THE EFFECT OF SHOULDER MOBILITY ON AGONIST AND SYNERGIST DURING SHOULDER PRESS

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The purpose of this study was to investigate the effect of shoulder mobility score on agonist and synergist muscle activation during shoulder press and to provide an underpinning fundamental to optimize the training effect while reducing the risk of injuries when instructing training in the field. The participants were divided to two different groups according to individual shoulder mobility score which is part of the Functional Movement Screen (FMS). There were five participants in the score of three group (upper group) and six included in the group with the score of less than three (lower group). The results of this study revealed that the shoulder mobility score showed a negative correlation with the ratio of the left and right latissimus dorsi/anterior deltoid muscle activation in the concentric contraction phase ($p<0.05$). There was negative correlation between muscle activation ratio of erector spinae/anterior deltoid and muscle activation ratio of latissimus dorsi/anterior deltoid ($p<0.05$). Therefore, shoulder mobility affects the muscle activation of agonist and synergist during shoulder press.

KEY WORDS: shoulder press, shoulder mobility, EMG.

INTRODUCTION: In shoulder joints, subacromial impingement syndrome (SAIS) may be caused by rounded shoulder and kyphosis due to limited upward and external rotation of the upper arm and limited posterior incline of the thoracic spine (Finley & Lee, 2003). SAIS is characterized by constant collisions and an inflammation of structures under the acromion that are narrowed when the limited shoulder joints are repeatedly moved. (Ludewig & Cook, 2000). During weight training, a shoulder press is often used to develop shoulder muscles and exercise without recognizing the risk of misalignment of the spine. Imbalance of muscles is caused by misalignment of the spine while exercising without basic physical preparation for training. This can cause pain or dysfunction in the shoulder and reduce the range of motion. The causes may lead to over activation of the erector spinae, latissimus dorsi, and hip flexor muscles due to instability of the intrinsic core and hyperextension of the back. It does not develop shoulder muscles, but often causes shoulder muscles and back injuries (Clark & Lucett, 2010; Hammer, 2007). Although many studies have been conducted to predict the risk factors of these injuries, it is still difficult to generalize due to a lack of resources and cost. There is FMS which can compensate cost problem and is also easy to use without any special equipment. FMS measures and evaluates the functional movements in accordance to basic human movements and results can be applied directly in the field so that it would predict the risk of the injuries prior to the weight training (Cook, 2010). FMS is composed of 7 kinds of movements. One of the movements evaluates shoulder mobility. This movement involves adduction, abduction, internal rotation and external rotation of both shoulders. After measuring the distance between the fist and the back, the shoulder mobility is examined by the fist distance based on the palm length. The purpose of this study was to investigate the effect of FMS shoulder mobility score on the anterior deltoid which is agonist and the activation of the erector spinae and latissimus dorsi caused by a decreased range of shoulder motion, and to provide evidence of the positive effects of training.

METHODS: The study participants included fourteen men who had no history of physical injury within the past six months. The participants were allocated into two groups according to their score of FMS shoulder mobility. The groups were divided into three-point group (upper group) and less than three-point group (lower group), and five and six participants were allocated respectively. Three participants were excluded from the experiment as they gained zero point in the shoulder clearing test. The shoulder mobility score of the upper

score group (age: 26±0.7 years, 174.6±2.4 cm, 76.8±2.1 kg) and lower score group (age: 21.5±0.8 years; 176.6±3.6 cm; 78.8±3.4 kg) were 3±0 points and 1.3±0.5 points respectively and 1 repetition maximum (1RM) was 35.0±5.5kg for the upper group and 35.8±4.9 kg for the lower group. FMS shoulder mobility was measured by an expert who had a FMS certificate. External rotation, abduction, internal rotation and adduction were performed on the right arm and left arm, respectively, after the participants' palm length was measured. Then, the length between the fists was measured. The score was given as follows; three-points for less than palm length, two-points for less than one and a half-length of palm, one-point for more than one and a half-length of palm, and zero-point for shoulder pain (Cook, 2010). The shoulder press was performed five times with the 60% weight of 1RM. The analyzing phases were set as he concentric contraction phase and the eccentric contraction phase. The reflection markers were affixed to both sides of the barbell to detect the accurate phases and three infrared cameras (Oqus 300, Qualisys, Sweden) were used to record the movements. Wire-less EMG (Aurion, Italy) was used to analyze the muscle activation. The sampling rates were set at 100 Hz for infrared cameras and 1000 Hz for EMG. An A/D board was connected to the infrared cameras and EMG equipment for synchronization, and data was collected with Qualisys Track Manager ([QTM], Qualisys Inc., Sweden). The shoulder press was performed five times with the 60% weight of 1RM.
The average value of four seconds in the middle of the data were included in the data analysis and the first and the last three seconds were removed. The noise of the data was filtered by a bandpass filter (20-450 Hz) and quantified as RMS (root mean square). In order to analyze the relative muscle activation ratio of anterior deltoid to erector spinae and latissimus dorsi using standardized data, the following equation was used (Ng & Zhang, 2008; Power, 2000).

$$Muscle\ activity\ ratio = \frac{EMG_{erector\ spinae}}{EMG_{anterior\ deltoid}} \qquad Muscle\ activity\ ratio = \frac{EMG_{latissimus\ dorsi}}{EMG_{anterior\ deltoid}}$$

RESULTS: The relative muscle activation ratios in erector spinae and anterior deltoid were significantly different in the ratio of left erector spinae and anterior deltoid muscle activation in the concentric contraction phase (Table 1, p<0.05). The ratio of muscle activation in latissimus dorsi and anterior deltoid was significantly different in all phases (Table 2, p<0.05). The correlation results of the muscle activation ratio and the shoulder mobility score were shown in <Table 3>. The shoulder mobility scores were negatively correlated with the ratio of muscle activation of both latissimus dorsi and anterior deltoid in the eccentric contraction phase (Table 3, p<0.05). In the concentric contraction phase, the ratio of muscle activation in both erector spinae and anterior deltoid and the ratio of muscle activation in latissimus dorsi and anterior deltoid were negatively correlated (Table 3, p<0.05).

DISCUSSION: The results of the left erector spinae/anterior deltoid muscle activation ratios showed a high ratio in lower group in the concentric contraction phase. This result can be interpreted that the lower group showed higher muscle activation in erector spinae based on anterior deltoid than the upper group when lifting barbell overhead. In the ratio of latissimus dorsi/anterior detoid, there were significant differences in both phases in lower group, which showed higher latissimus dorsi muscle activation than anterior deltoid. These results suggest that the shoulder press should be performed when the central line of the body is standing upright. However, the hyperextension of the back in the lower group shows that the muscle activation of erector spinae and latissimus dorsi is higher than that of the anterior deltoid. Therefore, it is considered that muscle activation of erector spinae and latissimus dorsi is relatively higher than muscle activation of agonist anterior deltoid.

Table 1. The muscle activation ratio of erector spinae and anterior deltoid

Variables		Upper group	Lower group	t(*p*)
		Mean±SD		
Ecc	R_Ere/R_AD	0.485±0.168	0.560±0.166	-.740(.478)
	L_Ere/L_AD	0.399±0.125	0.723±0.372	-1.847(.098)
Con	R_Ere/R_AD	0.206±0.085	0.431±0.208	-2.240(.055)
	L_Ere/L_AD	0.205±0.094	0.521±.156	**-3.944(.003)***

* Statistically significant at the level of p<.05; Ecc: Eccentric contraction; Con: Concentric contraction; AD: Anterior Deltoid; Ere: Erector spinae.

Table 2. The muscle activation ratio of latissimus dorsi and anterior deltoid

Variables		Upper group	Lower group	t(*p*)
		Mean±SD		
Ecc	R_Lat/R_AD	0.408±0.314	1.297±0.598	**-2.976 (0.016)***
	L_Lat/L_AD	0.446±0.399	1.448±0.657	**-2.969 (0.016)***
Con	R_Lat/R_AD	0.193±0.152	0.848±0.221	**-5.458 (0.001)***
	L_Lat/L_AD	0.200±0.164	1.076±0.315	**-5.587 (0.000)***

* Statistically significant at the level of p<.05; AD: Anterior Deltoid, Lat: Latissimus dorsi

Table 3. Correlation between muscle activation ratio and shoulder mobility

Variables			r(*p*)
Ecc	R_Ere/R_AD	- shoulder mobility score	-.144 (0.673)
	L_Ere/L_AD		-.578 (0.063)
	R_Lat/R_AD		**-.607 (0.047)***
	L_Lat/L_AD		**-.628 (0.038)***
Con	R_Ere/R_AD	- shoulder mobility score	**-.645 (0.044)***
	L_Ere/L_AD		**-.771 (0.005)***
	R_Lat/R_AD		**-.900 (0.000)***
	L_Lat/L_AD		**-.738 (0.010)***

* Statistically significant at the level of p<.05; AD: Anterior Deltoid, Lat: Latissimus dorsi;

The shoulder mobility scores and muscle activation showed negative correlation to the ratio of latissimus dorsi/anterior deltoid in the eccentric contraction phase and negative correlation in the ratio of erector spinae/anterior deltoid and latissimus dorsi/anterior deltoid in concentric contraction phase. The results showed that the low shoulder mobility score means a high muscle activation ratio. Thus, based on anterior deltoid, latissimus dorsi and erector spinae muscle activation is high. According to the previous study by Clark & Lucett (2010), when the shoulder presses the arch due to misalignment of the vertebrae, hyperactivation of the hip joint flexor muscle, erector spinae, and latissimus dorsi are observed. As the result of this study suggests, the lower score group appeared to have hyperextension of the body in the result of a compensation of latissimus dorsi and erector spinae caused by limited ranged of motion in shoulder and it is likely to exercise in the distorted form of spinal arch and to increase the risk of injuries. According to Brügger's study (2000), vertebrae are connected to the vertebral bones and affect other areas by chain reaction. Especially ribcage has a direct effect on the location of the thoracolumbar spine, and thoracolumbar spine has anterior flexion as the ribcage rises. Therefore, shoulder mobility testing of shoulder abduction, external rotation, adduction, and internal rotation movements is an indirect way to simply test round shoulder and turtle neck postures. The limited shoulder mobility can affect the thoracolumbar spine and deform the back into arch shape and it increases a risk of injuries when performing shoulder press. Therefore, functional movement evaluation like FMS would be effective and helpful for people who spend a long time in sitting position, so they can perform appropriate stretching and corrective exercise before starting exercise.

CONCLUSION: In this study, the muscle activation ratio was higher in the lower group of latissimus dorsi/anterior deltoid and erector spinae/anterior deltoid in the concentric contraction phase. The muscle activation ratio and shoulder mobility score were negatively correlated with latissimus dorsi/anterior deltoid ratio in the eccentric contraction phase and latissimus dorsi/anterior deltoid and erector spinae/anterior deltoid ratio in the concentric contraction phase. Therefore, this study proved that the evaluation of shoulder mobility affects the muscle activation of agonist and synergist during shoulder press.

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