Construction of a Physical Device for Abduction Movement Enhancement

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Abstract. The present research has made an attempt to theorize a physical device using the scientific method which will provide support to shoulder joint of a user. This physical orthotic device includes a rigid support, at least one pair of electrodes, at least one strap and the at least one-second strap. The rigid support is having an outer surface and an inner surface and is resting against the shoulder joint. The at least one strap is arranged on the rigid support to wrap around an upper arm of the shoulder joint for securing the orthotic device on the shoulder joint of the user. The at least one-second strap is extending from the rigid support and adapted to wrap around an armpit of a second shoulder joint for efficiently treating a subluxation condition.

1. Introduction
Generally, orthosis is used to support body parts of patients under the circumstances such as injuries, dislocations, subluxation, and the like. The orthosis is general term used for any orthotic device. These orthosis are also used to treat shoulder joint mis-alignments caused due to strokes (paralysis), shoulder subluxation and the like [1]. A stroke is an acute onset of neurological dysfunction caused due to the abnormality in a cerebral blood circulation with resultant sign and symptom that correspond to the involvement of focal areas of the brain. It can give the symptoms like paralysis (hemiplegia) or weakness (hemiparesis). Shoulder subluxation is a common problem in the stroke. The subluxation causes shoulder pain and hinders activity [1,2].

Presently existing orthosis or any such devices are not effective in reducing effects caused due to forces developed during movements of an arm of the user (abduction movement) and also in efficiently treating the subluxation condition during abduction movements [3].

A normal stirring action of the force couple of supra-spinatus and posterior fibers of the deltoid is affected due to a flaccid stage of the muscles. So, while abduction and flexion movement due to
gravitational pull to the head of the humerus subluxates caudally [4,5]. Presently, Orthotic devices (shoulder orthosis) are used to support the shoulder joint to decrease the glenohumeral subluxation [6].

Further, when a patient (user) suffering from the Shoulder subluxation condition is wearing the existing orthosis at the shoulder joint, an upper arm of the patient can be moved away from the torso up to a maximum of 30 degrees from a vertical reference [7]. Whenever the patient moves the upper arm away from the torso (In medical terms, this movement is called an “abduction movement”) there will be a set of forces acting on the shoulder joint and the upper arm.

Angle of abduction movement can be referred as a movement angle \( \theta_m \). These set of forces are caused due to movements along a direction away from the torso. These forces cause an enormous amount of pain to the patient even when the patient is wearing the orthosis [8]. Furthermore, these movements also effect the subluxation condition of the patient, thereby reduces efficiency of the orthosis in treating the subluxation condition.

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1.1 Objectives

i. To provide an orthotic device for supporting a shoulder joint of a user, which is simple in construction and easy to use.

ii. To provide an orthotic device for supporting a shoulder joint of a user, which nullifies forces caused on the user due to movements of an arm of the user while wearing the orthotic device.

iii. To provide an orthotic device for supporting a shoulder joint of a user for reducing the pain of the user caused due to movements of an arm of the user while wearing the orthotic device.

2. Literature Review

According to Pan et al. [9] the modified wheelchair arm-support is an ideal example of subluxation supportive device, designed to reduce hemiplegic pain through assisting in the maintenance of normal posture. Sharma et al. [10] suggested that pain associated with subluxation likely presents later after stroke as “fibrous changes or injury can occur in connective tissue of the ligaments and joint capsule due to incorrect alignment between the humerus and the scapula”. As well, the lack of consistency among findings may be related to the heterogeneity of patient characteristics and method/timing of assessment. In Arm orthosis arm sling is used. Arm sling is used for scapular or humeral fractures, rotator cuff injury, bicipital tendinitis, and hemiparesis with subluxation. It also includes cuff sling and glenohumeral support. Patient with proximal arm weakness involving the shoulder and arm, the functional arm orthosis is used. As tone returns to the shoulder muscle, the risk of shoulder subluxation decreases, and slings can then be withdrawn [11]. Slings tend to hold the limb in a poor position, which may accentuate the abduction and internal rotation posture and may contribute to shortening of tonically active muscles [12]. While some observational studies have reported a significant correlation between subluxation and pain in the hemiplegic shoulder [13,14], several others failed to find such a relationship.

3. Materials and Method

For this 20 studies (9 controlled tests and 11 pre and post-individual group studies) were finally selected for the review. The rehabilitation intervention: Functional electrical stimulation (FES) / electrical stimulation, orthosis / support, snapping / strapping, etc. were reviewed.

3.1. Orthotic Device Details

The orthotic device includes a rigid support, at least one pair of electrodes, one strap and at least one-second strap. The rigid support includes a shoulder section and an arm section. More specifically, the shoulder section covers a shoulder section of the user and the arm section covers an upper arm section of the user. The rigid support is having an outer surface and an inner surface b. The rigid support is resting against the shoulder joint.
In a preferred embodiment, the rigid support is configured according to a shape of a shoulder the user and the rigid support is arranged on the shoulder joint of the user with a surface contact of the inner surface of the orthotic device with the skin of the user. The rigid support is arranged on the shoulder joint of the user with a surface contact of the inner surface of the orthotic device with the skin of the user. The rigid support includes a cushioning layer arranged on the inner surface of the rigid support for providing comfort to the user while wearing the orthotic device. The cushioning layer can be made from materials, such as medicinal rubber or ethaflex and the like. The rigid support is made from materials, such as polypropylene and the like.

At least one pair of electrodes arranged on the inner surface of the rigid support for pain relief modality. The at least one pair of electrodes are connected to a power source and a control unit for supplying and controlling current flow thereto. The strap is wrapped around an upper arm of the shoulder for securing the orthotic device on the shoulder of the user. The strap is arranged with a pad. The pad is configured to provide support and pressure to the upper arm when the at least one strap is wrapped around the upper arm of the user.

The orthotic device includes two straps a & b. The straps a and b are having a securing arrangements, such as a snap lock, hook and loop arrangement or any such obvious securing engagements which are capable to secure the orthotic device on the upper arm of the user. The straps a and b are having a pad. The pad is arranged with the straps a and b. The pad is configured to provide support and pressure to the upper arm when the straps a and b are wrapped around the upper arm of the user. More specifically, the pad is arranged in such a way that, when the straps a & b are wrapped around the upper arm, an interior surface of the pad is in contact with the skin of the upper arm as shown in figure. In an alternative embodiment, the orthotic device can be configured without the pad.

When the orthosis is worn by the user around the shoulder joint, by securing the strap a around the upper arm and securing the second strap around the torso around the armpit of the second shoulder joint, the orthotic device applies pressure on the shoulder joint according to a point pressure system principle. In medical industry, this point pressure system is known as a Jordan’s principle. In the point pressure system, the applied force and two counteracting forces are in the opposite direction to each other.

Further, supplying therapeutic current through the pair of electrodes a & b results in pain relief of the user. This supplying therapeutic current is generally known as TENS (Trans-cutaneous Electrical Nerve Stimulation). More specifically, this TENS gives pain relief to the user in the shoulder subluxation condition. Therefore, the orthotic device is beneficial in reducing the shoulder subluxation condition along with the pain relief effect. Furthermore, when the user is wearing the orthotic device, if the user moves the arm away from the torso, the second strap distributes the force exerted on a shoulder and the upper arm of the user along the second strap towards the armpit of the
second shoulder joint, thereby nullifying the forces occurred during movements of an arm of the user. When the forces occurred during movements of arm a of the user are nullified, the resultant forces acting on the user will be equal to zero. Therefore, the forces caused due to movement of the arm a of the user do not result in causing pain to the user or any such discomforts.

4. Results
Measurements have shown increased shoulder and arm performance when the subjects were wearing the prototype. Upward and forward movements were easier to perform. The arm support is easy to put on and remove. Moreover, the device felt comfortable for the subjects. Shoulder support or orthosis while in situ may reduce the subluxation condition. X-ray was the most commonly used assessment tool for the subluxation. Implication of the rehabilitation technique on motor recovery has not been investigated.

5. Conclusion
The present research has the advantage of providing the orthotic device for supporting the shoulder joint of a user. It is observed that the presented orthotic device nullifies forces caused on the user due to movements of an arm of the user. Moreover, the orthotic device is simple in construction as well as the orthotic device is easy in use. Furthermore, the orthotic device is economical in construction and operations. The presented orthotic device reduces the pain of the user caused due to movements of an arm of the user while wearing the orthotic device. This orthotic device efficiently treats the subluxation condition of the patients even if any movements of an arm of a user is occurred while wearing the orthotic device.

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