

Original Article

Efficacy of core stability training on upper extremity performance in collegiate athletes

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Abstract

Objective: To determine the efficacy of a five-week core stability training program for collegiate athletes on upper extremity performance measures. **Methods:** Seventy healthy collegiate athletes (age 21.6 ± 1.7 years; height 175 ± 4.63 cm; body mass 65.31 ± 5.63 kg) were randomly allocated to experimental ($n=35$) and control group ($n=35$). The experimental group has undergone a five-week core stabilisation protocol (three days/week) and regular training, whereas the control group maintained their regular training. The upper quarter Y balance test (UQ-YBT) and Functional throwing performance index (FTPI) were assessed pre and post-training. **Results:** The results of mixed ANOVA show that there was a significant interaction between time and group variables on YBT ($p < 0.001$, $\eta_p^2 = 0.759$) and FTPI ($p < 0.001$, $\eta_p^2 = 0.411$) after five weeks of core stability training. Statistically, significant improvement was shown in YBT (mean change = 15.2, $p < 0.001$) and FTPI (mean change = 14.4, $p < 0.001$) in the experimental group; however, there was no significant change observed in both outcomes in the control groups. **Conclusion:** After five weeks of core stabilisation training program, the measures of UQ-YBT and FTPI were improved, thus advocating the use of a core stabilisation training program among collegiate athletes to enhance their upper extremity performance.

Keywords: Athletic Performance, Balance, Core Stabilisation, Sports Training, Throwing Performance

Introduction

During diverse sports activities, core stability is defined as the ability to control the position and movement of the trunk with the pelvis to allow force generation, transfer, and absorption from the proximal and distal segments^{1,2}. A weak core coupled with powerful extremities may result in altered biomechanics and insufficient force production and transfer, resulting in poor athletic performance and

injuries³. A strong core enables an athlete to perform rapid, coordinated movements more efficiently, which enhances athletic performance. As a result, core muscle training is considered to be an important part of sports training for improving athletic performance and avoiding injuries⁴. The lower spine's bone skeleton, ligaments, and musculature, as well as the pelvis, hips, and proximal lower limbs, are usually taken into consideration in core stability training studies. The upper quarter bone skeleton, ligaments, and musculatures are very crucial to examine in order to evaluate the impact of core stability training for overhead athletes. There's not much evidence supporting this kind of assessment practice.

The upper quarter Y balance test (UQ-YBT) is often administered for monitoring mobility and segmental stability of the upper extremity¹. UQ-YBT is a closed kinetic chain performance test that challenges proprioception, strength, and ROM of the upper extremity, thus allowing the assessment of mobility and stability of the scapular

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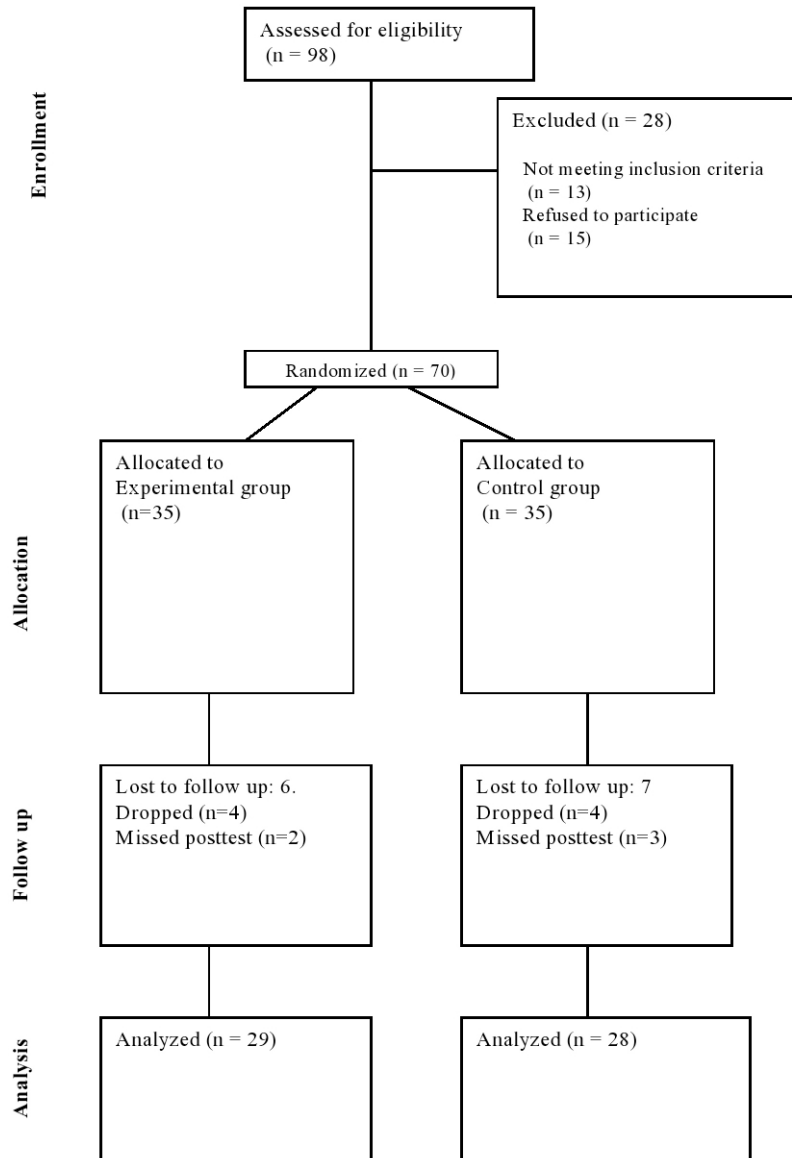


Figure 1. Consort Diagram showing the flow of the participants through each stage of randomized trail.

and thoracic movements out of the base of support¹. Both mobility and stability of the upper extremity are the key factors determining the upper extremity's performance and throwing accuracy. The relationship between UQ-YBT and throwing performance has been reported in various studies and is being used as a useful tool to detect training-related improvement measurement of the upper extremity¹⁻³. An association between; lower scores of UQ-YBT and upper extremity injuries has also been reported in some studies⁴. The functional throwing performance index (FTPI) is a functional assessment of throwing performance in athletes. FTPI measures throwing accuracy and is more associated with proprioception of the upper extremities⁵. It also assesses the ability of the athletes to utilize the entire kinetic chain during

throwing activity, throwing mechanics, and willingness to throw and has also been used as a tool to assess the return to play level of athletes⁶.

While most studies examined the impact of core training on athletic performance focused on lower extremity performances, only a few studies with contradictory results evaluated the influence of core training on upper extremity performance. Few studies propose core training as an effective tool for improving upper limb performance^{7,8}. At the same time, some of these studies indicated that core strength and core endurance do not influence the athletic performance of the upper extremity⁹. Isometric and dynamic core strengthening program improved distal limb velocities and force production during ballistic strike manoeuvres

in Muay Thai fighters¹⁰. A six-week conditioning program with core muscle strengthening as a major component demonstrated improved service velocity among elite junior tennis players¹¹. Six to ten weeks of progressive core training exercises with and without exercise sling has enhanced the throwing performance by five percentage in male and female handball players^{7,8}. At the same time, Tse et al.¹² reported that the core stability training program does not improve overhead medicine ball throwing performance in collegiate rowers. According to Larissa et al.¹³, even though a six-week season core training program significantly enhanced the core strength and endurance, it did not improve throwing performance in female handball players.

Further investigation is warranted on this issue. To the best of the author's knowledge, no studies have been investigated the efficacy of core training on the performance of UQYBT and FTPI in the athletic population. Therefore, the purpose of this study is to determine the effects of a five-week core stability training program for collegiate athletes on upper extremity performance measures. We hypothesised that the Upper quarter Y balance test (UQ-YBT) and Functional throwing performance index (FTPI) would improve following a five-week core stability training program in collegiate athletes.

Materials and methods

The experimental approach to the problem

A randomised control trial with a pre-test - post-test design was employed to determine the efficacy of a six-week core training program on throwing performance measured by UQ-YBT and FTPI in collegiate athletes.

Sample

The voluntary participants were 70 collegiate athletes (48 males; 22 females) with mean age 21.6 ± 1.7 years; height of 175 ± 4.63 cm; body mass of 65.31 ± 5.63 kg; and BMI of 21.98 ± 1.54 . All the athletes participated in a similar weekly training program (four days per week and competitions) with an average weekly training of 7.13 ± 0.62 hours. The sample size was determined as 27 in each group to estimate a difference of 6.88 cm in performance of 66.47 ± 8.92 cm in UQ-YBT with 80% power and 5% significance level based on an earlier study among athletes¹⁴.

The participants were free from musculoskeletal injuries, neurological, cardiovascular, systemic diseases, and metabolic disorders during the study period. Subjects with biomechanical or postural abnormalities, balance disorders or those who are on medication that may affect the testing or training were also excluded from the study. They were instructed to continue with their regular diet and daily activities. Two familiarisation sessions were conducted before the beginning of the study to make sure that the participants were well off with the research. They were randomly allocated to the experimental (n=35) and control group (n=35) by a blinded researcher who was not associated with the study

Table 1. Five-week Core training program performed by the experimental group.

LEVEL	EXERCISES	SETS / REPETITIONS/ TIME
Level - 1 Week - 1	Abdominal bracing	3 sets, 20 seconds hold
	Abdominal muscle contraction (in Quadruped position)	
	Side bridge	
	Supine bridge	
Level - 1 Week - 2	Supine dead bug	3 sets, 20 repetition
	Bridging (quadruped)	
	Seated medicine ball rotation	
	Cross over crunch	
Level - 2 Week - 3	Superman	3 sets, 20 seconds hold
	Supine bridge on Swiss ball	
	Prone bridge on Swiss ball	
	Cobra extension on Swiss ball	
Level - 2 Week - 4	Oblique pull with side shuffles	3 sets, 20 repetition
	Multidirectional lunge (Right & Left)	
	Swiss ball floor twist	
	Superman on swiss ball	
	Curl up on swiss ball	
Level - 3 Week - 5	TheraBand resisted march	3 sets, 20 repetition
	Diagonal curls on Swiss ball (R & L)	
	Twist on Swiss ball while holding medicine ball (R & L)	
	Physio ball alternate superman	
	Diagonal curl on swiss ball	

using a gender-specific randomization schedule (Figure 1).

The purpose and the procedure were explained to the participants, and informed consent was taken from the participants. The participants completed the physical activity readiness questionnaire. Ethical approval of the research was obtained from the institutional ethical committee of Jamia Hamdard, New Delhi (approval number: 02/14). The study was conducted according to the principles of Helsinki.

Procedures

The baseline measurements were taken 48 hours before the commencement of the five-week training program, and the post-test was conducted 48 hours following the final intervention. The tests were randomised for each participant to avoid the learning effect. The tests were carried out at the university sports complex of Jamia Hamdard in the morning hours (between 8.00 AM – 10.00 AM) for all the participants.

Upper quarter Y balance test: UQ-YBT has been reported as a valid and reliable method for assessing the dynamic balance of the upper limb¹. The Y balance tool kit consisting

Table 2. Subject's characteristics. Values are Mean (SD).

Characteristics	Control group	Experimental Group
Age (Years)	21.5(1.5)	22.1 (1.6)
Height(cm)	174.52 (3.43)	177.14 (5.36)
Weight (Kg)	69.42 (6.97)	69.92 (7.95)
BMI	22.08(1.54)	21.94(1.50)
Weekly training Hours	7.24(1.7)	7.09 (1.54)

Table 3. Pre- and post-intervention data for all upper limb performance tests in both the experimental and control group.

Performance tests	Group	Pre Mean (SD)	Post Mean (SD)	Change from baseline (marginal mean difference & 95% CI)	p-value
UQ-YBT	Experimental	76.8 (9.4)	92 (11.2)	15.2 (13.4, 17.0)	<0.001
	Control	82.2 (13.4)	81.8 (12.1)	-0.34 (-1.8, 0.97)	0.547
FTPI	Experimental	40.6 (6.5)	55.0 (9.0)	14.4 (10.8, 17.9)	<0.001
	Control	41.9 (7.7)	40.7 (7.5)	-1.2 (-5.3, 3.0)	0.555

CI = confidence interval; UQ-YBT – Upper quarter Y balance test, FTPI – Functional throwing performance index.

of a stance platform and three reach indicators was used to perform UQ-YBT. To perform UQ-YBT, the participants were in a closed chain push up position and assessed the ability to reach in to three directions by pushing the reach indicators with one hand while keeping the other hand on the stance platform and maintaining the push-up position. The testing order started with the right hand on the stance platform and allowed the left hand to maximally reach the medial direction (right medial reach) to the right inferolateral and right superolateral directions. The testing was repeated with the other hand. The reach distance was calculated by reading the tape measure at the position of the reach indicator. The greatest successful reach direction measure was noted (the maximal reach distance). The maximal reach distance was divided by the upper limb of each participant to normalise the data¹⁴. The composite reach distance scores were calculated and taken for analysis by taking the average of three normalised reach distances of both limbs.

Functional throwing performance index: Functional throwing performance index (FTPI) was performed by each participant to determine throwing accuracy. A 30.48 X 30.48 square target was marked on the wall at the height of 1.22 cm from the floor. The participants were instructed to throw the ball (50.8 cm circumference) as fast as and as accurate as possible towards the target as many times as possible within thirty seconds from 4.57 m from the wall. FTPI was calculated by dividing the total number of successful throws to the target with the total number of throws¹⁵. FTPI is deemed to be a reliable tool to measure throwing performance in a previous study¹⁶.

Training procedure

The participants in the experimental group underwent a five-week core training protocol (three days/week) in addition to their regular training, whereas the control group maintained their regular training. The five-week core stabilisation program consists of three progressive levels of exercises focusing on the abdominal, lower back and pelvic muscles¹⁷. The levels of difficulty of the program were based on five level mastery core training programs suggested by Jeffreys et al.¹⁸. Level 1 (week 1 & 2) consists of exercises in a stationary position with static contraction and then progress to slow movements on unstable surfaces. Level 2 (week 3 & 4) comprises exercises with static contraction on unstable surfaces progress to dynamic movements on unstable surfaces. Level three consists of dynamic movements in unstable surfaces progress to the addition of resistance in unstable surfaces. The participants progress to the next level at an interval of two weeks to allow proper acclimatisation. Each training session lasted around 45 minutes. Before the training, the participants have undergone ten minutes of warm-up activities, consisting of whole-body stretching, light jogging, butt kicks etc. All the training sessions were handled by the primary investigator. The detail of the training program is available in Table 1. The post-tests were performed after assumptions met. Statistical significance was set at $p \leq 0.05$. IBM SPSS Statistics for Windows, V24.0. Armonk, NY: I.B.M. Corp was used to analyse the data.

Results

Out of 70 collegiate athletes who took part in the study, eight were excluded as they skipped more than three training sessions and failed to attend the post-test measurement (five athletes). Demographic details of the participants in both groups are available in Table 2. There was no significant difference in height, body mass and training time per week ($p > 0.05$) between both groups. The results of mixed ANOVA shows that there was a significant interaction between time and group variables on YBT ($p < 0.001$, $\eta_p^2 = 0.759$) and FTPI ($p < 0.001$, $\eta_p^2 = 0.411$). Statistically significant improvement was showed in YBT (mean change=15.2, $p < 0.001$) and FTPI (mean change=14.4, $p < 0.001$) in experimental group; however, there was no significant change observed on both outcomes in the control groups (Table 3).

Discussion

The study was intended to establish the efficacy of a five-week core stability training program on upper extremity performance in collegiate athletes. The experimental group demonstrated $\approx 19\%$ improvement in UQ-YBT and $\approx 35\%$ improvement in FTPI following the training program, whereas the control group did not show any statistically significant improvement in the tested performance parameters.

Few studies in the literature suggest that there is a relationship between core stability and upper extremity function. The performance enhancement observed in our study is consistent with some of the previous studies^{11,19-21}. A combined core strength training program resulted in a 4.9% increase in service velocity among nationally ranked male junior tennis players¹¹. Our study also supports the study by Lust²¹, which demonstrated an improvement in the functional throwing performance index by 18.87% and the closed kinematic chain upper extremity stability by 23.48% following six weeks of core strengthening program among baseball players. Six to ten weeks of progressive core training exercises with and without exercise sling has enhanced the throwing performance in male and female handball players by 4.5% and 4.9% respectively^{7,8}. On the other hand, Tse et al.¹² reported that the core stability training program does not improve overhead medicine ball throwing performance in collegiate rowers. This study included college-level rowers who were not highly trained athletes. Therefore, the 16 workouts over 8 weeks might be too short to elicit significant effect. According to Larissa et al.¹³, even though a six-week season core training program significantly enhanced the core strength and endurance, it did not improve throwing performance in female handball players beyond that observed with standard training. However, throwing velocity during the jump significantly increased within the core training group by 12%.

The core can provide a rigid biomechanical platform for the peripheral muscles to act. The core muscles are the segmental link of the kinetic chain between the lower and upper limbs and have a crucial role in maintaining stability

and generating the forces while performing movements of the extremities²². The core muscles reported being activated in a feed-forward manner during upper extremity movements in subjects with high core strength^{23,24}. Exercises improving the core stability and strength might influence the athlete's ability to activate the muscles in a more coordinated way and to generate more forces. This may explain a significant improvement in UQ-YBT & FTPI following five weeks of core training.

Our study demonstrated an improvement in excursion distances on UQ-YBT measurement score and improvement in functional throwing performance score, perhaps related to increased dynamic postural control and increased spinal stability hypothesised to be attributed to the core stability training program. Improvement in spinal stability provides a stable base which makes the force generated by the upper limb muscles more efficiently get transferred into work, unlike the force generated will get absorbed by unstable core, so less force gets transferred into the work. Core stabilisation is a dynamic concept that persistently changes to meet postural adjustments or external loads taken by the body. Greater core stability offers a foundation for greater force production in the upper and lower extremities^{22,25}. Because the core plays such a substantial role during various activities, it makes sense to ensure its strength and stability.

The current study has some limitations, one of which is that the quantification of the engagement of core muscles during testing and training was not done in the study. Even though it was not assessed, all the participants in the experimental group might have improved the muscle strength and/or neuromuscular coordination of the core. Whether changes in performance reported in the study are caused by the improvement in core strength and the consequent better contribution of core region to segmental velocity summation or a more stable core resulting in decreased loss of force transfer between the segments cannot be determined in this study. Upper limb muscle tightness could have affected the measurement of UQ-YBT. The flexibility of the upper limb muscles might have been assessed before the baseline measurement. Another limitation of the study is that the activity level of the participants was not checked during the recruitment, and the groups were not matched according to the activity level, which might have influenced the results of the study. A small sample of volunteers with approximately similar demographic characteristics and a limited variety of sports were assessed in the current study. Future research should attempt to include a larger sample size with various sports and a more diverse demographic sample. Future research also should consist of quantifying core muscle engagement with instruments such as EMG during testing and training.

Conclusion

The result of the study indicated that a five-week progressive core stability training program could improve upper limb athletic performance parameters such as UQ-YBT

and FTPI among collegiate athletes. The result of the study is expected to help athletes, trainers, coaches and strength and conditioning experts to include a core stabilisation training program among collegiate athletes to enhance upper limb performance. The result of the study recommends incorporating core stability exercises for improving upper limb performance in collegiate athletes.

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