Athletic Performance

The correlations between anthropometrics and field based athletic performance tests are represented in Table 5. There were no statistically significant relationships between anthropometrics and the hang clean or back extension test. The vertical jump revealed significant inverse relationships with body fat

Table 5. Pearson Correlations between anthropometrics and field based athletic performance tests.

Variable	Vertical Jump	Hang Clean	BOMB	Back Extension	Abdominal Fatigue	Left Plank	Right Plank
Height (in)	-.219	-.421	.355	.140	-.146	-.318	-.361
Weight (kg)	-.327	.055	.636*	-.190	-.321	-.365	-.475*
BMI (kg/m²)	-.231	.316	.533*	-.264	-.292	-.230	-.339
BodPod (% Fat)	-.452*	.006	.276	-.378	-.419*	-.452*	-.501*
Fat Weight (kg)	-.455*	-.052	.377	-.363	-.425*	-.468*	-.535*
Lean Weight (kg)	-.162	.131	.739*	.031	-.183	-.248	-.351

*statistically significant at P=0.05 level of probability

percent ($r = -.452$) and fat weight ($r = -.455$). Significant relationships were found between performance on the BOMB throw and body weight ($r = .636$), BMI ($r = .533$), and lean weight ($r = .739$). The abdominal fatigue test indicated inverse significant correlations with percent body fat ($r = -.419$) and fat weight ($r = -.425$). Percent body fat and fat weight indicated significant inverse relations to the left plank test, $r = -.452$ and $r = -.468$ respectively. Lastly, the right plank test indicated statistically significant inverse correlations with body weight ($r = -.475$), percent body fat ($r = -.501$), and fat weight ($r = -.535$).

Field Based Athletic Performance and Isokinetic Core Strength

Of the field based athletic performance tests, only the BOMB throw revealed statistically significant relationships to all measures of isokinetic core strength. The BOMB throw and trunk flexion indicated the greatest significant relationship, $r = .680$ (Table 6).

Table 6. Pearson Correlations for Isokinetic Core Strength and Field Based Athletic Performance Tests.

Variable	Vertical Jump	Hang Clean	BOMB	Back Extension	Abdominal Fatigue	Left Plank	Right Plank
Trunk Flexion	-.179	.119	.680*	-.207	.000	-.053	-.159
Trunk Extension	.060	.340	.594*	.272	.195	.265	.068
Left Trunk Rotation	.099	.425	.607*	.354	.299	.397*	.227
Right Trunk Rotation	-.115	.315	.572*	.248	.336	.321	.157

*statistically significant at $P=0.05$ level of probability

DISCUSSION

Anthropometry and Isokinetic Core Strength

The present study found significant correlations between trunk flexion and anthropometric and athletic performance variables. Specifically, mean trunk flexion strength was the only variable with statistically significant correlations to all measures of anthropometry and body composition. At the outset of the present study, it was hypothesized that measures of body composition, specifically lean body mass and fat body mass, would show the greatest relationships to isokinetic core strength. However, it was found that body mass had the greatest correlation to isokinetic core strength, specifically with trunk flexion.

Anthropometrics and Field Based Athletic Performance

For field based performance tests, the hang clean and back extension yielded no statistically significant correlations with any measures of anthropometry. Contrary to the observed relationship between body weight and isokinetic core strength, measures of percent body fat, lean body mass, and fat body mass produced significant correlations with the field based athletic performance variables. Although body weight yielded significant correlations to the BOMB throw and right plank, noticeably more relationships were statistically significant with measures of body composition. Both body fat percentage and fat mass revealed statistically significant inverse correlations with vertical jump, abdominal fatigue, left plank, and right plank, suggesting greater abdominal fatigue capacity in leaner individuals. For all observed variables of athletic performance, lean body mass revealed the greatest correlation with the BOMB throw, $r = .739$, suggesting that this particular field measure of strength and power was associated with lean mass of the individual.

Field Based Athletic Performance Tests and Isokinetic Core Strength

The field based athletic performance measures with the exception of the BOMB throw yielded low and statistically insignificant correlations with isokinetic core strength variables. However, the BOMB throw yielded statistically significant correlations with all measures of isokinetic core strength ranging from $r = .572$ with trunk right rotation to $.680$ with trunk flexion. The significant relationship between the BOMB throw and trunk flexion conflicted with the researchers initial assumptions. The BOMB throw is a backward motion that incorporates extension of the upper body, lower body, and core, thus the movement itself would suggest that isokinetic measures of trunk extension would have reflected the greatest relationship. It is speculated that since the subjects began the movement in a forward athletic position with the knees and hips flexed, the power produced in the backward throw perhaps derives in the initial flexion stance rather than the extension movement. Alternatively, greater stability of the trunk as suggested from isokinetic measures of trunk flexion may produce greater performance on the BOMB test.

CONCLUSIONS

The complexity of the core anatomy challenges the researchers' ability to identify objective measures of core strength relative to dynamic athletic performance. In an attempt to more accurately assess athletic performance, this research included isokinetic and dynamic measures of core strength, in contrast to the commonly accepted McGill Battery which is limited to static tests of muscular endurance. Furthermore, using laboratory-objective data versus field based-subjective data allowed the researchers to examine variations in practical and applicable measures of core strength and performance. Performance on the BOMB throw yielded statistically significant relationships with anthropometric measures of body weight, BMI, and lean weight as well as the following measures of isokinetic strength: (a) trunk flexion, (b) trunk extension, (c) trunk left rotation, and (d) trunk right rotation. These data strongly suggest that the BOMB throw may be used as a practical and reliable predictor of core strength. These data contribute to the growing body of research on core strength and athletic performance. Future studies should investigate changes in isokinetic core strength and changes in performance tests (i.e., BOMB throw) with core training.

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