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Correlation between Shoulder Pain and Proprioception Post Abdominal Laparoscopic Surgeries

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Abstract

Background: Shoulder pain is one of the initial symptoms that occur after laparoscopic surgery, caused by the presence of carbon dioxide used for pneumoperitoneum, which stays in the abdominal cavity. Proprioception, the sensory perception of the position and motion of joints, plays a vital role in preserving joint stability as well as coordinating motions. The relationship among shoulder proprioception, pain intensity, as well as functional impairment in patients experiencing shoulder pain after abdominal laparoscopic surgery is still uncertain, as there are contradictory results in the existing literature. **Purpose:** The aim of this study was to assess the impact of shoulder pain on shoulder proprioception after abdominal laparoscopic surgeries. **Methodology:** Thirty-eight post abdominal laparoscopic surgery both sex patients, their age range was 30-50 years old, were randomly allocated from October 6 University Hospital, throughout the period between October and February 2023/2024, Patients were assigned to groups in a random manner **one group (study group)**, the study lasted one week, the assessments were performed on the selected patients three times; preoperative, first day postoperative then one week postoperative. All demographic data recorded and shoulder proprioception was evaluated via Laser pointer as well as digital inclinometer, to determine joint position sense at a specific angle of flexion (90°). Functional disability was assessed through the Shoulder Pain and Disability Index (SPADI), while pain intensity was assessed using the visual analog scale (VAS). All demographic data were properly recorded. Following this, statistical analyses were performed with a 95% confidence interval. **Result:** There was a moderately positive correlation between laser pointer angle reproduction test (LP-ART) as well as VAS ($r = 0.46$, $p = 0.003$), LP-ART and SPADI with pain ($r = 0.43$, $p = 0.007$), and total SPADI ($r = 0.32$, $p = 0.04$), while there was a non-significant correlation with disability score ($r = 0.20$, $p = 0.24$). **Conclusion:** A moderate positive correlation among joint position error (JPE) at 90 angle of flexion as well as pain intensity in addition moderate positive significant correlation among LP-ART with both pain score and total SPADI score, whereas there was non-significant correlation among LP-ART as well as disability score.

Keywords: Abdominal laparoscopic surgery, Functional disability, Laser pointer angle reproduction test, Pain intensity, Shoulder pain**,** Shoulder proprioception

Introduction:

Minimally invasive surgery is a fundamental principle of current surgical techniques. Laparoscopy is increasingly being used instead of conventional laparotomy in modern surgical practice due to its numerous advantages. Nevertheless, a significant proportion of individuals experience post-laparoscopic shoulder pain (PLSP) that can be more distressing than the discomfort from abdominal incisions and internal organs following surgery.[1] Furthermore, PLSP is less responsive to treatment than incision as well as visceral pain. Prolonged pain will not only make patients more uncomfortable but also raise the risk of several postoperative complications and postponed rehabilitation, which will greatly raise the cost of care.[2] Proprioception refers to our capacity to perceive the position and movement of our limbs and joints in relation to our body and the surrounding environment, even without visual input.[3]

Shoulder pain can disrupt the normal sensory feedback from the joint. Pain signals may interfere with the accurate perception of joint position, leading to proprioceptive deficits.[4]
The documented prevalence of PLSP varies between 30% as well as 90%, depending on the surgical techniques employed and the specific research studies conducted. Given the substantial number of patients receiving laparoscopic surgery annually, even with a conservative estimate of a 30% incidence rate, the prevalence of this clinical issue is concerning.[2] In general, referred pain is believed to be the mechanism by which laparoscopy-induced shoulder pain develops.
Connecting with the supraclavicular nerve (C3-4), which supplies sensory input for the acromion process, the phrenic nerve (C3-5) innervates the diaphragmatic pleural surface. By means of convergence on the spinothalamic tract, referred pain originates.5 Referred pain in the upper shoulder is the result of diaphragmatic irritation.[6]

Due to the high degree of mobility in the glenohumeral joint, it relies heavily on a strong sense of sensorimotor control, which includes maintaining an intact ability to perceive the joint's position and movement (joint proprioception). Consequently, it can be inferred that having a well-developed awareness of the position and movement of the shoulders is crucial for avoiding injuries and effectively carrying out our everyday tasks.[3]

Shoulder pain can disrupt the normal sensory feedback from the joint leading to proprioceptive deficits, changes in muscle activation patterns to avoid or minimize discomfort. This altered muscle recruitment that can affect the normal coordination required for precise shoulder movements and also compromise dynamic stability by inhibiting the proper functioning of muscles that contribute to joint stability. This may result in reduced control during movements, increasing the risk of injury. However, the precise impact of pain on proprioception senses is still not well understood.[3]

So that the current study was carried to investigate if there was affection on shoulder proprioception related to the post laparoscopic shoulder pain.

Subject, Material &Methods:

Study Design and Sample Size:

This study was conducted as a Prospective, Pre/ Post-assessment, randomized controlled trial. Following the permission of the ethics committee at the Faculty of Physical Therapy, Cairo University in Egypt, the methods of the study were extensively reviewed and all patients were required to provide written informed consent. The sample size calculation was conducted, taking into account a projected 20% loss to follow-up. It was determined that a minimum of 38 patients were required for this investigation. The sample size calculation was performed using G Power

and Sample Size Calculations software, specifically version 3.0.11 for MS Windows, developed by William D. Dupont and Walton D. at Vanderbilt University in Nashville, Tennessee, USA.

Participants:
Thirty eight adult patients of both sexes that underwent to abdominal laparoscopic surgery participated in this study. The patients were put into one group at random **(study group)**. The patients were recruited from General surgery unit, October 6 University hospital at the time from Otober 2023 till Febraury 2024. The assessments were performed on the selected patients three times; preoperative, first day postoperative then one week postoperative.

Inclusion Criteria:
The age of the patients ranged from thirty to fifty years old, Male and female patients participated in this study. All patients had undergone abdominal laparoscopic surgeries, all patients be able to read and write.

Exclusion Criteria:
The patient was excluded if had one or more of the following criteria: prior shoulder pain or injury, limitation to shoulder movement due to autoimmune rheumatoid arthritis, osteoarthritis, neurological disorders, prior shoulder surgery, any neurological impairment, any disorders affecting joint mobility such as strain, tendonitis, bursitis and stiffness, who couldn't follow instructions due to communication, vision, hearing disorders, any vigorous exercise in the past 24 hours before surgery, who wasn't cooperative in filling the questionnaire and diabetic.

Instruments:

A. Assessment Instrument:

1. Active Joint Position Test for shoulder proprioception

Materials were used to measure Shoulder Proprioception by shoulder joint position error via Laser Pointer.[8]

- **Laser pointer:** Strapped to the lateral side of the humerus, just proximal to the lateral epicondyle on the dominant arm of the patients, was the attachment.
- **Target paper:** The object is usually 40 cm in diameter and consists of concentric circles that are spaced 1 cm apart. These circles are divided into four quadrants that cross at the zero point.
- **Chair:** a stable chair with back support and positioned such that it wasn't move when the patient moved his/her shoulder during the test.
- **Colored stickers:** were used to determine the starting and the ending points of the laser.
- **Ruler:** to measure the distance between the start point and endpoint in each direction on the target paper.
- **Inclinometer App for shoulder flexion range of motion:** Smartphones equipped with inclinometer applications are convenient and easily accessible tools that are generally reliable as well as valid for evaluating the range of motion in joints. They have the potential to be used on a large scale when a traditional bubble inclinometer is not accessible.[9]

2. Visual analogue scale for pain (VAS-P)

The VAS-p is a technique used to quantify pain intensity. It involves a horizontal straight line of fixed length (10 cm), where the left end represents the highest pain score and the right end

represents the lowest pain score. The patient is then asked to mark the line according to their pain sensation, with a higher score indicating a higher level of pain.[10]

3. The Shoulder Pain and Disability Index (SPADI):

The patients' perception of their health status related to shoulder disorders was evaluated using the Shoulder Pain and Disability Index (SPADI) questionnaire. This questionnaire comprises 13 items that are divided into two subscales: pain (consisting of 5 items) and dysfunction (consisting of 8 items). The ultimate score spans from 0 to 100 points, with higher scores indicating diminished shoulder function. The questionnaire has been determined to be valid and has demonstrated great reliability, with an ICC ranging from 0.90 to 0.97. It also exhibits strong internal consistency, as indicated by a Cronbach's Alpha coefficient of 0.93. In terms of measurement error, the standard error of measurement (SEM) is 5.3, while the minimal detectable change (MDC) is 14.72.[11]

B. Evaluating Procedures:

i. Subjects Preparation:

- Medical history was taken from each patient in current clinical trials before starting the study and was recorded in a data recording.
- The researcher conducted all measurements.
- Verbal explanation about the study aims, importance and approach were instructed to every patient in all current study group to insure full cooperation from the patient.
- Each patient provided their signature on a written consent form after being fully informed about the study's objective, methodology, potential advantages, privacy measures, and data usage.

ii. Outcome measures:

- **Assessment for pain:**

We assessed pain intensity before application of the test each time via the VAS, this is a widely utilized and well-recognized self-report assessment tool that is commonly employed in both clinical and research environments. The patient continuously assessed his pain levels and measured its intensity on a fixed-length horizontal line (10 cm), with the highest pain score indicated at the left end and the lowest pain scores indicated at the right end. [10]

- **Assessment for pain and shoulder disability:**

Then the patient filled the SPADI, A validated questionnaire, specifically developed to assess functional limitations as well as pain linked to the shoulder, requires patients to mark a point on a 10cm line using a VAS for each item. The pain dimension's verbal anchors were "absolutely no pain" and "the most excruciating pain imaginable," while the functional activities' anchors were "absolutely no difficulty" and "so difficult that assistance was required." The sum of the individual ratings for each dimension produced the overall score. **Interpretation of scores:** Total pain score: / 50 x 100 = % Total disability score: / 80 x 100 = % Total SPADI score: / 130 x 100 = % the means of the two subscales were averaged to produce a total score ranging from 0 (best) to 100 (worst). MDC (90% confidence) = 13 points. [11]

- **Assessment for shoulder proprioception Active Joint Position Test:**

Shoulder Proprioception measured by shoulder joint position error via Laser Pointer. [8]

- The patient was positioned in a chair with a blindfold or eyes closed and a laser pointer attached to the side. The laser pointer was secured to the outside side of the upper arm, just above the elbow joint, on the arm that the patient uses most frequently.

- The target paper is positioned 100 cm away from the laser pointer, with the center of the target aligned with the end of the pointer.
- The patient raised their dominant arm to a 90° angle of flexion, while maintaining an extended elbow and a neutral wrist position with the thumb pointing upwards. This angle was measured using an inclinometer app to ensure that it is precisely 90°.
- Upon receiving the command, the patients lifted their dominant arm to a 90° angle with their eyes open. At this point, the examiner supported their shoulder to ensure that the laser was directed towards the center of the target.
- After that, an inclinometer attachment for a smartphone was fastened to the outside of the arm, somewhat above the elbow. While the patient stood, the experimenter measured and recorded the angle of the person's shoulders.
- The patient was directed to memorize this position for a duration of three seconds. Afterward, they were advised to lower their arm to the starting position. Then, while blindfolded, they were asked to raise their arm back to the target at a velocity of their own choosing.
- When they felt they had elevated their arm to the previously recalled position, they verbally confirmed by saying 'yes', and the angle from the two-dimensional chart was measured then documented.
- Patients then performed an additional four repetitions, with the examiner supporting the patient's shoulder at a 90° angle each time, while also providing a slight oscillation. The angle was documented by recording the position of the laser dot on the target. The angles on the target ranged from 0 to 9 degrees.

In order to determine the angle of error, which was determined by trigonometry, we divided the distance between the recorded laser dot and the center of the target by the distance between the laser pointer and the center of the target. This was done in the event that the reproduction angle error was greater than the target's maximal error angle of 9°.
The absolute angular deviation of the LP-ART measurement refers to the exact difference in degrees among the target position as well as the corresponding position of the laser dot on the scale. The “c” value (hypotenuse) was calculated through the horizontal (x) and vertical (y) distances of the position of the laser dot on the scale from the target, and the “c” value was converted from cm to the absolute angular deviation in degrees via the following formula in the Excel software (2010), which 100 is the distance from the target (1 meter):

$$\alpha = tan^{-1}(\frac{c}{100})$$

The absolute error (AE) was determined by calculating the average of the 5 trials for each test.

Statistical analysis:

The demographic and gathered data of the patients were presented using descriptive statistics. To examine the relationship between LP-ART, VAS, as well as SPADI, the Pearson Correlation Coefficient was obtained. We compared LP-ART in individuals with low VAS to those with high VAS using an unpaired t test. A p-value less than 0.05 was established as the threshold for statistical significance. With the help of SPSS version 25, a Windows program, we ran all of our statistical analyses. [12]

Results

Subject characteristics:

Thirty-eight adult patients underwent abdominal laparoscopic surgery took part in this study group. Their mean ± SD age, weight. height as well as BMI were 39.26 ± 6.47 years, 92.63 ± 18.43 kg, 167 ± 8.14 cm and 33.25 ± 6.92kg/m² respectively. Patient characteristics is presented in table (1).

Table 1. Participant characteristics.

	Mean ± SD	Maximum	Minimum
Age (years)	39.26 ± 6.47	50	30
Weight (kg)	92.63 ± 18.43	139	55
Height (cm)	167 ± 8.14	180	150
BMI (kg/m²)	33.25 ± 6.92	49.70	22
	N	**%**	
Sex distribution, n (%)			
Females	25	66	
Males	13	34	
Type of surgery, n (%)			
Cholecystectomy	18	47.4	
Hiatus Hernia	6	15.8	
Sleeve (Bariatric)	4	10.5	
Umbilical Hernia	4	10.5	
Appendectomy	3	7.9	
Bypass (Bariatric)	3	7.9	
Site of shoulder pain, n (%)			
Right	25	66	
Left	13	34	

SD, Standard deviation

- VAS and SPADI of subjects:

The average value ± standard deviation (SD) of LP-ART was 6.04 ± 1.98 degrees, ranging from a low of 3 degrees to a maximum of 11 degrees.

The average value ± SD of shoulder pain, as measured by the VAS, was 5.87 ± 1.80. The lowest recorded value was 3, while the highest recorded value was 10.

The average value ± SD of the overall SPADI score was 42.14 ± 15.21%, ranging from a minimum of 15% to a maximum of 81.50% (Table 2).

Table 2. ***Descriptive statistics of LP-ART, VAS and SPADI of subjects:***

	Mean ± SD	**Minimum**	**Maximum**
LP-ART (degrees)	6.04 ± 1.98	3	11
VAS	5.87 ± 1.80	3	10
SPADI (%)			
Pain	53.63 ± 18.32	22	94
Disability	35.02 ± 15.31	0	74
Total SPADI Score	42.14 ± 15.21	15	81.50

SD, Standard deviation

Correlation between LP-ART, VAS and SPADI:

The correlation between LP-ART and VAS was moderate positive substantial correlation ($r = 0.46$, $p = 0.003$).

The correlation among LP-ART and SPADI was moderate positive substantial with pain ($r = 0.43$, $p = 0.007$) as well as total SPADI ($r = 0.32$, $p = 0.04$); and was non-significant with disability score ($r = 0.20$, $p = 0.24$). (Table 3).

Table 3. Correlation between LP-ART, VAS and SPADI:

	LP-ART (degrees)	
	r – value	**P- value**
VAS	0.46	0.003*
Pain	0.43	0.007*
Disability	0.20	0.24
Total SPADI Score	0.32	0.04*

r value: Pearson correlation coefficient; p value: Probability value, * significant at $p < 0.05$.

DISCUSSION

The objective of this study was to assess the proprioception of the shoulder and its correlation with the level of pain and functional impairment in persons experiencing shoulder pain after laparoscopic surgery.

Although shoulder pain following laparoscopic abdominal surgery does not pose a major risk of mortality, it is a regular occurrence that greatly diminishes patient satisfaction and may

impede recovery, leading to a large rise in healthcare costs. This form of pain is commonly known as "referred pain" and is usually induced by the carbon dioxide gas utilized to expand the abdominal cavity during the surgical procedure. This gas has the potential to cause irritation to the diaphragm by excessively stretching it. The diaphragm shares neural pathways with the shoulder through the phrenic nerve, which can result in referred pain to the shoulder. This can lead to discomfort in the shoulder area.[2,13]

Several studies proved significant defect on shoulder proprioception related to pain intensity in patients with shoulder pathology or neurological disorder. Ager and colleagues' 2020 systematic study revealed that, when assessed in painful shoulders compared to healthy controls, the presence of pain and conflicting nociceptive inputs affects different forms of proprioception (JPS/kinesthesia/SOF).[3] However, no previous study implemented to examine the potential impacts of laparoscopic surgery on shoulder proprioception, specifically focusing on the occurrence of shoulder pain following the procedure.

In our research investigation, we meticulously examined the occurrence of shoulder pain across various surgical procedures. The study cohort consisted of patients who underwent specific laparoscopic surgeries, each affecting different shoulder regions. Here are the key findings: Laparoscopic Cholecystectomy (Right Shoulder) Incidence: Eighteen patients reported shoulder pain following this procedure. Severity: the average pain severity, as assessed by the VAS, was 5. Laparoscopic Hiatus Hernia (Left Shoulder) Incidence: Five patients experienced shoulder pain after laparoscopic hiatus hernia repair, Severity: The mean pain intensity (VAS) was 7. Laparoscopic Umbilical Hernia (Both Sides, Commonly Affecting Right Shoulder) Incidence: Four patients encountered shoulder pain following laparoscopic umbilical hernia repair, Severity: The mean pain intensity (VAS) was 6. Laparoscopic bariatric Surgery (Left Shoulder) Incidence: Seven patients reported shoulder pain after laparoscopic bariatric surgery, Severity: The mean pain intensity (VAS) was 9. Laparoscopic Appendectomy (Right Shoulder) Incidence: Three patients exhibited shoulder pain post laparoscopic appendectomy, Severity: The mean pain intensity (VAS) was 3.5. The data yielded useful information regarding the correlation between surgical procedures, shoulder pain, as well as the intensity of pain.

Notably, the variation in pain intensity across different surgeries underscores the need for tailored management strategies. Further investigation into the underlying mechanisms and potential interventions is warranted.

The findings of the current study showed that there was moderate positive substantial correlation among shoulder proprioception as well as pain intensity in both groups; group A low VAS (score 1 to 5) and group B high VAS (score 6 to 10), The mean difference among groups was -1.75 degrees. There was a substantial improvement in LP-ART of group B when contrasted with that of group A ($p = 0.005$) indicating that the ability to recognize the target angle was distorted by the presence of pain. Despite the moderate positive significant correlation between LP-ART with both pain score and total SPADI score, there was non-significant correlation between LP-ART and disability score.

The findings of this study are consistent with earlier studies carried out on the correlation among shoulder proprioception as well as pain intensity among individuals with shoulder disease. these studies have found significant positive correlations among joint position error (JPE) as well as pain intensity. For example**, Alfaya et al. [(4)]** conducted a study on 42 patients suffering from Subacromial Impingement Syndrome (SAIS) to assess shoulder proprioception, investigate its correlation with pain intensity, in addition evaluate functional disability. The study revealed strong positive correlations among JPE as well as pain intensity. A further study by **Sahin et al. [(14)]**

evaluated proprioceptive impairments among patients with SAIS and found strong positive correlations among pain severity along with shoulder proprioception deficits. Their research showed that those who had more pain typically exhibited worse proprioceptive impairments, and the authors in **Vittersø et al.**[15] discovered that the impairment in proprioception could potentially interfere with the typical neuromuscular regulation of the shoulder joint. This could result in modified patterns of motion and potentially exacerbate pain.

However previous studies results evidenced strong positive correlation, our study results showed it as moderate positive correlation among pain intensity as well as shoulder proprioception, the underlying cause for this discrepancy of outcomes, are the previous studies conducted their investigations on patients with shoulder disorders, who have anatomical changes, tissue injuries and inflammatory processes that may interfere with the typical sensory input as well as processing systems, resulting in altered proprioceptive feedback and impaired it. [4] while in our study we recruited individuals who were experiencing referred shoulder pain and had no diagnosed for any shoulder injuries, these findings can be explained by the fact that pain can disrupt proprioception at different neurophysiological levels, causing a disturbance in the normal sensory feedback from the joint. This can result in proprioceptive deficits and alterations in muscle activation patterns, as a way to avoid or reduce discomfort. This altered muscle recruitment, which can affect the normal coordination, required for precise shoulder movements leading to decrease the ability to recognize the target angle and increasing active joint sense error. [3,16]

In addition to its strong positive correlation among shoulder JPE as well as pain severity, also improved significant correlation between deficits in shoulder proprioception and functional disability these results have been repeatedly reported in previous literatures. [4,14,17] In contrast the outcomes of our study showed non-significant correlation among proprioception impairments as well as functional disability in PLSP patients. However, the correlation among proprioception defects as well as functional disability was not always significant in other conditions, It's important to note that these are general observations and the exact relationships can vary from person to person which may be impacted by various factors for example the type as well as severity of the proprioceptive defect and the specific functional tasks assessed.[18]

The patients that enrolled in this study have PLSP, which, as we mentioned before is refer pain from an irritating diaphragm caused by excessive stretching that occurs during laparoscopic abdominal surgeries.[19] The intensity level of this refer pain may reach 10/10 on VAS but it's acute and doesn't last for too long only one week and may be less. Short-term pain may not significantly affect shoulder proprioception compared to chronic or persistent pain because it's a temporary condition tends to resolve quickly once the underlying cause is addressed.[20] In addition to the effects of general anaesthesia on the patient's body, which include fatigue, sleep disturbances, mood changes and difficulty, concentrating persisting for days to a week.[21] The experience of acute noxious pain and fatigability can also affect the normal coordination, required for precise shoulder movements leading to decrease the ability to recognize the target angle and increasing active joint sense error.[22] This may explain the moderately positive correlation among pain intensity as well as shoulder JPE and the non-significant correlation between proprioception defects and functional disability found in this study.

Even though the findings of this study demonstrated a moderate positive correlation among pain intensity and as well as proprioception defects on the first day postoperative and there was a statistically substantial improvement in the LP-ART (laser pointer angle reproduction test) at the first day postoperative compared with before surgery, there was no substantial difference in LP-ART between the preoperative assessment and the evaluation one week after

surgery**.** This lack of difference is attributed to the resolution of factors that influence the precision in replicating the target angle**,** such as pain and the impact of general anaesthesia, allowing proprioception accuracy to normalize.

Although our study offers new insights into the correlation between shoulder proprioception, pain intensity, as well as functional impairment in individuals having PLSP, it is important to address numerous limitations. Firstly, the study design hinders our capacity to definitively identify cause-and-effect linkages and the order in which events occur. Further longitudinal investigations are required to investigate the evolution of proprioception, pain severity, as well as disability over time. These studies should also evaluate the efficacy of therapies that specifically address proprioceptive impairments, with a particular focus on patients with cholecystitis who experience prolonged right shoulder pain. Furthermore, the sample size was rather small, perhaps limiting the generalizability of the results. Additional research using bigger sample sizes is necessary to corroborate our findings and improve the statistical significance. Furthermore, our study mostly consisted of different types of general abdominal surgeries, limiting to examine the causality of the difference of pain intensity level, which may relate to the more affection of diaphragm between different surgeries. Future studies should aim to incorporate a more precise category of laparoscopic surgery. Future research should prioritize the inclusion of varied samples in order to gain a more comprehensive understanding of the significant gender variations in proprioceptive deficits.

CONCLUSION

The results obtained from the current study and the discussion that followed it, can lead to concluding that It was a moderate positive correlation among joint position error (JPE) at 90 angle of flexion as well as pain intensity. In addition, moderate positive significant correlation between LP-ART with both pain score and total SPADI score, while there is non-significant correlation between LP-ART and disability score. This means that presence of pain may distorted our ability to replicate the target angle and increase proprioception error with high intensity pain.

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LIMITATIONS

- A quite number of patients have no shoulder pain post laparoscopic abdominal surgeries.
- Some patients had not continued the study by not applied the third measurments.
- Some patients unable to read and write, unable to fill the questionaieer.
- The low rate of patients who coped with the inclusion criteria followed had elongated the period of study.

RECOMMENDATIONS

The result of the study indicated a need to consider the following recommendations:

- More future longitudinal studies are needed to examine changes in proprioception, pain intensity, and disability over time and assess the effectiveness of interventions targeting proprioceptive deficits maybe focusing on patients with cholecystits who suffer from right shoulder pain for long period time.
- Further studies needed to examine changes in proprioception at various angle with more objective methods in patients with PLSP.
- Explain the effect of acute pain on shoulder proprioception still remain unclear need to be more investigated in future researches.
- The sample size was relatively small, which may restrict the generalizability of the findings. Further studies with larger sample sizes are warranted to validate our results and enhance statistical power.
- Clinical trial for another type of acute pain and its correlation with shoulder proprioception.
- Future research should aim to include a specific one type of laparoscopic abdominal surgery.

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