CHAPTER II

LITERATURE REVIEWS

1. Shoulder joint complex

The shoulder complex consists of the sternoclavicular (SC), the acromioclavicular (AC), the GH joint and the ST articulations (2, 5). The SC joint connects the shoulder complex to the axial skeleton. The lateral end of the clavicle contacts on the anterior part of the medial border of the acromion process of the scapula to form the AC joint (5). The GH joint is a multiaxial ball and socket synovial joint. The ST articulation connects the scapular and the thorax. The scapula is a flat, triangular bone that lies on the posterolateral aspect of the thorax between the second and seventh ribs. Scapula is angle 30 degrees anterior to the coronal plane of the thorax (6).

2. Muscles of the shoulder joint complex

The shoulder complex muscles consist of thoracoscapular muscles, thoracohumeral muscles and scapulohumeral muscles.

2.1 Thoracoscapular muscles attach between the thorax and the scapula. This muscle group consists of trapezius (upper trapezius, middle trapezius and lower trapezius), levator scapulae, rhomboid minor, rhomboid major, serratus anterior and pectoralis minor (4, 7).

2.2 Thoracohumeral muscles attach between the axial skeleton and fasten directly to the humerus. Thoracohumeral muscles consist of pectoralis major (clavicular and sternocostal head) and latissimus dorsi (4, 6).

2.3 Scapulohumeral muscles consist of deltoid, rotator cuff muscles and teres major. The deltoid has three parts including the anterior, middle and posterior parts (4, 6). The rotator cuff is composed of supraspinatus, infraspinatus, subscapularis, and teres minor muscles (8, 9).

3. Motion of the shoulder joint complex

The essential physiological motion of the shoulder joint complex includes the GH and the ST motions. However, the actual movement of shoulder joint complex requires the coordination of the GH and the ST motion which is called the scapulohumeral rhythm (SHR).

3.1 Glenohumeral motion

The GH joint motion consists of flexion, extension, abduction, adduction, internal rotation, external rotation, horizontal adduction, and horizontal abduction (10).

3.2 Scapular Motion

The scapula has many directions of movement. Scapula movements consist of upward rotation, downward rotation, elevation, depression, adduction, abduction, anterior tilt and posterior tilt (11). Upward rotation is about a sagittal axis which inferior angle moves away from spine of vertebral body and scapula moves cranially. Downward rotation is about a sagittal axis which inferior angle moves to near of spine of vertebral body and scapula moves caudally. Elevation is a gliding movement in which the scapula moves cranially. Depression is a gliding movement in which the scapula moves caudally and is the reverse of elevation and anterior tilt. Adduction is a gliding movement in which the scapula moves toward the vertebral column. Abduction is a gliding movement in which the scapula moves away from the vertebral column and into full abduction. Anterior tilt is a movement about the coronal axis in which the coracoid process moves in an anterior and caudal direction. Posterior tilt shows inferior angle of scapula that move anteriorly (4).

Ebaugh et al. (12) compared the position of the scapula on the thorax during active and passive arm elevation in subjects without a history of shoulder pathology. There was significantly more upward rotation of the scapula under the condition of active arm elevation (12). This rotatory motion was most pronounced through the mid-range (90-120 degrees) of arm elevation. Borsa and coworkers (13) demonstrated that active humeral elevation in the scapular plane produced more upward rotation of the scapula than did the sagittal plane of humeral elevation.

Therefore, understanding normal scapular motion may assist in the identification of abnormal motion associated with various shoulder disorders. Careful assessment of muscles activity and upward rotation of the scapula in the mid-range of arm elevation should be an important component of any shoulder examination.

3.3 Scapulohumeral rhythm (SHR)

Scapulohumeral rhythm is the ratio of the GH to the ST motion. Two degrees of GH and one degree of ST motion results in 120° GH joint motion and 60° of scapular motion at the completion of shoulder elevation (4). Shoulder elevation is defined as the movement of the humerus away from the side either in the frontal or the sagittal plane. Examination of SHR in detail reveals that the ratio of GH to ST is not equal to 2:1 through the entire range of shoulder elevation (4). McClure and coworkers (14) who determined a 3-dimensional scapular motion using a direct measurement method reported the mean ratio of GH to ST motion was 1.7:1. SHR can be described into three phases.

3.3.1 Initial phase of the glenohumeral elevation

This phase is started from 0° to 60° of the glenohumeral abduction or flexion. The deltoid muscle produces an upward shear of the humeral head (6, 8). This shearing peaks at 60° of abduction and is counteracted by the transverse compressive forces of the rotator cuff muscles. The rotator cuff muscles are important stabilizers of the humerus in this phase. The principal function of the subscapularis muscle is to depress the humeral head, counteracting of the deltoid. The ratio of GH to ST motion at the initial phase of elevation is 3.29:1 (GH:ST). The upper trapezius and lower serratus anterior muscles provide the necessary rotatory force couple to produce upward scapular rotation during the initial phase of arm abduction (6).

3.3.2 Middle or critical phase of the glenohumeral elevation

This phase is defined as the GH elevation from 60° to 140°. Maximal shearing of the deltoid muscle happen in the early part of this phase. At the end of this phase, shear forces of the deltoid are almost zero. External rotation of the humerus is critical for elevation of the arm. The ratio of GH to ST motion has been calculated to be 0.71:1 during this phase of abduction (6). The trapezius (upper and lower portions) and serratus anterior muscles are essential in producing scapular upward rotation especially throughout the mid-range of arm elevation (12).

3.3.3 Final phase of the glenohumeral elevation

The final phase of elevation is started from 140° to 180° of the GH joint. The ratio of GH to ST motion is 3.49:1. The rotatory force arm of the upper trapezius muscle reduces supportive of the scapula. The middle trapezius becomes a prime mover for downward scapular rotation. The lower trapezius and the serratus anterior muscles continue to increase in activity during the final phase of elevation, acting as an upward rotation. As the humerus elevates towards the end of the elevation range of motion, it must detach itself from the scapula. Good flexibility of the teres major and the subscapularis muscles is important in order to allow shoulder full range of motion (6).

In conclusion, each phase of shoulder elevation requires different degree of scapular movement. The movement of humerus is greater than the motion of scapula during the initial and the final phase of GH elevation. However, ST motion is slightly greater than GH motion during the middle phase of shoulder elevation.

4. Shoulder impairments in patients with hemiplegia

4.1 Shoulder pain

Shoulder pain is a common complication observed in patients with hemiplegia (15). The painful hemiplegic shoulder may result from glenohumeral subluxation, spasticity of shoulder muscle, impingement, soft-tissue trauma, rotator cuff tears, and shoulder-hand syndrome or reflex sympathetic dystrophy (15).

Aras (1) used the ultrasonographic method to evaluate the changes of soft tissue around the shoulder complex after stroke. The patients with shoulder pain were found to have more structural changes in several components of the shoulder joint complex compared with the patients without shoulder pain. However, this change did not reach a statistically significant difference.

Approximately 40-80% of patients with stroke presented shoulder pain at least once during the period of six months after the onset (16). The variation of incidences depends upon the population studied, time after stroke, and the method of assessment used. About 50-70% of patients with shoulder pain after two months will continue to have pain at six months (16).

The hemiplegic shoulder pain may be classified as pain with and without mechanical mechanism. Non-mechanical origin is unrelated to motion, and resolves more quickly if it occurs during the early weeks after stroke. The non-mechanical pain associations include sensory loss, visuospatial deficit and clinical changes of reflex sympathetic dystrophy. Both light-touch sensory abnormalities and spinothalamic pathway-mediated abnormalities (sharp/dull; temperature) have been associated with the later development of pain. The spinothalamic pathway can lead to a neuropathic (thalamic) pain, known as central poststroke pain when it occurs after stroke (16).

Poststroke upper limb pain resulted from mechanical origins is associated with muscle weakness, spasticity and subluxation (16). The mechanical pain will be made worse by movement of the shoulder and relatively relieved by finding a suitable resting position. It commonly reflects physical changes to the shoulder girdle (16). The musculoskeletal pain of shoulder hemiplegic patients occurs when minor alterations in the precision of movement cause microtrauma and, if allowed to continue, will cause macrotrauma and pain. These alterations result in the development of movement impairment (4). The present study will focus on the hemiplegic shoulder with pain resulted from the mechanical mechanism.

4.2 Shoulder complex alignment

4.2.1 Humeral alignment

GH subluxation occurs when any of the factors contributing to the glenohumeral joint stability are disrupted, which may be a cause of shoulder pain (17-19). Generally, patients with neurological condition had humeral inferior subluxation, in which the humeral head is positioned below the glenoid fossa (2). The flaccid arm induces a traction force on tissues around the shoulder joint complex whenever the patient assumes an upright position and the arm hangs by the side of the body. As the humerus is pulled down by gravity, the superior portion of the capsule becomes permanently laxity, and the muscles connecting the humerus to the scapula lengthen (20).

Glenohumeral subluxation was greater in the hemiplegia with low tone than the high tone. There was no significant correlation between scapular or humeral orientation and glenohumeral subluxation in either low tone or high tone group of hemiplegia (21). Price and coworker (20) also confirmed that shoulder subluxation is not linked with a particular scapular resting position after stroke.

Culham (21) found that the absolute humeral abduction angle was not significantly different between the affected and nonaffected sides in either the low-tone or high-tone groups. Arsenault (22) found a greater GH abduction angle on the affected side compared with the nonaffected side in a group of hemiplegic subjects with subluxation. However, the magnitude of the differences was small (3 degrees) (22).

4.2.2 Scapular alignment

The resting scapular position is a downward tilt in both normal and subjects with stroke (20). In patients six months after stroke, the resting position of the scapula is more upwardly rotated than the control side (16). The different results from these two studies may be party explained by the duration post-onset of subject. However, Price and coworkers (20) did not reported the duration post onset and the level of muscle tone in the patients with stroke. For the active humeral elevation, patients with shoulder pain six months after stroke had either faster or slower rate of scapular rotation than a normal

(16). This result suggested the disruption of SHR which may be one of an important mechanism of pain.

Culham and coworkers (21) reported that scapular upward rotation was significantly greater on the nonaffected in the hemiplegia with low tone group compared with the affected side. In contrast to the hemiplegic subjects with high muscle tone, scapular orientation were not sigificantly different between the affected and nonaffected side (21).

The studies of shoulder complex orientation in patients with hemiplegia were mainly related to the resting position and compared with the normal subjects or with different muscle tone. These changes in hemiplegic shoulder with and without pain are not conclusive.

4.3 Soft tissue and muscle tightness

The subjects with hemiplegia with and without shoulder pain showed structural changes of the shoulder joint (1). Soft tissue and muscle tightness or contractures are common after hemiplegia. This change leads to atypical patterns of arm movement and may induce shoulder pain. Andrews and Bohannon (23) demonstrated that patients with stroke tend to lose shoulder lateral rotation. Shoulder lateral rotation decreases as time passes following stroke. Some patients demonstrated increasing localized shoulder pain which was associated with spasticity of the shoulder internal rotators and shoulder adductors (24). The spasticity associated complications adversely affect soft tissue contracture (25).

Spasticity and flaccidity are also associated with muscle shortening, which affected joint during movement. Soft tissue restrictions are characterized by changes of the muscular cross bridge connections, sarcomeres and other connective tissue (2, 26). These mechanical changes contribute to resistance during passive motion and limit active motion. Soft tissue and muscle tightness may limit scapular rotation, humeral external rotation and disassociate the scapula from the humerus motion (2).

In conclusion, patients whose primary problems are weakness and loss of movement control and abnormal muscle tone (both spasticity and flaccidity) have been suggested to develop tightness of the muscles and tissue around the shoulder complex. Soft tissue and muscle tightness are a problem observed in hemiplegic patients with shoulder pain. However, only a few studies have been reported the changes in the length of muscles crossing the shoulder complex in patients with hemiplegia. The muscular impairments as indicated by muscle weakness, abnormal muscle tone, and muscle tightness, can significantly affect the resting position, as well as the scapulohumeral rhythm. These musculoskeletal changes may contribute to shoulder pain in patients with hemiplegia.

5. Shoulder complex assessment

5.1 Resting alignment of shoulder assessment

5.1.1 Assessment of humeral alignment

Humeral alignment is often assessed by observation. The proximal and distal ends of the humerus should be in the same vertical plane. There should be less than one third of the humeral head protruding in front of the acromion (4). Glenohumeral subluxation (GHS) in hemiplegia is common complication after stroke, which can be considered an important risk factor for shoulder pain and other problems. Three methods of evaluating inferior GHS have been reported (18).

a. Palpation

Palpation of space between the acromion and the head of the humerus is used to measure GHS (18). Fingers breadth are recorded to indicate the degree of subluxation (19). Boyd and Torrance (17) demonstrated that the finger breadth method has high reliability. Therefore, clinical evaluation can be useful as a screening assessment.

b. X-ray

Radiographic measurements are considered as a standard measurement of GHS. Three different main views or techniques of X-rays have been reported: the anteroposterior view (18, 19), the scapular plane view (at 30° anterior to the coronal plane), and of three-dimensional technique using two X-rays (at 0° and at 45° or at 30° anterior to the coronal plane) (19).

c. Thermoplastic jig**.**

Hayes (27) made a thermoplastic jig for measuring subluxation of hemiplegic shoulder. A thermoplastic jig is an L-shaped device constructed of thermoplastic material with a 21-cm tape measure, visible from only one side, which embedded in it. A sliding beak-like marker, which can be anchored with a thumbscrew, is used to identify landmarks and to compute measurements. The intraclass correlation coefficient by a single rater was 0.89 and for more than one rater was 0.75. This jig provided accurate and reliable measurements of shoulder subluxation in patients with hemiplegia (27). The present study used this technique to measure GHS.

5.1.2 <u>Assessment of scapular alignment</u>

Normally, the vertebral border of the scapula is parallel to the spine and is positioned approximately 3 inches from the midline of the thorax (4). The scapula sits on the thorax between the second and seventh thoracic vertebrae (4). The scapula is flat against the thorax and is rotated 30 degrees anterior to the coronal plane (4, 6).

A number of techniques or instruments have been used to measure scapular kinematics, that is, a three-dimensional magnetic device (14, 28), 2-D radiography (29), a digital inclinometer (30), and a clinical test of lateral displacement (31).

A magnetic tracking system mounted sensors on the subject at the spinous process of T3 spine, the lateral arm just below the insertion of the deltoid, and on the acromion process or at the spine of scapula (14). This system can assess dynamic three-dimensional scapular kinematics and the technique was validated (14, 28) with moderate to good reliability (ICC=0.74-0.99) (12). The limitations of this technique are the availability of the instrument and the attachment of sensors to the skin may not represent the actual movement of the bone. Dayanidhi (32) reported the error in studying scapular kinematics at higher ranges beyond humeral elevation of 125°.

The radiographic examination can be used to measure scapula at the static position. The digitalization of the body landmarks on the film used a computer with an image scanner (33). Greenfield (34) compared measurements of scapular position obtained through bony palpation with the radiographic method. Using the palpation method, a good intrarater (ICC=0.97) and interrater reliability (ICC=0.96) of the scapular protraction have been reported. However, only fair correlation (r=0.73-0.79) in scapular position between radiographic and palpation methods were found (34). The limitation of this method are the exposure of x-ray and its accuracy (29).

The Plurimeter-V gravity inclinometer can be used effectively and reliably (ICC = 0.88) for measuring upward rotation of the scapula in 0°, 45°, 90°, 135° and at the end of range of shoulder abduction in the coronal plane (30). Johnson (35) used a Pro 360 digital protractor inclinometer for measuring scapular upward rotation in the scapular plane. This measurements of scapula upward rotation showed good to excellent intrarater reliability (ICC = 0.89 to 0.96) and good validity (35).

Odom et. al. (31) used the lateral scapular slide test (LSST) for measure scapular position with the arm abducted 0°, 45°, and 90° in the coronal plane. Assessment of scapular position is based on the derived difference measurement of bilateral scapular distances between the inferior angle of the scapula and the spinous process of the vertebra at straight of inferior angle each degrees. The results have demonstrated low reliability of asymmetry and weak associations between measurements of scapular position and muscle performance (31). The poor inter-tester reliability (ICC=0.50-0.70) was also presented in other study (36).

Motion of the scapula is important for dynamic positioning of the glenoid during humeral elevation. Asymmetrical scapular upward rotation may cause the shoulder pain (37). Assessment of SHR is essential for the management of neuromusculoskeletal dysfunction of the shoulder girdle (38).

5.1.3 Assessment of thoracic kyphosis

The curve of the thoracic kyphosis was determined by locating the T1 and T12 vertebrae using palpation technique, and placing a flexible ruler along the contour of the spine between these landmarks (39). The depth of the curve divided by the height of the curve determined a Thoracic Kyphosis Index which uses to quantify the curve of the thoracic spine.

Patients with hemiplegia may have a poor to good postural control depending on many factors. The thoracic posture alignment can change the kinematic of the scapula during humeral elevation (40, 41). Advanced thoracic kyphosis may lead to shoulder movement impairment during both resting and movement. Furthermore, age and thoracic kyphosis also affect humeral alignment. The poor posture alignment decreased scapular upward rotation, scapular posterior tilting and shoulder abduction (42, 43). Therefore, thoracic spine positions at rest and during functional activities need to be considered during evaluation and treatment of shoulder disorders (42).

Bullock (44) evaluated the effect of slouched versus erect sitting posture on shoulder pain intensity and range of motion (ROM) in subjects with impingement. An erect sitting posture appeared to increased active shoulder flexion, and reduced pain in subjects with shoulder impingement.

5.2 Muscle length assessment

Few studies have reported objective measures of shoulder muscle length (39). Full range of scapulohumeral and scapular motion for normal elevation of the arm requires adequate length of the following muscles: pectoralis major, pectoralis minor, latissimus dorsi, teres major, and subscapularis (45).

5.2.1 Thoracoscapular muscles

a. Pectoralis minor

Muscles length of pectoralis minor can be tested in the supine position. A measurement was taken from the distance between the treatment table and the posterolateral angle of the acromion (PLA) (4, 41, 45, 46). A clear plastic ruler with 1-mm increments (45, 46) or a tape measure (46) can be used. If the lateral border of the spine of the scapula is more than one inch from the table, it will be considered as pectoralis minor shortening (4).

Borstad (39) calculated the resting length of the pectoralis minor muscle, which was termed as the scapular index by measuring the distance from the midpoint of the sternal notch (SN) to the medial aspect of the coracoid process (CP) and the horizontal distance from the posterolateral angle of the acromion (PLA) to the thoracic spine (TS) with a soft tape measure. The Scapula Index is calculated using the equation: [(SN to CP/PLA to TS) X 100].

Borstad (39) reported a relationship between posture and pectoralis minor muscle length. These results also support a proposed model linking posture, an anatomical variable, movement dysfunction, and impairment (39, 47). A short pectoralis minor muscle length was related to increased scapular internal rotation and decreased scapular posterior tilting during arm elevation (2, 41). Thus, the short pectoralis minor may influence scapular kinematics and is therefore a potential mechanism for subacromial impingement (47).

b. Levtator scapulae

The test of levtator scapulae muscle length is applied by passive stretch contralateral lateral flexion and rotation with flexion of the neck, with shoulder girdle depression. Restricted range of movement and tenderness on palpation over the insertion of levator scapulae indicates tightness of the muscle (48).

c. Upper trapezius

Upper trapezius muscle length test is applied by passive contralateral lateral flexion, ipsilateral rotation and flexion of the neck with shoulder girdle depression. Restricted range of movement indicates tightness of the muscle (48).

d. Teres and rhomboid

The length of teres major and minor muscles are tested in the supine position by raising both arms in full flexion. Normal muscles length will be able to bring arms down to the treatment table level, and keeping them close to the head. Furthermore, the elbow will remain extended and the lumbar spine remains flat against the supporting surface.

Muscle tightness indicated by the inability to get the arms down to the table level (45, 46, 48) and the protusion of the inferior angle of scapula out of the thoracic wall more than ½ inch (4). The number of inches between the table and the lateral epicondyle can be recorded, or the range of shoulder flexion can be recorded in degree using a goniometer (45, 46). Goniometric readings are used to provide objective measures of range of motion (ROM) at synovial joints. Intrarater reliability for both active and passive measurements of shoulder flexion is extremely high (49). However, this test is not specificed to the teres muscles. Shortening of latissimus dorsi also presented as a limitation of the shoulder elevation.

For the rhomboid muscles, horizontal displacement between the medial border and the spinous process of the spine may be used as an objective measurement of muscle length. However, differentiation from the length of middle trapezius is difficult.

5.2.2 <u>Thoracohumeral muscles</u>

a. Pectoralis major

The measurement of pectoralis major muscle length is important for scapular movement. The sternal part of pectoralis major is evaluated by placing an arm in a position of approximately 135° of shoulder abduction with elbow extension. The clavicular part of pectoralis major is evaluated by placing an arm in horizontal abduction. The humerus is positioned in the lateral rotation. If muscle length is normal, an arm will remain flat on the table. The limitation may be recorded in degrees using a goniometer or a tape measure (45). The axis of goniometer is at the lateral tip of acromion, a stationary arm of goniometer is lied parallel to a supporting surface and a moving arm is positioned along midline of the humerus toward lateral epicondyle. Tape measure method is measured the distance between the lateral epicondyle of humerus and a treatment table (50).

A clinical test of pectoralis major muscle length can be performed in supine with hands behind head. Patients relax shoulder muscles, allowing elbows to move toward a treatment table. A ruler is used to measure distance between the olecranon process of humerus and a supporting surface (46, 50).

b. Latissimus dorsi

The length of latissimus dorsi muscles can be tested using the same upper limb motion as described in teres major and minor (section 5.2.1 d.).

5.2.3 Scapulohumeral muscles

a. Internal and external rotators of the shoulder

The testing position is in supine lying with the shoulder abduction 90 degrees, and the elbow flexion 90 degrees. Muscle lengths of medial rotators are examined in the lateral rotation of the shoulder. Normal range of motion is 90 degrees (forearm flat on a table, while maintaining low back flat on a table). Muscle lengths of lateral rotators are tested in the medial rotation of the shoulder. Normal range of motion is 70 degrees (forearm at 20 degrees angle with a table) (45). Translation of head of humerus out of the glenoid cavity of the scapula during shoulder rotation suggests the shortening of the shoulder rotators (4).

5.3 Shoulder pain assessment

A hand-held digital pressure algometer can be used to measure the Pressure pain threshold on muscles. The intratester ICCs showed correlations varying from moderate to good (ICC=0.78-0.93) (51).

Patients with stroke often have cognitive and communicative impairments. Patients with aphasia, for example, may have difficulty understanding and responding to verbally based questions. A vertical visual analogue scale may be preferable to a horizontal scale, especially in patients with unilateral visuo-spatial neglect. The ShoulderQ is designed to assess hemiplegic shoulder pain in patients with cognitive and communicative deficits (52).

6. Managements of shoulder pain in patients with hemiplegia

A few methods of physical therapy treatment in hemiplegic shoulder pain have been reported. However, none of these methods is the effective treatment for hemiplegic shoulder pain.

6.1 Passive ROM

Range of motion exercises in the hemiplegic shoulder should begin early after the onset of stroke (53). Passive range of motion can be defined as soft tissue and joint mobilization, which are the treatments of choice for preventing contracture (54) and secondary orthopedic problems (impingements), maintenance of soft tissue length, reduction of spasticity (55) and increased range of motion (56). Range of motion exercises should be performed in the scapular plane (13). Scapula and humerus movements affect SHR or biomechanics of the shoulder complex. Protraction and upward rotation of the scapula on the thoracic wall should be maintained for prevention of the shoulder impingement (55). A lack of scapular motion may produce greater stress on the glenohumeral joint capsule and potentially lead to overstretching and laxity (14). Passive of the shoulder external rotation is also another essential factor for reducing the risk of pain and impingement of the shoulder during elevation (55).

6.2 Positioning

Positioning of the hemiplegic shoulder can reduce the development of shoulder internal rotator and adductor contractures (57, 58). The shoulder was positioned in external rotation and abduction two 30-minute sessions a day (57). The positioning prevents muscle and soft tissue contracture around shoulder complex, which promotes a good scapular resting alignment during passive range of motion.

6.3 Strapping

Strapping may reduce development of hemiplegic shoulder pain in stroke patients at risk of shoulder pain (53, 59). Strapping helps supporting, stabilizing, correcting alignment of humerus, and prepares for functional improvement of hemiplegic shoulder. However, this therapeutic result did not maintain after removing the adhesive tapes.

6.4 Management of shoulder subluxation

The main methods used to treat shoulder subluxation in neurological patients are the functional electrical stimulation (FES) and the use of shoulder supports. The FES reduces the severity of shoulder subluxation (15, 60, 61) and pain, and possibly facilitating recovery of arm function (60, 61). The FES can improve muscle activity, which help correct alignment of the shoulder complex. Some shoulder supports may correct the vertical asymmetry of GHS (62). However, this shoulder orthosis only shows a benefit result during the wearing period (63). Main function of a shoulder support is to correct alignment of the shoulder complex. Good alignments of the shoulder may prevent and reduce shoulder pain in patients with hemiplegia.

In conclusions, physical therapy treatment reviewed from the literatures concerned structural alignments around shoulder complex, for example, positioning, strapping, and reduction of shoulder subluxation. However, physical examination and analyzing of problems are required before the initiation of treatment. Each hemiplegic patient may present with different impairments, therefore, a set routine program may not be appropriate with every patients. Examination of musculoskeletal impairments in hemiplegic patients with and without shoulder pain will gain a better understanding and may provide a proper rehabilitation method in the future.