ORIGINAL ARTICLE

# EFFECTS OF POST STROKE SHOULDER PAIN ON UPPER LIMB MOTOR FUNCTION AND PROPRIOCEPTION

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ABSTRACT

**Introduction**: Stroke is a leading cause of death and disease. Stroke causes hemiplegic shoulder pain, which leads to many central and mechanical disorders such as spasticity and shoulder subluxation. Hemiplegic shoulder pain is thought to interfere with proprioception and motor function, reducing the patient's quality of life and hindering their ability to recover. The main objective of this study was to determine whether hemiplegic shoulder pain affects motor function and proprioception of the affected upper limb.

**Material & Methods**: After ethical approval from ethics board and providing informed consent, a total of 130 participants took part in this study, who were 18 years and above, divided into two groups of 65 each based on pain presence i.e. hemiplegic shoulder pain (HSP) and no hemiplegic shoulder pain (NHSP). Motor function was assessed through Fugl Myer Motor Assessment Scale-Upper Extremity and Proprioception was assessed via Laser pointer assisted angle reproduction test (LP-ART). The angle deviations from normal were recorded. Visual Analogue Scale (VAS) was used to assess pain intensity. SPSS 25 was used for analysis.

**Results**: Mean age of the participants was 58.97(13.05). Males were 105 (80.8%) and females 25(19.2%). HSP group had 48 males and 17 females, whereas NHSP group comprised of 57 males and 8 females respectively. Demographic data had no differences at baseline. Motor function and proprioception was highly associated with increase pain ($P<0.001$) i.e. stroke individuals with hemiplegic pain had decreased motor function and proprioception in the painful limb compared to stroke individuals without pain.

**Conclusion**: Hemiplegic shoulder pain affects motor function and proprioception. Increase intensity of pain leads to an increase in movement errors as well as decreased motor function.

**Key Words**: motor activity, proprioception, shoulder pain, stroke, upper extremity.

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## INTRODUCTION

Stroke is the most common debilitating condition leading to death and disability and is defined as “rapidly developing clinical signs of focal (or global) disturbance of cerebral function, with symptoms lasting 24 hours or longer or leading to death, with no apparent cause other than of vascular origin.[1,2] Two of the most common types of stroke are ischemic and hemorrhagic with the former accounting for almost 70% of strokes worldwide and the latter almost 10-15% but with a high mortality.[2,3] Pain is a common experience for many chronic stroke patients and can negatively affect quality of life. Patients may develop many different types of post stroke pain, having many causes each playing a role in pain etiology.[4]

Hemiplegic shoulder pain is a commonly described post stroke painful symptom[4], a clinical entity not seen or observed clearly; defined differently by every clinical investigator.[8] It has been shown to occur two to three months post stroke.[5] It is a debilitating condition interfering with both ADLs and quality of life.[11] Similarly, a study conducted by Demirci et al. has reported an incidence of 55% in a retrospective study of one thousand hemiplegic patients.[6]

Etiology of Post stroke shoulder pain remains unclear with many siding with the commonly accepted multifactorial cause theory, which consists of features reminiscent of both neurological, and musculoskeletal pathology like spasticity, paralysis, shoulder subluxation, rotator cuff abnormalities, biceps tendinitis CRPS, frozen shoulder and increased muscle tone. Hemiplegic shoulder pain was associated with reduced motor function, decreased ROM and other muscular or sensory impairments.[7] Including mechanical and central factors.[8] Mechanical factors like (shoulder subluxation, soft tissue injuries, rotator cuff tears/injuries, bicipital tendonitis, muscle imbalance, scapular dyskinesia) and Central factors can be (paralysis, spasticity, neuropathic pain, altered sensation, psychological distress).[9]

HSP impedes rehabilitation, slows recovery, prolongs hospital stay and leads to a decrease in quality of life.[8] A study done in Copenhagen showed that 34% of admitted stroke patients experienced pain and motor deficits, out of which, 55% stroke population remained useless in terms of upper extremity functions.[10] Another factor that contributed to upper extremity function loss or recovery was proprioception loss. This was, proved from a study in which proprioceptive loss was appropriated together with motor loss for decreased function and impairment.[8] Motor paralysis is often accompanied by proprioception deficit. This was found in a large percentage of patients. A study by Smith, Akhtar and Garraway reported 44% of patients as proprioceptive deficit.[11] Another study by Tinson et al. reported proprioception deficits in addition to motor deficits in 28% patients.[12] Proprioception deficit leads to loss of movement control causing the patient to use visual input, consequences of which are, difficulty learning novel movements or maintaining the same movement quality over a series of repetitions.[13] Various studies have iterated that proprioception is important in shoulder joint to improve functional and working status post stroke.[14]

Proprioception is affected in the initial stages of stroke due to the nature of stroke, which affects multi-input sensors. Proprioception dysfunctions interfere with the rehabilitation of the patient, due to decreased body position perception and movement as well as impaired cognitive sense together with the lack of control in the affected limb.[14] Proprioception is evaluated by tests which measure a subject’s ability to detect, externally imposed passive movement, or the ability to reposition a joint to a predetermined position.[15] The prevalence of proprioceptive deficits in individuals with an affected upper extremity post stroke has been reported to range between 30%-48%.[16]

Hemiplegic Shoulder pain prevalence has been observed a plenty but as per researcher’s knowledge its effects on motor function and proprioception have not been observed much. Most studies have used isokinetic dynamometer to observe shoulder proprioception. Studies have observed movements at specific ranges such as 60 degrees and not higher. This study observed proprioceptive and motor movements at three various angles and then determined whether proprioception and motor function decreased or increased or remained same at all target angles.

## MATERIAL AND METHODS

### Participants and Study Design

This cross-sectional study was conducted at Habib Physiotherapy Complex, Peshawar from January 2021 to June 2021. The concerned population were hemiplegic individuals with and without shoulder pain. Sample size was 130 with 65 accounting for hemiplegic patients with shoulder pain and 65 without shoulder pain calculated via non-probability consecutive sampling.

**Inclusion and exclusion criteria:**

Hemiplegic individuals afflicted with stroke at least in the past three months, exhibiting unilateral hemiplegia and stroke related pain. Age range was 18 years and above. Participants who were conscious as well as cognitively stable with a score of 24 and above on the Mini Mental Score Exam. Participants with adequate tone without excessive spasticity in the range of 1 and 2 and not more on the Modified Ashworth Scale were included in our study while participants with Shoulder pain due to any other reason may, it be trauma, or any other neurological disease. Visually blind and deaf as well as aphasia ridden participants were excluded from our study. Cognitively unstable, TIA or stroke mimics along with participants admitted for palliative care were also excluded.

**Ethical Approval**

After approval from Graduate Committee (GC) and Advance Studies & Research Board (AS&RB) No. KMU (IPM&R)/MSPT/719 dated 07-01-2021, a formal approval was granted from the respective hospital prior to start of data collection. All the willing participants were briefed about the purpose and procedures of this study. Participants were informed about the aims and objectives of the study and an informed consent was signed from the willing participants, giving them the right to quit at any time of the study.

**Data Collection and Instruments:**

Standard demographic questionnaire was used to collect baseline information. Two standard questionnaires were used to collect information relevant to study. Shoulder pain intensity was assessed via VAS (Visual Analogue Scale). Upper extremity motor function was calculated using Fugl Myers Motor Assessment-Upper Extremity. Upper Extremity subsection was used to determine motor severity and recovery in the hemiplegic shoulder. FMMA-UE uses a 3-point ordinal scale 0= no function 1= partial function and 2 =full function. UE maximum score was 66 out of which 0-22=No motor Function, 23-31 = poor, 32-47 = limited, 48-52 = notable and 53-66 = full motor function intact. Upper extremity section reliability is Intra rater reliability ICC=0.95 CI= 0.66-1.00. Inter rater reliability ICC=0.99 CI=0.97-1.0

For proprioception testing Laser Pointer Assisted Angle Reproduction test was performed to assess proprioception at 45°, 60° and 90° of shoulder flexion and shoulder abduction. This technique was previously used by Balke et al in 2011 for evaluation of shoulder proprioception in shoulder instability patients.[17] Three repetitions were performed and the mean was calculated for proprioceptive deviation. Normal score (0-4cm error) within center target excellent. (4-8cm error) within the non-red zone was good. Within the second red zone (8-12cm error) fair. Outside the second red zone (>12cm error) on the target indicated poor and outside the target zone (>16cm was very poor). Each participant was instructed on how to perform the task. Three repetitions with eyes open at 45°, 60° and 90° of shoulder flexion as well as shoulder abduction, were performed by each individual for trial purposes and learning. After trials, the participants were instructed to perform the same movements but this time with a blindfold on. Error in proprioception was recorded by the placement of the laser pointer. Three trials were performed and mean of the score was calculated as final value. The procedure was same for both painful and non-painful hemiplegic shoulder patients.

**Data analysis procedure**

Data was analyzed through SPSS version 25. For continuous data, mean and standard deviation was calculated. While categorical data like gender, FMMAS score was presented in the form of frequency and percentages. Shapiro Wilk test was applied to check for normality of data. FMMAS and proprioception data at all angles were non-normally distributed. That led to Mann Whitney U test being used to compare means. Chi square test was applied to develop association between categorical variables. The significance level was determined at $P < 0.05$ with 95% Confidence Interval (CI).

## RESULTS

**Demographic characteristics**

The participants were divided on the basis of pain and no pain in the hemiplegic shoulder. Mean age of the participants with pain was 59.29±11.74 whereas; pain free group mean age was 58.66±14.32. Gender wise distribution in the painful group showed that males outnumbered females with males totaling 48 and females 17 respectively. In the painless group the trend was same; male outnumbered the females 57: 8respectively as shown in table 1 in detail.

**Upper limb motor functions and proprioception**

The FMMAS-UE score was categorized into FIVE components. Most participants ranged in the poor motor function category, followed by limited, notable, no function and full motor function respectively. Mean combined FMMAS-UE score was 34.02±14.26. The participants showed variation in proprioception control at different angles of flexion and abduction with most of the participants exhibiting weakness at an angle of 45° in both flexion and abduction.

**Association of FMMA-UE, proprioception and pain**

Of the 130 participants, relation between motor function, proprioception and pain was established. Both painful and painless participants were considered. Association results for FMMAS-UE were significant i.e. $P<0.05$**.** Proprioception via angle deviation was calculated and was highly significant i.e. $P<0.05$ as described in Table 2 and 3 and 4 in detail.

**Comparison of FMMAS scores and absolute errors of angle deviation at 45°, 60° and 90°**

Comparison of FMMAS scores and absolute errors of angle deviation at 45°, 60° and 90° of both flexion and abduction showed significantly poor FMA-UE scores with poor proprioception ($p<0.05$) as shown in Table 5 in detail.

## DISCUSSION

The results of this study determined three main features. 1) Patients with hemiplegic shoulder pain had greater loss in motor function 2) Increased pain led to decrease in proprioception. 3) Proprioceptive control was less at lower angle compared to greater angles in both abduction and flexion.

A 2019 study by Cherpin et al. found a significantly greater absolute error of proprioception in stroke population when compared to healthy individuals. That study comprehends the present study because of same study population although the present study does not have any controls except for the fact that the pain free group could be called a control group.[18]

Mean age determined in both HSP and non-HSP participants were 59.29±11.74 and 58.66±14.32. A study by Lindgren et al. 2014 studied the effect of pain on shoulder proprioception. The mean age of target population in that study was 65±10 and 63±8 respectively.[19] This is somewhat in contrast to the mean age of the present study. The reason for this difference in mean age could be that the age range studied by Lindgren was 44 years and above, whereas the current study looked at population 18 and above. A study by Rand D in 2018 looked at proprioceptive deficits in stroke population. The mean age of the target population in that study was 59.6±10.9 which is almost similar to the present study. Also proprioceptive deficit was associated with increasing age similar to the present study, showing that with increasing age pain increased and proprioception decreased.[16]

Absolute errors of proprioception were maximum at lower angles and minimum at increased angles. This ambiguity has not yet been determined. Various authors have had varied results. This ambiguity together with the why does HSP affect proprioception have had no concrete backing? Although, a 2019 systematic review by Ager et al. hypothesized that nociceptive signals interfere with proprioceptive signals, affecting the motion.[20] The general consensus is still, that proprioception decreases as pain increases.[19,21,22] The present study shows that proprioception increases at increased angles which in this case were 60° and 90° but decreases at 45°.[17,19,23] Various studies have demonstrated that as the shoulder approaches 90°, the repositioning errors decrease. King et al. 2013 while observing repositioning at 50°, 70° and 90° also observed the same trend.[17,23,24] Edwards et al 2016 observed that repositioning errors increased at 50°.[25] The reason for increased errors and decreased proprioception at lower angles than higher could be due to decreased or no tension of shoulder muscles and ligaments at lower angles i.e. 45º. Similarly, proprioception increases at increased angle because of external factors and biomechanical factors together with tension.[26]

Lindgren et al. 2014 found out that the upper limb abduction was most deteriorated by post stroke shoulder pain, this observation is somewhat similar to the present study but the difference is that they did not observe it for proprioception but rather as part of pain effect on motor function.[19] The results of our study coupled with the accompanyingevidencesprovetosomeextentt hatawarenessofone'slimbin space especially at higher angles >90°, as well as positional errors at lower angles are high in the painful shoulder.

The present study showed that a lower FMMA-UE score was associated with a high proprioception error in both abduction and flexion, but a study by Gabriela Lopez found no correlation between FMMAS and proprioception absolute errors.[27] Similarly, a study by Chae et al. failed to find any relationship between HSP and FMA scores.[28] This difference could be due to small sample size of their studies compared to a large sample size of the present study. The present study showed a strong association of FMMAS and pain. The reason could be that due to pain, secondary changes take place in the shoulder leading to altered biomechanics, which prevent the individual from using the upper limb functionally for e.g. in overhead activities, eating etc. These activities manifest as consequences of spatial perception, which are linked to proprioception.

The mean value of FMMA- UE in the present study was 23.44±10.09 for HSP and 44.60±8.98 for Non HSP participants. These values are almost similar to the observed FMMA-UE values in a study done by Rand D in 2018, which were 25.4±15.6 and 45.1±18.7.[16]

The present study proved that with increased pain, motor function decreased. This is consistent with the observation that HSP affects ADLs as is shown from relationship of HSP and low Barthel scores. To achieve a greater motor function score for the HSP patient, early rehabilitation was shown to be beneficial.[29]

Trunk sway during proprioception evaluation could not be stopped nor recorded, which might have altered the results.

Patients tended to tilt their wrists when pointing towards the target; this could have theoretically influenced the data. The reason for this being was maybe the participants didn't have adequate control of the wrist or they might have been fatigued.

The laser didn't have a strap so used tape to adhere it to the wrist which could have perturbed the participants. Theoretically speaking, no one complained.

Most of the participants were outpatient so they didn't have the necessary medical record always at hand.

As our survey was cross-sectional, no treatment was given for shoulder joint pain. Future studies should focus on treatment trials targeting improved joint proprioception via pain reduction therapies in hemiplegic stroke patients using more reliable and valid tools.

## CONCLUSION

The results were highly significant for the painful population. The greater the intensity of pain, more poor was the motor function as well as a decreased proprioceptive control. Further research with various tools could be explored in randomized trials.

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*Table 1: Demographic data and characteristics of participants*

| Variables | Yes HSP | No HSP |
|---|---|---|
| Age | 59.29±11.74 | 58.66±14.32 |
| Gender | Male 48 (73.8%)<br>Female 17 (26.2%) | Male 57 (87.7%)<br>Female 8 (12.3%) |
| Hemiplegic Side | Left 23 (35.4%)<br>Right 42 (64.6%) | Left 19 (29.2%)<br>Right 46 (70.8%) |
| Stroke Duration (months) | 9.16±2.69 | 13.03±5.22 |
| Pain Intensity | 6.91±1.55 | N/A |

*Table 2: Association of FMMAS-UE with Pain*

| | No. (%) OF PATIENTS | | |
|---|---|---|---|
| FMMAS-UE | WITH PAIN (n=65) | WITHOUT PAIN (n=65) | P |
| 0-22- NO MOTOR FUNCTION | 27(41.5) | 1(1.5) | |
| 23-31- POOR MOTOR FUNCTION | 28(43.0) | 7(10) | |
| 32-47 LIMITED MOTOR FUNCTION | 8(12.3) | 24(37) | <0.001 |
| 48-52 NOTABLE MOTOR FUNCTION | 2(3.0) | 28(43) | |
| 53-66 FULL MOTOR FUNCTION | 0(0) | 5(7.7) | |

*FMMAS-UE= Fugl Myers Motor Assessment Scale-Upper Extremity, P=Chi-square test*

*Table 3: Association of Absolute Errors at Flexion with both HSP and NHSP*

| Absolute Errors at different angles of | WITH Shoulder PAIN (n=65) | | | WITHOUT SHOULDER PAIN (n=65) | | | P |
|---|---|---|---|---|---|---|---|
| Flexion | $45^0$ | $60^0$ | $90^0$ | $45^0$ | $60^0$ | $90^0$ | |
| 0-4cm Excellent | 0(0) | 0(0) | 0(0) | 27(41.5) | 28(43.07) | 27(41.5) | |
| 5-8cm good | 0(0) | 12(18.4) | 36(55.3) | 26(40) | 30(46.15) | 29(44.61) | |
| 9-12cm fair | 10(15.3) | 36(55.3) | 27(41.5) | 9(13.8) | 7(10.76) | 7(10.76) | <0.001 |
| >12cm poor | 22(33.84) | 17(26.1) | 1(1.53) | 3(4.61) | 0(0) | 2(3.07) | |
| >16cm very poor | 33(50.7) | 0(0) | 1(1.53) | 0(0) | 0(0) | 0(0) | |

HSP= Hemiplegic Shoulder Pain, NHSP=Non-Hemiplegic Shoulder Pain, P=Chi-square test

*Table 4: Association of Absolute Errors at Abduction with both HSP and NHSP*

| Absolute Errors at different angles of Abduction | No. (%) of Hemiplegic Participants WITH Shoulder PAIN (n=65) | | | WITHOUT SHOULDER PAIN (n=65) | | | P |
|---|---|---|---|---|---|---|---|
| | 0(0) | $60^0$ | $90^0$ | $45^0$ | $60^0$ | $90^0$ | |
| 0-4cm Excellent | 3(4.61) | 0(0) | 0(0) | 1(1.53) | 12(43.07 ) | 8(41.5) | |
| 5-8cm good | 15(23.07) | 31(47.69) | 21(32.30) | 40(61.5) | 49(75.3) | 54(83.07) | <0.001 |
| 9-12cm fair | 20(30.7) | 25(38.4) | 36(55.3) | 20(30.7) | 4(6.15) | 3(4.61) | |
| >12cm poor | 27(41.5) | 7(10.7) | 7(10.7) | 3(4.61) | 0(0) | 0(0) | |
| >16cm very poor | 0(0) | 2(3.07) | 1(1.53) | 1(1.53) | 0(0) | 0(0) | |

*Table 5: Comparing Means of Proprioception and Motor Function*

| Variables | HSP | No HSP | *P* |
|---|---|---|---|
| FMMAS-UE | 23.44(10.09) | 44.60(8.98) | <0.001* |
| Absolute error at 45° Flexion | 15.87(3.77) | 6.10(3.18) | <0.001* |
| Absolute error at 60° Flexion | 10.93(2.53) | 5.36(3.01) | <0.001* |
| Absolute error at 90° Flexion | 8.58(2.39) | 6.18(3.07) | <0.001* |
| Absolute error at 45° Abduction | 14.84(3.54) | 8.41(2.39) | <0.001* |
| Absolute error at 60° Abduction | 9.43(2.62) | 6.40(2.23) | <0.001* |
| Absolute error at 90° Abduction | 10.00(2.55) | 6.52(1.84) | <0.001* |

*FMMAS-UE: Fugl Myer Motor Assessment Scale-Upper Extremity. *Mann Whitney U*