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A Correlation Between Core Stability and Athletic Performance: An Electromyographic Study

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Abstract

Study Design: Correlation study.

Objectives: To objectively evaluate the relationship between core stability and athletic performance measures in male collegiate athletes.

Background: The relationship between core stability and athletic performance has yet to be quantified in the available literature. The current literature does not demonstrate whether or not core strength relates to functional performance. Questions remain regarding the most important components of core stability, the role of sport specificity, and the measurement of core stability in relation to athletic performance.

Methods: A sample of 30 volunteer student athletes from Jamia Millia Islamia provided informed consent. Participants performed two tests: single arm raising experimental (core stability test) and a backward overhead medicine ball throw (power performance). Each participants performed tests in randomized order.

Results: Correlations between the core stability test and performance test was determined using Karl's Pearson correlation coefficient. Medicine ball throw positively correlated to the core stability test (r =0.71, p=0.023). Coefficient correlation minutely changed in between top and bottom performers. Gender was the most strongly correlated variable to core strength, males with a mean measurement of double leg lowering of 47.43 degrees compared to females having a mean of 54.75 degrees.

Conclusions: There appears to be a strong link between a motor control of core stabilizers and athletic performance tests. Performance test used in study needed precise timing of core muscles so that explosive power created in legs and core can be efficiently transferred to the throwing arm. More research is needed to determine if there are specific sub-categories of athletic performance (other than power) which can correlate with motor control of core. However, future studies should seek to correlate more tests of athletic performance with motor control of core stabilizers.

Keywords: Core stability; BOMB-throw; Performance; Power.

Introduction

In most of sports activities, the human body acts in the form of a kinetic chain and the core serves as the center of this functional kinetic chain. The kinetic chain is the coordinated, sequenced activation of body segments that places the distal segment in the optimum position at the optimum velocity with the optimum timing to produce the desired athletic task. For optimum functioning of kinetic chain, two aspects of it i.e. stability and mobility should work together in harmony. Mobility is required at distal segment of limb to complete athletic task. On the other hand, stability is required at proximal part of kinetic chain i.e. core. For the kinetic chain to function at its maximal capability, athletes must maximize the relationship between providing sufficient stability while producing forceful motions of sport performance. Since the core is central to almost all kinetic chains of sport performance tasks, control of core stability,

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core strength, and motion will maximize upper and lower body extremity function.[1]

Success in a majority of sports is dependent upon producing external forces while maintaining dynamic stability. Balance is maintained by keeping the body's center of gravity over its base of support. External forces have the potential to disrupt balance by altering the center of gravity.[17] While external loads are acting on the body, internal forces, particularly in the lumbo-pelvic-hip complex, are utilized to maintain equilibrium of the body.[18] Communication between the musculature of the core and the neuromuscular system is what enables the body to regain this new equilibrium state[19], and allow for core stability to occur.

Figure 2: Electrode Placements

Anticipatory postural adjustments of the core are determined by pre-programmed muscle activations.[1] Ebenbichler et al[20] demonstrated this concept in showing that other muscles contract before the limb agonist when stability is challenged due to limb movement. These postural adjustments allow the body to increase proximal stability and allow distal mobility. A model for evaluation of motor control strategies for stabilization of spine would necessarily involve identification of the coordination of muscles contributing to spinal stiffness generation. On the basis of previous argument, Tr.A should be included. Garry et al[21] were the first to show that the feedforward response of Tr.A is clearly directionally specific to the side of the arm movement, and is not bilaterally symmetrical.

Particular attention has been paid to the core because it serves as a muscular corset that works as a unit to stabilize the body and spine, with and without limb movement. In short, the core serves as the centre of the functional kinetic chain. In the alternative medicine world, the core has been referred to as the "powerhouse," the foundation or engine of all limb movement. This relationship may prove challenging to define because functional and core demands are typically sport or position specific and many questions, such as which element of core stability is most essential to performance, remain unanswered.

Role of core in athletic performance has given a task to physical trainers, coaches, and physical therapists to properly train the core. Proper assessment precedes the proper training of core. Core stability is thought to have many components like core strength, endurance, power, coordination, balance etc. There has many tests for different components of core stability but previous studies were unable to establish a correlation between these components and measures of athletic performances. Core strength as a component of core stability was used by Sherrock et al[2] & Shinkle et al[3] .Similarly, core endurance was used by Nesser el al[4], Stanton et al[5] Sato & Mokha[6] Scibek et al[7] and they also failed to explain its relation with sports performance. Because of these results, relation between core stability and performances remained theoretical only.

Present study is addressing the power component of performance. This component along with strength is considered the assert for athletes in a number of sports. These athletes require high amount of energy to perform sporting activities. This high force cannot be created locally but need entire body to work as a single unit. For efficient execution of athletic tasks this single unit needs to have a stable base to work upon. Apart from creating a foundation, core has responsibility of creating, transferring, and finally controlling these forces towards limbs.

Above mentioned fundamental functions of core require core to be stable. On the other hand, repetitive limb movements of an athlete (during sporting activities) always endanger core stability. During a particular event repetitive movements of athletes challenges the core stability. Thus in sports, core has to

Figure 3: EMG showing muscle onset of Tr. A

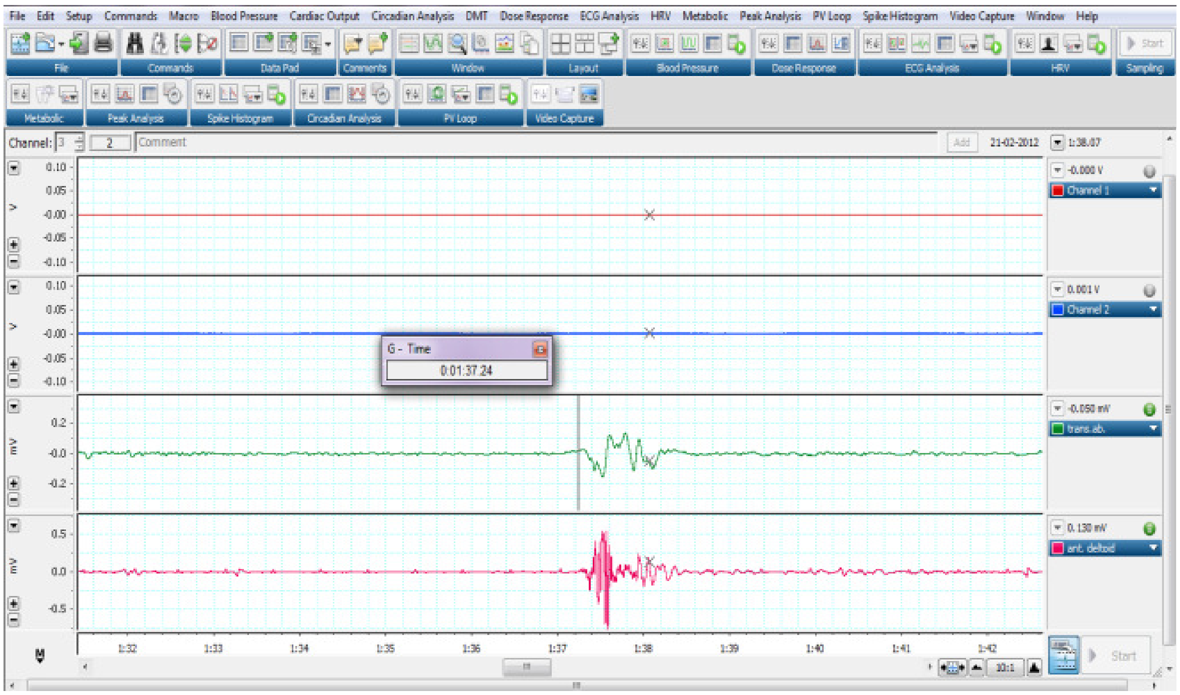
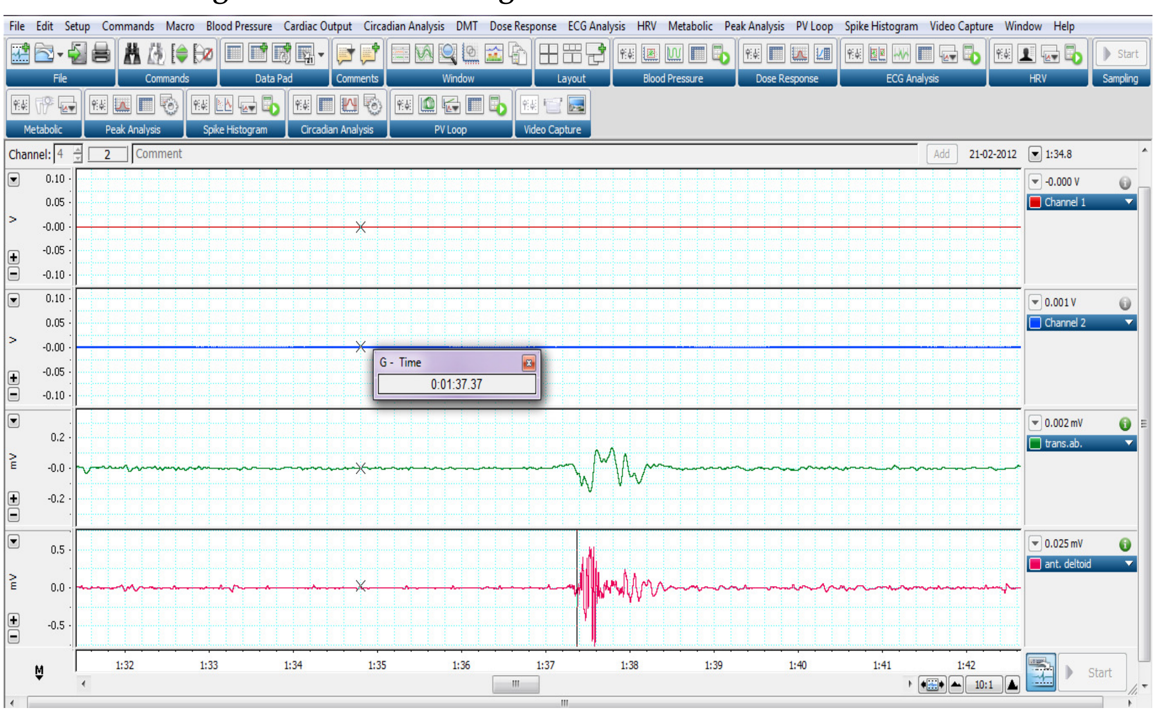


Figure 4: EMG showing muscle onset of Anterior deltoid



maintain its stability against these perturbations along with performing its other fundamental functions. These added demands further increase the importance of core stability. Several trunk muscles (especially Tr.A) work in anticipation to cancel out deteriorating effects of these perturbations.

Table 1: Descriptive statistics for entire group (n=30)

Parameter	Minimum	Maximum	Mean	SD
Age (yrs.)	18	25	20.6	1.77
Weight (kg.)	48.9	78.2	62.59	7.44
Height (m.)	1.5	1.8	1.7	0.065
BMI	18.99	24.65	21.60	1.75
Latency period (msec.)	23.25	18.05	53.16	18.72
BOMB – score (ft.)	88.85	40.3	30.87	5.38

SD= standard deviation

Table 2: Correlation matrix for entire group (n=30)

Parameter	r-value	p-value
Age (yrs.)	-0.121	0.525**
Weight (kg.)	0.636	0.000*
Height (m.)	0.486	0.006**
BMI	0.474	0.008*
Latency period (msec.)	0.772	0.000**
BOMB –score (ft.)	1	

*Statistically significant (p<0.05)

**Statistically significant (p<0.01)

Table 3: Correlation between core stability and performance (n=30)

Sports	n	r-value	p- value
Cricket	12	0.8936	0.00*
Hockey	5	0.7179	0.172*
Badminton	4	0.6409	0.359
Football	3	0.6996	0.507
Sprint	6	0.9398	0.005**

*Statistically significant(p<0.05)

**Statistically significant (p<0.01)

Previously many efforts have been made to establish correlation between measures of athletic performance and core stability, with most of them failing. This is the first study that is using motor control of core stability to relate it with athletic performance Author of present study is hypothesizing that motor control of these trunk muscles could be one of determinant of power performance.

Results of these studies made present author to think of other core components as a measure of sports performance. Previous literature of rehabilitation field has a done a lot of work on motor control of core muscles in LBA populations. They have confirmed the role of precise timing of Tr.A in core stability. Feed forward mechanism of Tr.A in response to sudden limb movements has given a new measure of core stability i.e. latency period. This latency period is the time difference between recruitment of Tr.A and prime mover. It was the purpose of this study to examine the relationship between latency period and bomb throw among college aged males.

Table 4: Correlation between core stability and performance (n=30)

Performance	n	r-value	p- value
Top	15	0.6666	0.007**
Bottom	15	0.6646	0.007**

*Statistically significant(p<0.05)

**Statistically significant (p<0.01)

Table 5: Correlation between core stability and performance (n=30)

Performance	n	r- value	p- value
BOMB Ist	12	0.8768	0.000**
EMG Ist	18	0.7090	0.001*

*Statistically significant(p<0.05)

**Statistically significant (p<0.01)

Materials and method

Subjects

It was a correlation study which was conducted on 30 collegiate male athletes who were in age group of 18-26 years. The participating players in this study had means height (170cm±6.5), mean weight (62.59±7.44kg), mean age (20.6±1.77) and mean BMI (21.6±1.75). Subjects were excluded if they had neurologic symptoms or pathological conditions in the back, shoulder, elbow, wrist. The study was approved by the Institutional Medical Research Ethics Committee.

Experimental design

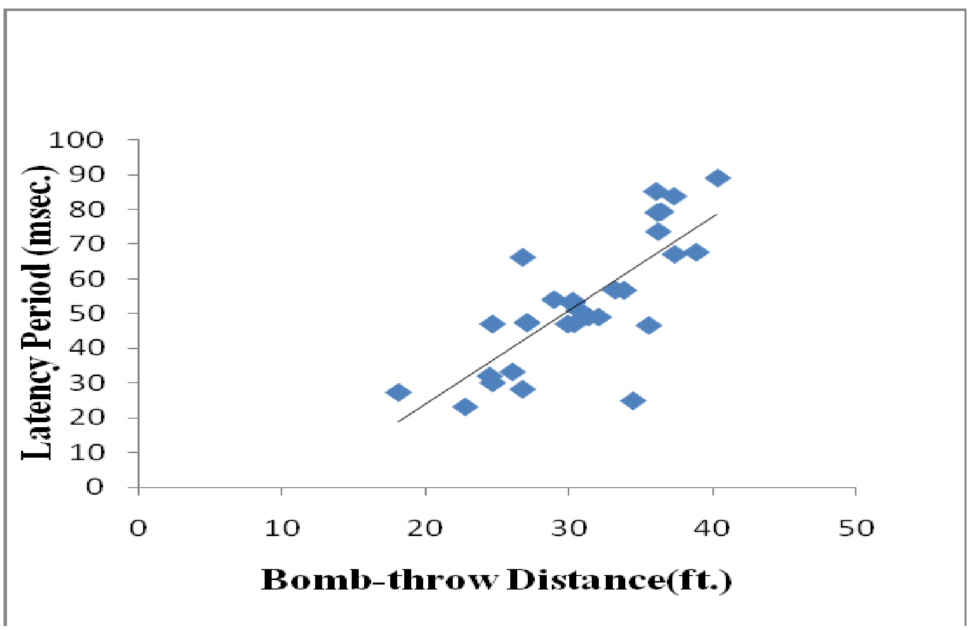
Standing subjects performed rapid unilateral upper limb movement at the shoulder in flexion. Measurements were made of electromyographic activity (EMG) of the Tr.A and deltoid muscles. Analyses concerned primarily the perturbation provoked by the initiation of limb movement.

ASIS and for anterior deltoid it was on the centre muscle belly.

Procedure

The EMG activity of the muscles evaluated was monitored throughout the procedures, and the subjects were encouraged to relax consciously if the degree of muscle activity increased above a resting level. Subjects stood relaxed with the feet comfortably spaced shoulder width apart and were encouraged to maintain equal weight bearing. Ten consecutive repetitions of rapid upper limb movement in flexion were performed as fast as possible in response to a verbal command with the emphasis on speed of movement rather than distance moved. At the completion of each movement the limb was immediately returned to the start position. Each repetition

Figure 1: Scatter Plot showing relationship between latency period and BOMB-throw score



Electromyographic Recordings

Surface electromyography (EMG) electrodes were used. Ag/AgCl surface electrodes were placed over the anterior portion of the left deltoid & right Tr.A. Surface electrodes were placed in parallel with the muscle fibers with an interelectrode distance of 32mm. The Tr.A electrode was placed 2 cm infero-medial to

was separated by a rest period until EMG activity was at resting level. Shoulder flexions were performed to approximately 180° from the initial position with the arms resting by the side.

Due to the role of the Tr.A in respiration[8], the command to move was timed to coincide with the end of expiration. In order to achieve this timing, the examiner continually monitored the subjects' breathing cycle by observation of the chest wall and abdominal movement. Comman to move was given just prior to the end of expiration. The subjects were not informed of this coordination of the stimuli and phase of respiration. A trial was not considered if the subject was attempting to laugh, cough, and talk, and so on.

Data processing

EMG data were sampled at 1,000Hz, bandpass filtered between 20 and 1,000 Hz, and stored on computer for analysis (AD Instrument, Australia). Following data processing the onsets of EMGs were identified visually as the point where the EMG activity exceeded the background level of activity. EMG onsets identified in this manner earlier have been compared with onsets using Matlab software values and found to be accurate[9]. All EMG onsets were checked visually to ensure that they were valid and not interrupted by artifact from movement or the ECG.

The latency between the onset of EMG of anterior deltoid and Tr.A muscles formed the basis of the analysis. The trunk muscle activity was regarded as "feedforward" if its onset occurred between 100msec before to 50msec after that of deltoid. This period provides insufficient time for a response of the trunk

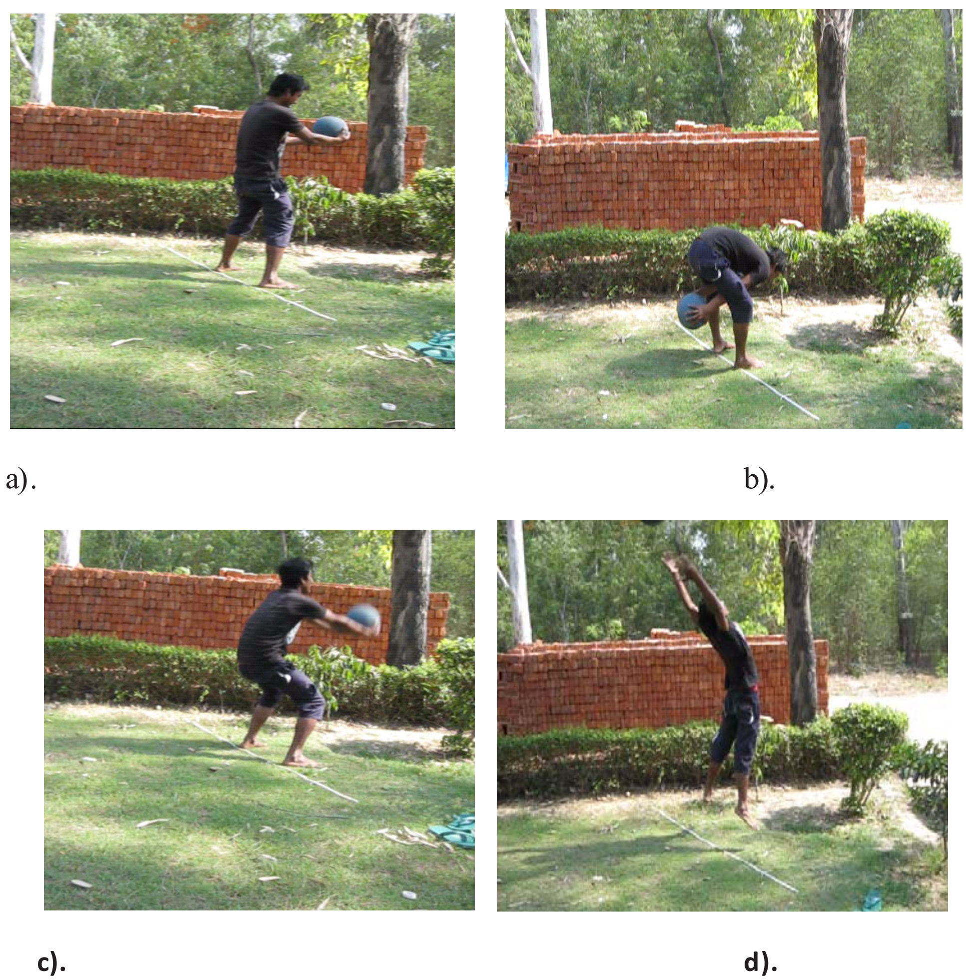


Figure 3.5. Backward overhead medicine ball throw from lateral view. a) Preparatory phase. b) Countermovement phase. c) Upward acceleration phase. d) Deceleration phase.

muscles to be mediated as a result of even the fastest monosynaptic reflex.[10]

Performance test (Backward, Overhead Medicine Ball Throw)

Before any testing, the protocol was explained to the participants. This was followed by a demonstration of the backward, overhead medicine ball throw. The backward, overhead medicine ball throw was then performed individually by each participant in accordance with recommended protocols previously outlined by Stockbrugger & Haennel.[11] Participants performed the protocol 6 times, using a 3 kg rubber medicine ball.[11] Out of 6 throws first 4 were warm up throws to reduce incidence of injury and to familiarize participant. Each trial was measured for distance (ft.) to the nearest 0.1 ft, and each trial was followed by approximately 2 min of passive rest before the subsequent trial. This time interval was measured manually by stopwatch and was selected as restoration of ATP-PC stores following short burst alactic anaerobic exercise takes place in approximately 2 minutes.[12]Incorrectly performed trials were repeated.

Data Analysis

Correlation tests was used in order to determine whether relationships existed between core stability (latency period) and core power tests (Backward Overhead Medicine Ball test). All data were entered into SPSS 20.0 for statistical analysis. Descriptive statistics, including age, height (m.), weight (kg.), BMI and mean scores for core stability and performance tests were calculated for all subjects. A two-tailed Pearson Correlation analysis was performed to determine if relationships existed between core stability (latency period) and performance (BOMB-throw).

Results

All 30 subjects successfully completed the testing procedures. Descriptive variables including both the mean and standard deviations of subject characteristics and the test scores are presented in Table 1.

Recall that latency period was selected as a measurement of core stability. Correlation data results showed positive correlations between latency period and BOMB- throw (r=0.772). A strong positive correlation was discovered between performance test and subject's descriptive variables i.e. weight(r =0.636), height(r =0.486), BMI(r =0.474) too. However performance measure had a negative correlation with age (r = -0.121). As most general statistical descriptors of relationship require greater than 0.5 to begin the moderate to strong rankings. The medicine ball throw was shown to have strong correlation with latency period along with descriptive parameters of subjects with exception of age. See Tables 2 for data

When the results were divided into different categories according to sports they play, the medicine ball throw was still strongly correlated to core stability. Sports wise categorized data was still found to have statistically significant strong correlations (0.640–0.939) with best correlation seen in cricketers and lowest with badminton (table 3).

To determine if there was a difference in correlation between test values in those who had higher performance scores and those who had lower performance scores, the data were halved. The median performance score (BOMB-throw) was used to divide the participants. Both top and

bottom performers showed the strong and significant correlation between the medicine ball throws and core stability. The top performers showed a very close correlation with bottom performer i.e. 0.666 and 0.664 respectively (table 4).

Further categorization of data was done to see if correlation (between core stability and performance) changes test order. So, data was again bifurcated according to testing procedure performed first (BOMB-throw or EMG). Although in both situations, correlation was still strong positive, but performance test done first (r =0.876) showed higher correlation than EMG done first (r =709). See Tables 5 for data.

Figure 1 is showing scatter plot showing relationship between latency period and BOMB-throw score.

Discussion

The purpose of the study was to determine the correlation between dynamic core power test (BOMB-Throw) and core stability (i.e. latency period). There was strong positive correlation between these two attributes (r=0.772, *p*-value <0.0001). This could be because of specificity of tests being used in the study.

Function of core during BOMB- throw can be summarized as generation of force, transfer of force to throwing shoulder & formation of stable foundation for execution of a power throw. These fundamental functions require core to be stable.[1] On the other side, fast moving body segments (while throwing) would cause spinal perturbations compromising core stability. So subject having higher latency period would be able to negotiate spinal perturbations in better manner that in turn would lead to stable core finally leading to better scoring in power throw.

Although power throw with medicine ball are designed in three ways i.e. forward abdominal power test (FAPT), side abdominal power test (SAPT) & BOMB throw. Nikoleno et al[13]suggested that FAPT & SAPT tests are easy to perform in the field but not specific to the power measures used in his study. Nikoleno further suggested that in order to properly evaluate the core musculature or its role in performance, sports-specific core tests need to be utilized. Furthermore, the BOMB-throw has been suggested as an appropriate method to assess total body explosive power in athletes[11] as it assesses integrated movement and is specific to sports performance.[14]

Similar kind of study was performed by Shinkle et al[3] The results of the medicine ball throws were compared with several athletic performance measurements: 1 repetition maximum (1RM) squat, squat kg/bw, 1RM bench press, bench kg/bw, countermovement vertical jump (CMJ), 40-yd dash (40 yd), and proagility (PrA). The results indicated that core strength does have a significant effect on an athlete's ability to create and transfer forces to the extremities.

To properly measure the core and its role in performance, sport and skill-specific tasks (throwing velocity, club or bat velocity, tennis serve velocity, etc.) may need to be evaluated.[15] Although some previous studies have focused on some sport-related tasks, such as the 100-yard swim[7] and 2000-m rowing[15], significant results were not found, either because the core training protocols were not specific to performance or the performance tests focused more on cardiovascular fitness and muscle endurance. One study[16] that looked at a specific task and how it was affected by an 8-week training program was that of, who looked at club head speed in golfers. They found that the experimental group had an increase in club head speed of 4.9%, while the control group slightly decreased.

Conclusion

The results of present study indicated that a significant strong positive correlation exits between latency period as a measure of core stability and medicine ball throw. These results consolidated importance to core as a mean of transferring force from core itself to distal segments. This study also gives importance to specificity of test for measuring attributes of core stability or athletic performance. Although present study showed strong positive correlation between motor control of core stabilizers and athletic performance, but some limitations were observed during tests procedures. Equal weight bearing on feet, speed of arm during EMG measurement and motivational component of the participants' performance during couldn't be assured. It would be beneficial to examine relationship between latency period and additional athletic performance tests. Future researcher should also seek to correlate latency of Tr.A during lower extremity with athletic performance. Additional researcher should focus on specific sports performance e.g. points per game, goal scored etc.

Prior to this study, relation between core stability and athletic performance remained hypothetical & theoretical in nature. This is the first study that is establishing strong correlation between these two attributes.

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