

Assessment of Manual Dexterity in Patients with Frozen Shoulder

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Background: Frozen shoulder (adhesive capsulitis) severely impacts upper limb function, causing pain, stiffness, and limited range of motion that affects essential daily activities requiring manual dexterity. This study evaluated fine motor skills using the Nine-Hole Peg Test to assess dexterity impairment and its association with functional limitations in frozen shoulder patients.

Methodology: A cross-sectional study over 6 months included 89 diagnosed frozen shoulder patients using convenient sampling. The Nine-Hole Peg Test measured manual dexterity, with additional data collected on pain intensity, range of motion, and functional limitations.

Results: Participants included 20 males (22.5%) and 69 females (77.5%). The affected shoulder showed significantly impaired performance: mean test time was 28.21 ± 4.73 seconds versus 23.09 ± 4.82 seconds for the unaffected side. Fewer pegs were placed on the affected side (6.78 ± 1.18) compared to unaffected (7.99 ± 0.88), with more pegs dropped (2.24 ± 1.18 versus 1.01 ± 0.88). Mean pain score was 5.26 ± 1.88 , with left shoulder more commonly affected (55.1%).

Conclusion: Frozen shoulder significantly impairs manual dexterity, with patients demonstrating slower task completion, reduced precision, and increased errors on the affected side. The study highlights how pain, mobility loss, and compensatory strategies affect fine motor skills, emphasizing the need for comprehensive rehabilitation addressing fine motor skills alongside joint mobility and pain management.

Key Terms: Frozen shoulder, Manual dexterity, Nine-Hole Peg Test, Upper limb function, Therapy.

Introduction

Frozen shoulder, medically known as adhesive capsulitis (AC), is a common condition characterized by stiffness and pain in the glenohumeral joint that significantly impacts patients' daily activities and quality of life. It causes fibrosis and thickening that restricts movement in a progressive manner, primarily affecting the rotator cuff muscles including the

supraspinatus, infraspinatus, teres minor, and subscapularis. As the condition progresses, individuals experience marked reduction in both passive and active range of motion, leading to functional limitations.¹

The condition progresses through three distinct stages: freezing, frozen, and thawing, each with

individual clinical features and durations. The shoulder's role as the most movable joint in the body enables reaching, lifting, and fine manipulation, making this painful condition's gradual movement restriction particularly debilitating. The cause of frozen shoulder remains largely idiopathic.²

Adhesive capsulitis is categorized into two types: primary (idiopathic) and secondary (occurring due to surgery, trauma, or underlying disease). The condition is characterized by stiffness and pain that begins gradually, worsens over time, and typically resolves within one to three years.³ Diagnosis is primarily clinical, with gradual onset of deep, poorly localized shoulder pain that worsens at night. The hallmark finding is global limitation of both active and passive range of motion, especially passive external rotation.⁴

Global prevalence varies significantly across populations. Nearly 25% of Australians experience daily shoulder pain, soreness, or stiffness, with many having known risk factors for idiopathic frozen shoulder, including diabetes, thyroid disorders, high cholesterol, and hypertension. The prevalence ranges from 3-5% in the general population and up to 20% in diabetic patients. The condition predominantly affects women (1.6-4 times more than men) with a peak age of 56 years, being rare before 35 and uncommon after 70.⁵

Worldwide prevalence affects 2-5% of the population, increasing to 10-38% among those with diabetes or thyroid conditions, particularly hypothyroidism.¹⁵ Type 1 diabetes represents a significant risk factor with 76% lifetime prevalence and 59% incidence in people over 45. Elevated HbA1c levels from poor glycemic control further increase risk.¹⁶ The left arm is more frequently affected (53.4% vs 46.6%), with non-dominant arm involvement being more common (58.9% vs 41.1%). Recent research suggests brain asymmetries may influence frozen shoulder development.¹⁷

The pathophysiology involves inflammatory processes followed by fibrosis, leading to capsular thickening, particularly of the coracohumeral ligament and rotator interval. This results in contractures and adhesions that restrict joint volume and mobility, with inflammatory mediators and fibroblasts contributing to capsular thickening and pain generation.¹⁸

The three overlapping stages include: (1) Freezing Phase (2-6 months) marked by intense pain and progressive mobility limitation; (2) Frozen Phase (4-12 months) characterized by varying pain and stiffness intensities, with widespread fibrosis replacing inflammation; and (3) Thawing Phase (6-26 months) featuring pain subsidence and gradual mobility restoration as inflammation and fibrosis decrease.⁶ Recent studies emphasize early diagnosis and treatment importance, particularly in stages 1 and 2, when interventions show greater efficacy.¹⁹

Manual dexterity, defined as the capacity to coordinate hand, finger, and arm movements for object manipulation, represents a crucial functional outcome often overlooked in frozen shoulder assessment. It encompasses both gross manual dexterity (handling larger objects requiring substantial coordination) and fine manual dexterity (precise manipulation of small objects with thumb and index finger while maintaining hand-eye coordination).⁷ Occupational therapists recognize dexterity assessment as essential when evaluating upper extremity function, defining it as **"fine, voluntary movements used to manipulate small objects during specific tasks, measured by task completion time."**⁸

The Nine-Hole Peg Test (NHPT), initially developed by Kellor et al. in 1971 and refined by Mathiowetz et al. in 1985, serves as a widely used clinical assessment method for manual dexterity. Recent research demonstrates that

dexterity training significantly improves clinical tests for motor and sensory impairment, with specialized training showing particular benefits for individuals with modest motor impairment. These improvements suggest enhanced cortical inhibition associated with motor control, indicating potential neuroplastic changes.¹⁰ Contemporary evidence supports manual therapy and exercise interventions for adhesive capsulitis, though optimal protocols remain under investigation.²⁰

Understanding manual dexterity impairment in frozen shoulder patients is crucial for comprehensive assessment and treatment planning. The condition's impact extends beyond obvious range of motion limitations to affect complex coordination between shoulder and distal upper limb segments, particularly hand, wrist, and finger function.²¹ Recent systematic reviews emphasize the importance of multimodal approaches combining manual therapy, exercise, and targeted interventions to address both mobility and functional limitations.²² Studies demonstrate that shoulder dysfunction significantly affects manual dexterity performance, with implications for activities of daily living, occupational performance, and quality of life.²³

This relationship between shoulder pathology and manual dexterity has gained increased attention in rehabilitation science, with evidence supporting integrated assessment approaches that consider both gross motor function and fine motor skills.²⁴ Recent advances in understanding neuroplasticity and motor control suggest that comprehensive rehabilitation addressing both shoulder mobility and hand function may optimize outcomes for patients with adhesive capsulitis.²⁵

The purpose of assessing manual dexterity in adhesive capsulitis patients is to understand how shoulder stiffness and pain impact fine motor skills and daily tasks, enabling

occupational therapists to identify specific functional limitations, design targeted interventions, monitor progress, and enhance patient independence and quality of life through evidence-based practice.

Methodology

Study Design

The study design was a cross-sectional study to assess manual dexterity among frozen shoulder patients.

Study Duration

The duration of the study was 6 months after approval of the synopsis.

Study Settings

The study was conducted at PSRD (Pakistan Society for Rehabilitation of Differently Abled) hospital, based in Lahore, Punjab, Pakistan.

Sampling Technique

Non-probability convenient sampling technique was used.

Sample Size

The sample size was 89, calculated using Epi Info software with a 95% confidence interval and appropriate precision. The sample size for this study was calculated using the formula: $n = (Z^2 \times P \times (1 - P)) / e^2$, where Z is the value from the standard normal distribution corresponding to the desired confidence level (Z = 1.96 for a 95% confidence interval), P is the expected true proportion, and e is the desired precision.

Sample Selection Criteria

Inclusion Criteria:

- Age range from 40 years to 60 years.
- Both genders (male and female) included.
- All patients clinically diagnosed with frozen shoulder (adhesive capsulitis) by an orthopedic specialist or physiotherapist with supporting investigations.

Exclusion Criteria: Individuals with:

- History of hand and wrist disorders.
- Neurological conditions affecting hand function or other upper limb function.
- Any previous shoulder surgeries.
- Comorbid conditions like diabetes and hypertension.

Assessment Tool and Data Collection Procedure

The assessment tool used for this study was the Nine-Hole Peg Test (9HPT). Eligible participants meeting the inclusion criteria were provided with clear information about the study. Informed consent was obtained from participants prior to data collection.

The Nine-Hole Peg Test (NHPT) assesses hand dexterity using a board with 9 holes and pegs placed next to it. The person picks up pegs one by one, places them in the holes, then removes them and places them back in the container. The test is performed with one hand at a time, usually starting with the dominant hand and then with the affected hand. Time is recorded from start to finish. The time taken to complete the task is measured, with longer times indicating slower dexterity.

Eligible participants were informed, briefed, and provided informed consent. The NHPT was first performed on the unaffected hand to establish a baseline, then performed by the affected hand to provide comparison specific to the individual patient. Pain was assessed using the Visual Analog Scale (VAS), and functional difficulties in dressing and overhead reaching were evaluated through patient questionnaires.

Data Analysis

Tables and graphs were utilized for data presentation, and the Statistical Package for Social Sciences (SPSS) software version 26 was used to analyze data using appropriate statistical techniques. Mean and standard deviation were used for quantitative variables.

Frequencies and percentages were used for qualitative variables. Paired t-tests assessed differences between affected and unaffected sides. Significance was set at $p < 0.05$.

Ethical Considerations

After Institutional Review Board approval and approval from PSRD hospital, individuals were selected based on inclusion and exclusion criteria, and informed consent was obtained. Every participant received explanation of the study's goal, procedures, and requirements (age, gender, diagnosed frozen shoulder, non-diabetic, and non-hypertensive status). All participants were informed about the study's purpose, risks, and benefits. Confidentiality and anonymity were maintained with utmost importance. Informed consent was obtained from all patients involved in the study. Bias was minimized as much as possible during the study.

RESULTS**Demographic Characteristics****Table 1: Participant Demographics (N=89)**

Variable	Category	Frequency (n)	Percentage (%)
Gender	Female	69	77.5
	Male	20	22.5
Age (years)	Mean $\pm$ SD	46.7 $\pm$ 7.88	Range: 40-60
Affected Side	Left Shoulder	49	55.1
	Right Shoulder	40	44.9

The study involved 89 participants in total. Participants' average age was 46.7 ± 7.88 years, suggesting that the sample was middle-aged and typical of the frozen shoulder population.

Women comprised the majority of participants in terms of gender distribution. Of the total, 20 (22.5%) were men and 69 (77.5%) were women, indicating that the frozen shoulder was more

prevalent in females. Analysis of affected shoulder distribution shows that the left shoulder is more affected (55.1%) than the right (44.9%).

Nine-Hole Peg Test Performance

Table 2: Comparison of Manual Dexterity Between Unaffected and Affected Sides				
NHPT Parameter	Unaffected Side	Affected Side	Diff	p-value*
Test Time (seconds)	23.09 ± 4.82	28.21 ± 4.73	+5.12	<0.001
Pegs Placed (n)	7.99 ± 0.88	6.78 ± 1.18	-1.21	<0.001
Pegs Dropped (n)	1.01 ± 0.88	2.24 ± 1.18	+1.23	<0.001

Paired t-test Analysis

The baseline dexterity ability on the uninvolved side was demonstrated by the unaffected shoulder's mean test time of 23.09 ± 4.82 seconds. The affected shoulder's mean test time, conversely, was significantly longer at 28.21 ± 4.73 seconds, indicating considerable delay in task performance. The affected side performed worse than the unaffected side, with an average of 6.78 ± 1.18 pegs placed during the test, whereas the unaffected side performed better with an average of 7.99 ± 0.88 pegs. The affected side demonstrated a higher drop rate (mean of 2.24 ± 1.18), indicating decreased precision and hand coordination during the test, while the unaffected side had a mean of 1.01 ± 0.88.

On the numerical pain scale, the mean score for reported pain intensity on the affected shoulder was 5.26 ± 1.88, indicating a significant degree of discomfort during activity. Additionally, functional restrictions were noted and observed. With a mean score of 2.55 ± 1.14 for dressing difficulties and a mean score of 2.60 ± 1.14 for reaching overhead, participants reported mild to moderate interference in performing daily tasks as a result of shoulder impairment.

The results demonstrate that frozen shoulder significantly affects manual dexterity. This shows that the affected limb has experienced substantial reduction in both precision of motion and speed of reaction. A stark difference between the affected and unaffected sides demonstrates how pain affects fine and gross motor movements in patients.

Pain and Functional Assessment

Table 3: Pain and Functional Limitation Scores			
Assessment Variable	Mean ± SD	Range	Interpretation
Pain Intensity (VAS 0-10)	5.26 ± 1.88	2-9	Moderate Pain
Dressing Difficulties (1-5)	2.55 ± 1.14	1-5	Mild-Moderate
Overhead Reaching (1-5)	2.60 ± 1.14	1-5	Mild-Moderate

Discussion

The results from this study highlight a significant reduction in manual dexterity in the affected shoulder. The NHPT results demonstrate that the affected upper limb exhibits slower and less accurate fine motor performance. This finding is clinically important as manual dexterity is critical for independence in activities of daily living.

The mean test time on the affected side (28.21 seconds) was notably higher than the unaffected side (23.09 seconds). This difference underscores the impact of frozen shoulder on motor performance. The increased NHPT completion time on the affected side reflects pain-related movement inhibition, joint stiffness, muscle weakness, and tenderness. This pain can lead to involuntary guarding, increased consciousness, and hyperawareness of tasks to be performed. This also leads to altered motor movements and planning, contributing further to slower task execution.

Additionally, the affected side showed fewer pegs placed (6.78) and a higher number of pegs dropped (2.24) compared to the unaffected side, indicating compromised coordination and precision. This could result from impaired proprioceptive feedback due to the condition, reduced shoulder stability, and limited arm positioning affecting hand function.

Pain measured using the Visual Analog Scale (VAS) averaged 5.26/10, correlating with moderate functional impairment. Difficulty in dressing (2.55/5) and reaching overhead (2.60/5) further emphasize how frozen shoulder limits daily activities. The substantial standard deviations suggest variability among individuals, potentially due to differences in age, duration of symptoms, or baseline functionality.

These findings align with prior studies on adhesive capsulitis. For instance, research has found that reduced grip strength and pain in the shoulder significantly hinder fine motor tasks.¹¹ High VAS scores, as reported in this study, are consistent with adhesive capsulitis patients experiencing a pain-dexterity trade-off, where discomfort leads to slower or less accurate movements.¹²

A systematic review of manual therapy interventions highlights that pain reduction and mobility improvement contribute to restoring

dexterity. Interventions such as manual therapy, exercise, and glucocorticoid injections are commonly used to address frozen shoulder. While this study focused on dexterity, the broader literature emphasizes a multimodal approach for better outcomes. Research has found that mobilization techniques significantly improved range of motion (ROM) and pain, which indirectly enhances fine motor performance.¹³ Rehabilitation aimed at improving joint flexibility and reducing pain could further decrease NHPT test times and peg-drop errors in affected patients.

Studies show that combining manual therapy with exercises is superior to exercises alone in improving ROM and reducing pain. This combination addresses both the mechanical and functional impairments caused by frozen shoulder. Exercise alone, while helpful, may not fully restore function in severe cases.¹⁴

Recent systematic reviews on upper limb exercise and training show moderate certainty of evidence supporting targeted interventions for addressing dexterity problems.²³ These findings suggest that training protocols should employ task-related approaches, which aligns with contemporary understanding of motor learning and neuroplasticity principles. The evidence indicates that specialized dexterity training can lead to measurable improvements in both clinical assessments and functional outcomes.

Proprioceptive training has emerged as a promising intervention approach. Recent meta-analyses suggest that proprioceptive training may improve both dominant and non-dominant hand fine motor dexterity, as well as gross manual dexterity, following 2-8 weeks of intervention.²⁴ While findings remain somewhat inconclusive due to small sample sizes, the evidence supports the potential for neuroplastic changes associated with targeted training.

Contemporary exercise approaches, including Pilates-based interventions, show promise for addressing upper limb dysfunction. Recent studies demonstrate that short-term, structured exercise programs can be feasible and safe for patients with upper limb impairments, with changes in bradykinesia encouraging further research into comprehensive rehabilitation approaches.²⁵

Clinical Implications

Incorporating dexterity tests like NHPT allows therapists to quantify fine motor impairment that may be otherwise overlooked, helping to transfer subjective feelings of pain and tenderness into quantifiable measures that can assist assessment and treatment. Treatment plans would be better able to address pain management, joint mobility, and targeted exercises to improve hand coordination. As each patient has their own baseline, adhering to these tests helps personalize treatment plans further, making therapy more individualistic and leading to better results and more person-centered care.

Awareness of dexterity deficits can motivate adherence to therapy and adaptation of tasks by patients in their daily lives. They might become more willing to work on themselves with renewed vigor, be more receptive to the level of care provided, and be more vigilant about how they conduct themselves. They might be more willing to undergo all possible treatment programs and follow them consistently.

Limitations

One limitation of this study is the use of a cross-sectional design, which limits the ability to establish causal relationships between frozen shoulder and observed changes in hand dexterity. How these two factors affect one another cannot be explored in detail with such a study design. The cross-sectional nature does not allow tracking changes over time in response to interventions such as different types of

therapy, as it provides only a snapshot view of the population.

Secondly, the sample was collected from only one center, which could limit generalizability of results. For finding a broader, more comprehensive view, more hospitals and centers should be approached. The findings should be interpreted with caution, and replication in multicenter studies would help enhance external validity and lead to variety in different patient populations with different results.

Excluding patients with diabetes mellitus and hypertension, while reducing potential confounding variables, can also limit the practicality and applicability of results. Both conditions are quite prevalent in patients with frozen shoulder and may influence mobility, hand function, and overall physical performance. Thus, the study sample might not be truly representative of the wider patient population.

Other factors that could affect the study were not included, such as duration of the condition and whether it is chronic. Occupational demands, physical activity levels, and psychosocial factors like pain perception by patients, and conditions like anxiety or depression, all affect the level of pain felt by patients and can lead to slightly altered results.

CONCLUSION

study emphasizes how patients' capacity to carry out daily tasks requiring fine motor control is significantly impacted by joint stiffness, compensatory movement patterns, and persistent pain. As manual dexterity declines, tasks like buttoning clothing, writing, using tools, and handling small items become more challenging—not just reaching or lifting objects. This especially becomes problematic for patients whose occupation is severely affected,

those who have hand movement and coordination integrated in their work, because it hinders their independence and ability to perform fine and gross motor tasks themselves.

Another important factor to consider is that patients use different coping strategies that lead to overall decline of muscles and tissues surrounding the glenohumeral joint because more pressure and strain are exerted on them, leading to quicker functional decline. This leads to increased secondary discomfort and injuries caused by strain and overuse. Pain and stiffness can also lead to lack of use of that joint, causing negative impact. All of this provides more reason to have interventions that can detect frozen shoulder early and improve treatment to bring back ease in fine and gross motor activities.

Good focus should be on integrating fine motor exercises along with joint strengthening. Occupational therapy can play a significant role as it can help replicate real-life tasks so patients can start feeling better more quickly and in a smoother manner. Addressing issues like frustration, anxiety, or lack of motivation to undergo treatment should also be done to ensure timely recovery. Its impact on manual dexterity should be addressed as it allows a more comprehensive view of how severely it affects patients. With fine motor training and understanding its physical and psychological impact, the road to recovery for patients can be accomplished in an effective and efficient manner.

Thus, frozen shoulder is not only a condition that debilitates movement, but it also severely disrupts the function of the entire upper limb. Comprehensive assessment and treatment approaches that address both mobility and dexterity are essential for optimal patient outcomes.

Author Contributions

Khadija Shaukat Ali Mehar: Leading roles in conceptualization, supervision, and overall project management.

Laiba Ali & Kashaf Saleem: Primary data collection and analysis roles.

Ramma Inam: Data collection and methodology support.

Sabeen Masood: Senior supervision and validation roles.

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None.

Conflict of Interest

The authors declare no conflicts of interest in relation to this research study.

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None.

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