Muscle Strength of Upper Extremities and Trunk in Collegiate Throwing Players

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Abstract

The overhead throwing, a complex movement skill used in sports, involved the series of linked movement of the body from legs through arm and hand with rotating each body segment to transfer velocity, momentum and energy in sequence such as tennis and volleyball serves, baseball pitching, javelin throw. The objectives of this study were to compare the strength of the upper extremities muscles of collegiate overhead throwing players, and healthy students who did not participate in these sports. The muscle strength of the dominant and non-dominant sides of the participants were included in the analysis and comparison. Sixty participants were divided into two groups; an experimental group consisted of 15 male players (age 20.47±1.19 years, bodyweight 69.57±8.25 kg, and height 168.47±24.73 cm) and 15 female players (age 19.87±0.99 years, bodyweight 61.20±12.16 kg, and height 162.27±5.28 cm). The other group was control group, consisted of 15 male non-players (average age 20.60±1.12 years, bodyweight 70.51±12.30 kg, and height 174.33±5.65 cm) and 15 female non-players (age 20.07±0.70 years, bodyweight 54.47±6.59 kg, and height 162.67±6.39 cm). Participants were tested and measured by the Upper Quarter Y-Balance test, in which the participants bore a weight on the testing arm at the center and reached in various directions. Paired and independent t-tests were used for comparing the differences of average composite scores between dominant and non-dominant, and between control and experimental groups respectively. The significant level was set at .05 ($p < .05$). The results revealed that there was no difference of the composite scores between dominant and non-dominant arms in all participants but there were significant differences of the composite scores on the dominant arm ($p = .05$) and non-dominant arm ($p = 0.02$) when comparing between control and experimental groups. It was concluded that there was no significant difference of the muscle strength of upper extremities and trunk, both dominant and non-dominant sides but the muscle strength of upper extremities and trunk of the overhead throwing players was lower than of the regular exercise group. It could be feedback information for coaches and players to improve training plans, skill development and injury risk reduction.

Keywords: Overhead throwing, Muscle strength, Upper extremity, Trunk muscles

Introduction

Overhead throwing is a movement with limit contact and impact, a complex movement skill used in sports. The skill involves the series of linked movement of the body from legs through arm and hand with rotating each body segment to transfer velocity, momentum and energy in sequence. The distal segment of arm is moved backward, called lagging back, then the proximal end of the arm is pulled forward in sequence. The hand can be made to travel so fast by the sequential acceleration of the body segments. This flexible open chain of links is call “sequential segmental rotation” which makes a movement with high velocity and transfers the velocity to the object to be thrown (Hamilton & Luttgens, 2002) such as volleyball serve, tennis serve and softball throwing. Upper extremity’s muscles play the major role of both the mobility and stability of the shoulder. The trunk muscles are used for stabilizing the posture in balance and producing the initial velocity of the throwing. Rotator cuff, a group of muscles surrounded shoulder joint, maintaining the humeral head firmly within the shallow glenoid fossa of the scapula, consists of 4 muscles; Supraspinatus, Infraspinatus, Teres minor and Subscapularis. It helps stabilizing the glenohumeral joint and controlling humeral head translation during rapid motion of the shoulder, especially repeated overhead motions in sports. Rotator cuff injuries are most often associated with this motions and have gradually had severe pain in the shoulder (McConnell, Donnelly, Hamner, Dunne, & Besier, 2011; McConnell, Donnelly, Hamner, Dunne, & Besier, 2012). The less strength these muscles group, the more the risk of shoulder injuries (Yuktanant, 2002). In addition, the trunk muscles play a role in controlling the whole body and initiating the speed from trunk to arm during rapid overhead throwing as well (Lee et al., 2016).

The muscle strength test can be performed by using the equipment to test either individual muscle group or multiple muscle groups, which synchronize movement together, or using the test to evaluate the overall function of movements which are similar to the sport activities. Several measurements have been developed, allow for easily applying, and have specialty for relative movements. Therefore, the dynamic tools have been widely popular to identify the risk of injuries and to predict the injuries' occasion (Dennis, Finch, Elliott, & Farhart, 2008; Kiesel, Plisky, & Voight, 2007; Plisky et al., 2009). The Y-Balance test is one of the most widely popular test since it is easy to perform with high efficiency and reliability. Upper Quarter Y-Balance Test (UQYBT) is the dynamic functional test, which uses for evaluating the mobility and stability in closed kinetic chain of upper extremities and trunk muscles together. To perform the UQYBT, the participant is asked to stabilize the trunk in plank position and reach with the free hand in the given directions while maintaining weight bearing on the testing hand. During each reach, the muscles around scapula of the stance limb will contract to stabilize the scapula in place while the scapula of free limb will combine with thoracic rotation and core stability as the athlete is encouraged to reach as far as possible without loss of balance (Gorman, Butler, Plisky, & Kiesel, 2012). With reliable, easy to interpret and similar to function, the UQYBT has been recommended as a measure of dynamic stability between limbs, a part of planning of training program and injuries' risk reduction. The purposes of the study were to investigate the muscle strength of upper extremities and trunk of overhead throwing players between dominant and non-dominant arms and to compare the muscle strength of upper extremities and trunk between collegiate overhead throwing players and healthy students.

Methods

Participants

Sixty collegiate students, Burapha University with age between 18-22 years old were participated in the study and divided into 2 groups; control group who exercised regularly at least 3 days a week, 60 minutes or more a day and experimental group who were representatives of the overhead throwing players such as volleyball, softball. Each group contained 30 participants (15 males and 15 female). All participants were healthy, had no evidences of shoulder and back injury at least 6 months prior to the test. All participants were informed about the purposes, procedures and advantages of the study, then the consent forms were signed before starting the experimental procedures. This study received ethics clearance from the Burapha University's ethical committee No. Sci 085/2560.

Procedures

UQYBT measures the individual's ability to perform single a unilateral stance while maintaining 3 points of contact (one hand and two feet) in a plank position with the feet no more than shoulder width apart. The participants performed the reach in three given directions (Medial, Inferolateral, and Superolateral). The medial direction was positioned 135 degrees from inferolateral and superolateral directions, and the inferolateral direction was positioned 90 degrees from superolateral. The participant was asked to reach as far as possible with the free hand pushing the box by contacting only the side of the box in the area of the tape before returning to the starting position in a controlled manner. For a successful trial, the following criteria had to be met; 1) 3 points of contact were maintained between the floor and feet and between the stance hand and stance platform at all times, 2) the participants did not use momentum to move the reach box such as push the box so that it was in motion when contact between the hand and box was lost, and 3) the participants did not let the reach hand touch the ground during the trial and returned the reach hand to the starting position at the end of the trial. Before beginning data collection, the participant performed a short warm-up for 3-5 minutes. Then the participant was asked to start the test in plank position with feet placed shoulder width apart, the trunks were in straight alignment. The body weight was on the stance hand, the free hand reached as far as possible in the given directions without losing balance (Figure 1)

(a) (b) (c)

Figure 1 Description of the reach directions of the UQYBT; (a) Medial, (b) Inferolateral และ (c) Superolateral.

If the participant failed to maintain the unilateral stance, touched the floor with the reach hand, lifted the pelvis higher, lifted either foot off the floor, the participant was allowed to stop and begin the new complete trial. Three successful trial in each direction on each hand had been completed as one session. Between each session, the subjects were allowed a minimum of 2 minutes of rest. The maximal value of each direction on each hand was used for analysis. The sum of the 3 reach directions was calculated for a total excursion score. To normalize for limb length, a composite score was calculated taking the total excursion distance and dividing it by 3 times the upper limb length as the formula below.

$$Composite\ score = \frac{(Medial + Inferolateral + Superolateral)}{(3x limb\ length)} x100$$

Statistical analysis

Composite scores were performed using software package for statistical analysis. Descriptive statistics of all participants were performed for each limb. The composite scores were compared between dominant and non-dominant sides in overhead throwing players and regular exercise students by Paired t-test to analyze the differences between dominant and non-dominant sides and independent t-test to analyze the differences between experimental and control groups. The significant level was set at .05 ($p<.05$).

Results

In this study, the analyses of the muscle strength of the upper extremities and trunk of collegiate overhead throwing players were presented in mean and standard deviation of the status of experimental and control groups (Table 1). It revealed that the fundamental information between groups were not significantly different.

Table 1 Mean and Standard deviation of the status of experimental and control groups.

Variables	Control group		Experimental group		Sig. Level
	Male (n=15)	Female (n=15)	Male (n=15)	Female (n=15)	
Age (years)	20.60±1.12	20.07±0.70	20.47±1.19	19.87±0.99	0.538
Body weight (kg)	70.51±12.30	54.47±6.60	69.57±8.25	61.20±12.17	0.350
Body height (cm)	174.33±5.65	162.67±6.40	168.47±24.74	162.27±5.28	0.388
Limb length (cm)					
- Dominant arm	73.87±3.34	69.80±4.39	76.56±2.48	69.53±2.84	0.291
- Non-dominant arm	73.73±3.17	69.56±4.09	76.66±2.74	69.66±2.71	0.180

When comparing the differences of the average composite score between dominant and non-dominant arms, it revealed that there was no significant difference between arms, both in control (t = 20841, p = 0.08, ES = 0.52) and experimental groups (t = 1.630, p = 0.11, ES = 0.30). It showed that the muscle strength of upper extremities and trunk between dominant and non-dominant arms was not different.

Table 2 The average composite scores of experimental and control groups.

Composite score	$\bar{x}$±SD	t	Sig. Level
control group (n= 30)			
- Dominant arm	82.17±11.21	2.841	0.08
- Non-dominant arm	85.31±11.47		
experimental group (n= 30)			
- Dominant arm	76.58±10.45	1.630	0.11
- Non-dominant arm	78.77±9.93		

*Significant level at .05

But when comparing the differences between groups, it revealed that the control group's composite scores was higher than of the experimental group, both dominant (t = 2.001, p = 0.05, ES = 0.52) and non-dominant arms (t = 2.361, p = 0.02, ES = 0.61). It showed that the muscle strength of upper extremities and trunk between dominant and non-dominant arms in control group were significantly higher than experimental group as shown in figure 2.

Table 3 The average composite scores of dominant and non-dominant arms.

Composite score	Control group (n= 30)	Experimental group (n= 30)	t	Sig. Level
Dominant arm	82.17±11.21	76.58±10.45	2.001	0.05*
Non-dominant arm	85.31±11.47	78.77±9.93	2.361	0.02*

*Significant level at .05

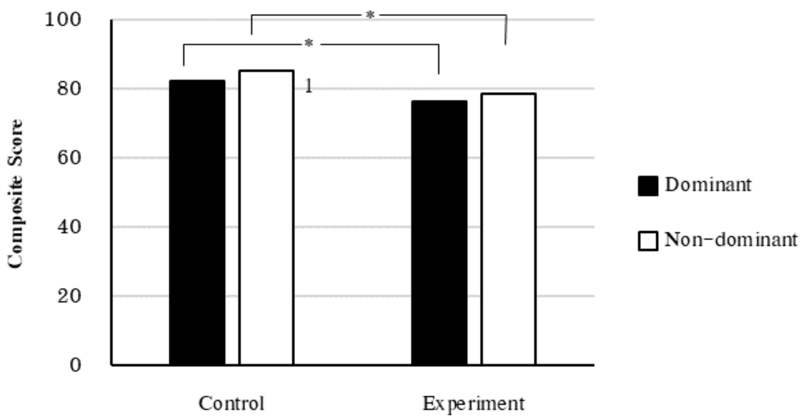

Figure 2 The composite scores of dominant and non-dominant arms between control and experimental groups.

Discussion

The objectives of the study were to evaluate muscle strength of upper extremities and trunk between dominant and non-dominant hands by UQYBT and calculate to composite scores. This composite scores can be interpreted to represent strength of the shoulder muscles which contract to stabilize and obtain body weight on only one hand and also represent the strength of trunk muscles which contract to stabilize the body alignment in straight line while other hand is reaching to the given directions. When comparing between dominant and non-dominant hands, the limb symmetry is revealed since human has tended to use limbs by specific task complexity and rhythmic motor skills which lead to different muscular strength (Serrien, Ivry, & Swinnen, 2006). In addition, there is a tendency for preferential lateralization of the lower limbs which may lead the potential connection of asymmetry to the risk of injury and the ready to play sport. Our research reported that the composite scores between dominant and non-dominant hands, both control and experimental groups were not significantly different. It showed the strength of muscles groups working at almost the same level though the dominant had has tended to use more than the other. This preference occurs from learning process by rhythmic movements until the neural networks can generate and rapidly transfer during practice (Lissek et al, 2007; Serrien et al., 2006).

The results of the second objective found that the control group's composite score was significantly higher than of the experimental group, both in dominant and non-dominant hands. It has not corresponded with the previous research. It indicated that the sport players had regularly trained, therefore, their muscles should be stronger than healthy people. For example, Vilím, Juránková, and JaníČková (2015) compared hand grip's strength between 10 tennis players, 10 javelin players and 225 health people and found that the sport players' hand grip strength was higher than of healthy people. Dimitrova (2017) studied hand grip's strength of 9-11 years old students; 15 tennis players and 24 students and report that tennis players' hand grip strength was higher than of students. In addition, Moghadam and Salimee (2012) investigated shoulder muscle strength of overhead throwing athletes and found that the athletes' shoulder muscles were significantly stronger than of non-athletes since overhead throwing is a movement pattern used the speed of hand-arm movement while accelerating forward movement. This forward hand-arm movement is controlled by rotator cuff muscles. The external rotators contract eccentrically to control the speed of forward movement as well as the internal rotators contract concentrically to initiate the movement with stabilizing the humeral head in the glenoid cavity (Burkhart, Morgan, & Kibler 2003; Ramsi, Swanik, Swanik, Straub, & Mattacola, 2004). This muscle group plays a major role to stabilize the shoulder joint during moving and is important to reduce the risk of shoulder injuries as well. Because of our results which did not coincide with the previous studies, the interview and observation of the experimental group's training program was added. The training program included lower back and leg strength training by continuous running, squat and step-up training, etc. for overview of dynamic movements during competition. The upper extremities' strength, especially shoulder muscles, had done during sport specific training or skills based on the position of the athlete. Therefore, the training program focused more on skills without awareness of injury risk because the shoulder muscles worked both moving and stabilizing the joint during overhead throwing movement.

Conclusion

In this study, the strength of upper extremities and trunk muscles between dominant and non-dominant hands were not significantly different but the strength of muscles in overhead throwing players lower than in healthy people. It leads to competitive skills, therefore, the information feedbacks to coaches and athletes for improving training program, developing skills and reducing the risk of injuries.

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