SYSTEMATIC REVIEW

Effectiveness of virtual reality in pain management, range of motion and functional performance in frozen shoulder patients: A systematic review

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Abstract

Objective: To evaluate the effectiveness of virtual reality in improving pain management, range of motion and functional performance among frozen shoulder patients.

Method: The systematic review was conducted at Khyber Medical University Peshawar between February 2023 - November 2023 and comprised literature search regardless of the year of publication across multiple databases, including Medline via Ovid, Cochrane Library and Physiotherapy Evidence Database, and Google Scholar search engine. Covidence software was used to screen titles, headings and abstracts from the retrieved articles. Experimental trials comparing virtual reality with any other intervention or no intervention with diagnosed cases of frozen shoulder, either unilateral or bilateral, among patients aged >20 years, were included in the systematic review. The risk of bias was evaluated through the Cochrane risk of bias checklist.

Results: Of the 8,616 studies, 4(0.04%) were identified by Medline, 7,696(89.32%) by Cochrane Library, 0(0%) by Physiotherapy Evidence Database and 916(10.63%) by Google Scholar. Overall, 31(0.36%) studies were retrieved for full-text review, and, of them, 7(22.6%) were reviewed in detail; 3(42.85%) randomised controlled trials (level of evidence: 2), 2(28.57%) quasi-experimental studies (level of evidence: 3), and 2(28.57%) experimental studies (level of evidence: 3).

Conclusion: Virtual reality was found to be a promising intervention for rehabilitating patients with frozen shoulder. Evidence indicated potential improvements in joint range, pain and functional mobility, although findings were mixed, and the quality of evidence was variable.

Keywords: Frozen shoulder, Virtual reality, Pain management, Range of motion, Rehabilitation. (JPMA 76: 571; 2026)

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Introduction

Shoulder pain is one of the most frequent musculoskeletal complaints reported in healthcare settings, often stemming from conditions affecting the glenohumeral (GH) joint.[1] Adhesive capsulitis (AC), also known as frozen shoulder (FS), is a particularly troublesome disorder of this joint. It causes significant pain and a drastic reduction in both active and passive range of motion (ROM), leading to a substantial decline in quality of life (QOL) for those affected.[2] AC can be either primary or secondary.[3] Primary AC is an idiopathic, painful stiffness of the GH joint that develops spontaneously without any predisposing factor.[4] Secondary AC can result from pre-existing shoulder conditions or traumas, or may occur in patients with breast cancer post-mastectomy or any systemic disorders, such as diabetes mellitus (DM), hypo- and hyper-thyroidism, hypo-adrenalism, and other hormonal imbalances.[5-7]

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The incidence of FS is reported to be 2-5% worldwide, although estimates range from as low as 0.5% to as high as 10%.[8,9] This condition is mainly experienced between the ages of 40 and 65 years, with females exhibiting a higher occurrence rate than men.[8] AC reports contracture of the GH capsule as its hallmark.[10]

Common conservative treatments for AC include medications, such as non-steroidal anti-inflammatory drugs (NSAIDs), physiotherapy, manipulation under anaesthesia, exercises, nerve blockers, steroidal injections, etc., which are successful in up to 90% patients.[10,11] In the late 1960s, the concept of artificial reality was instituted by Myron Krueger, an American computer artist.[11]

Virtual reality (VR) users wear head-mounted displays with screen adjacent to them that creates a feeling of presence in a three-dimensional (3D) world.[12] For pain management, the aim of VR technology is to distract the patient from painful regions by immersing the patient in the environment, and by blocking external sensations associated with pain and the real environment.[5] VR technologies have proven to be highly effective in the recovery of walking and upper limb motor function.[11]

Several systematic reviews have been conducted on FS. Tarang K. Jain et al. in 2013 evaluated the effectiveness of

various physiotherapeutic interventions (PTIs) in the treatment of FS. However, the review, which included 39 studies, did not focus on investigating the use of VR.[13] Similarly, a 2020 study by Michael G. et al. examined the outcomes of physical therapy in FS, including interventions such as modalities, manipulations, mobilisations, transcutaneous electrical nerve stimulation (TENS), thermal therapy and stretching. However, despite the diverse range of interventions assessed, VR was not included.[14]

To our knowledge, no systematic review has explored the efficacy of VR in FS treatment. There is limited literature on this topic, which lacks comprehensive insights into the benefits of VR in managing pain, improving ROM, and enhancing functional performance for FS patients. The current systematic review was planned to fill the gap in literature by evaluating the effectiveness of VR interventions in managing pain, improving ROM and enhancing functional performance among FS patients.

Materials and Methods

The systematic review was conducted at Khyber Medical University Peshawar, between February 2023-November 2023 and comprised literature search across multiple databases, including Medline via Ovid, Cochrane Library and Physiotherapy Evidence Database (PEDro), and Google Scholar search engine. The review was conducted in line with the preferred reporting items for systematic review and meta-analysis (PRISMA) checklist[15] and the protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO) database in June 2023 (PROSPERO registration ID: CRD42023435632).

The search was conducted with the help of medical subject heading (Mesh) terms and Boolean operators without any restriction of timeframe. The key words used included Virtual reality OR Exergaming AND Frozen Shoulder OR Adhesive capsulitis OR Frozen Adhesive Capsulitis AND Pain Management OR Pain OR Range of Motion OR ROM OR Functional Performance OR Activities of Daily Living OR ADL.

Regardless of the year of publication, all the relevant articles published in English were included for initial screening. The target was experimental studies, both randomised and non-randomised, that compared VR with no interventions or any conventional physical therapy interventions for managing FS symptoms. While randomise controlled trials (RCTs) provide the highest level of evidence, the body of literature on VR for frozen shoulder is still emerging. To comprehensively map the current state of evidence, the inclusion criteria were expanded to encompass all experimental studies, including quasi-experimental studies. Studies were excluded if the intervention had been performed under anaesthesia. Participants aged >20 years with diagnosed FS (unilateral/bilateral) were included. Trials included were those that assessed the effects of any form of VR on confirmed cases of FS in adults. VR is a 3D stimulation device that gives the users an immersive feel of a virtual world. The participants in the control group may receive no interventions or any conventional physical therapy interventions, like steroid injections, ultrasound therapy, laser therapy, and active and passive ROM exercises.

Outcomes were FS symptoms measured on any validated measurement tool, such as the numerical pain rating scale (NPRS),[16] the Shoulder Pain and Disability Index (SPADI) (16), and the Disabilities of Arm, Shoulder and Hand (DASH) Questionnaire.[17]

The search results were imported on Covidence software. The title and abstract screening were done by two independent authors, while another set of two independent authors extracted data regarding authors, year of publication, study design, intervention detail, comparator, sample size, age of participants, and outcome measures, including pain intensity, functional performance, and ROM. The disparity was cross-checked, and conflicts were resolved with consensus.

All the included studies were checked for the risk of bias using Cochrane risk of bias tool (ROB 1)[18] by two independent researchers, which was cross-checked by an independent reviewer.

The method for data synthesis (meta-analysis or narrative synthesis) was dependent on the characteristics and homogeneity of the included studies. Due to significant clinical heterogeneity in the VR interventions (gaming systems vs. sensor-based rehabilitation) and outcome measurement timelines, a meta-analysis was deemed inappropriate. The strength of the evidence was evaluated using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach.[19] A narrative synthesis was conducted to summarize the findings, and an attempt was made to explore patterns by informally grouping studies by VR type and comparator, where possible.

Results

Of the 8,616 studies, 4(0.04%) were identified by Medline, 7,696(89.32%) by Cochrane Library, 0(0%) by PEDro and 916(10.63%) by Google Scholar. Overall, 31(0.36%) studies were retrieved for full-text review, and, of them, 7(22.6%) were reviewed in detail(16, 17, 20-24) (Figure-1).

Among the studies reviewed, 3(42.85%) were RCTs with level of evidence 2, 2(28.57%) were quasi-experimental

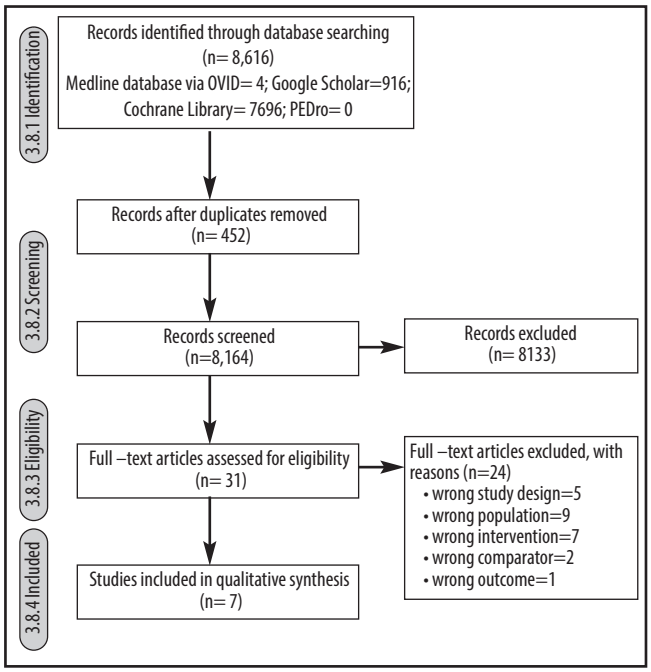

Figure-1: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

studies having level of evidence 3, and 2(28.57%) were experimental studies with level of evidence 3 (Table 1-2)

VR interventions varied considerably in their technological approaches, treatment protocols, and comparator groups, making it challenging to draw definitive conclusions about the optimal VR approach for FS rehabilitation (Table 3).

The risk of bias assessment revealed significant concerns across several studies, with only 2(28.57%) RCTs showing a low risk of selection and reporting bias, necessitating the use of caution while interpretation the findings (Figures 2-3).

RCT: 15,16,19; Exp: 17,20; Quasi: 18,22

Discussion

The current systematic review investigated the effectiveness of VR in AC management by comparing its effectiveness with traditional rehabilitation methods. The findings align with previous research, demonstrating significant improvements in shoulder ROM and activities of daily living (ADLs) for patients undergoing VR therapy.[13,16]

Table-1: Level of evidence in the studies reviewed.

S. No	Topic	Study Design	Level of Evidence
1	Effect of virtual reality aided physical therapy in adjunct to traditional therapy in frozen shoulder patients.[16]	RCT	LEVEL: 2
2	Association between Stretching Exercise with Virtual Reality Game and Over Head Pulley of Frozen Shoulder Patients.[20]	RCT	LEVEL: 2
3	The App Game Interface Design for Frozen Shoulder Rehabilitation. [23]	Experimental study design	LEVEL: 3
4	Experimental Studies of Virtual Reality-Delivered Compared to Conventional Exercise Programmes for Rehabilitation.[17]	Quasi Clinical Trial	LEVEL: 3
5	Intelligent frozen shoulder rehabilitation.[22]	RCT	LEVEL: 3
6	Effect of game-based virtual reality training versus conventional physiotherapy in peri arthritis shoulder.[22]	Quasi-experimental study	LEVEL: 3
7.	Motor Ingredients Derived from a Wearable Sensor-Based Virtual Reality System for Frozen Shoulder Rehabilitation.[21]	Experimental study	LEVEL: 3

RCT: Randomised controlled trial.

Table 2: Summary of the included studies.

Study	Design	Sample Size	Intervention	Pain	ROM	Functional Performance	Follow-up	Outcome
Shrutika et.al. 2021[16]	RCT	50	Oculus PT+Maitland Mobilisation	Improved	Improved	Improved	2 weeks	VR group showed greater improvement in pain, ROM, and function
Donny et.al. 2020[20]	RCT	NR	VR stretching+Ultrasound	Improved	Improved (Abduction, Flexion)	NR	2 months	VR stretching similar to conventional stretching for ROM improvement
Chia-En Chung et.al. 2016[23]	Experimental	3	VR game design	NR	Measured	NR	NR	App game interface improved range of motion
Heidi Sveistrup et.al. 2003[17]	Quasi-experimental	NR	VR exercise Programme	NR	NR	Improved	3 months	VR group showed slightly greater improvement in function.
Ming-chun et.al. 2014[22]	RCT	40	VR training Programme	NR	Improved (Ext. Rotation, Int. Rotation)	NR	4 weeks	VR group showed greater improvement in ROM
Sharmila.S et.al. 2022[24]	Quasi-experimental	30	VR game training	Improved	No significant improvement	Improved	4 weeks	Both VR and conventional therapy improved pain, VR showed no significant difference in ROM or function compared to conventional therapy
Si-Huei Lee et.al. 2016[21]	Experimental	16	VR GDSR system	NR	Improved (Flexion, Abduction, Ext. Rotation, Int. Rotation)	NR	4 weeks	VR GDSR system effective for frozen shoulder rehabilitation based on motor indices, task performance, and CATs

RCT: Randomized Controlled Trial; PT: Physical Therapy; Mobilisation: Manual therapy technique to improve joint mobility; VR: Virtual Reality; ROM: Range of Motion; NR: Not Reported; GDSR: Goal-Directed Shoulder Rehabilitation; CMT: Constant Murley Tool (functional outcome score); CAT: Clinical Assessment tools.

Table 3: Characteristics of Virtual Reality Interventions in Included Studies.

Study	VR Type/Device	VR Protocol Frequency, Duration)	Comparator Group	Key Findings
Shrutika et al. (2021)[16]	Oculus-guided physical therapy	Duration: 2 weeks (Frequency not specified)	Maitland's mobilization	VR group showed greater improvement in pain, ROM, and function
Donny et al. (2020)[20]	Virtual Reality Game (VRG) for stretching	3-9 times/week for 2 months	Over Head Pulley (OHP) stretching	VR stretching similar to conventional stretching for ROM improvement
Chia-En Chung et al. (2016)[23]	App-based game interface with wearable sensors	Duration: 2 months (Frequency not specified)	Not applicable (design study)	App game interface improved range of motion
Heidi Sveistrup et al. (2003)[17]	VR-delivered exercise programme	3 sessions/week for 6 weeks (60 min/session)	Conventional exercise programme	VR group showed slightly greater improvement in function (DASH scores)
Ming-chun et al. (2014)[22]	VR-based immersed training programme	Duration: 4 weeks (Frequency not specified)	Traditional rehabilitation	VR group showed greater improvement in ROM (26% vs 18%)
Sharmila S. et al. (2022)[24]	X-box Kinect 360 wireless sensor gaming	40 min/session for 4 weeks (Frequency not specified)	Conventional physiotherapy	Both groups improved pain; no significant difference in ROM or function between groups
Si-Huei Lee et al. (2016)[21]	Wearable sensor-based VR system (GDSR)	Duration: 4 weeks (Frequency not specified)	Traditional rehabilitation	VR system effective for frozen shoulder rehabilitation based on motor indices

VR: Virtual reality, ROM: Range of motion, DASH: Disabilities of the arm, shoulder and hand, GDSR: Goal-directed shoulder rehabilitation.

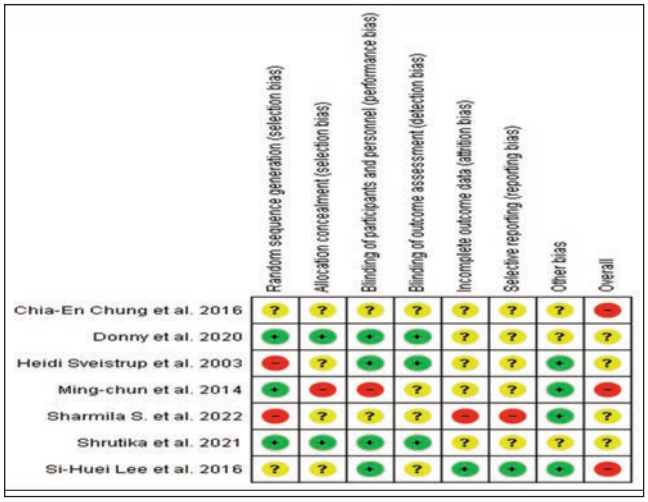

Figure-2: Risk of bias in the studies reviewed.

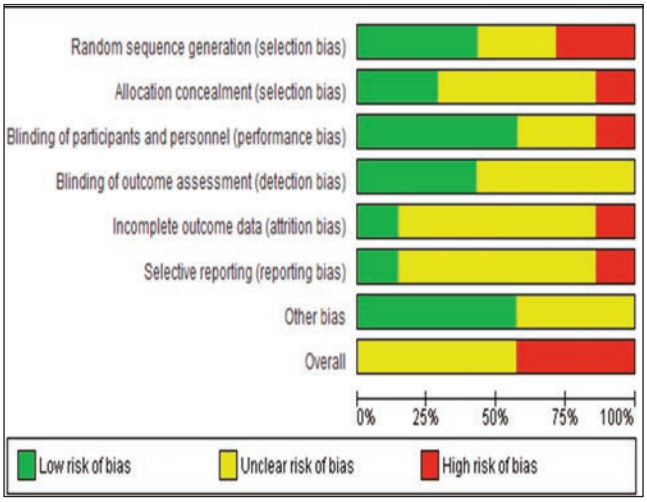

Figure-3: Risk of bias in the studies reviewed.

Similarly, two studies reported substantial improvements in patient function using different assessment tools;[17,22] one reporting >15-point improvement on the DASH score after a 6-week VR intervention, and the other documenting a 26% improvement in the VR group compared to an 18% improvement in the control group. These findings suggest that VR therapy may be a more effective approach for improving functional outcomes in AC patients.

However, the current results contradict the findings two earlier studies that reported no significant differences in joint ROM between VR and traditional therapy groups.[20,24] These discrepancies may be attributed to methodological variations, such as sample size, VR intervention protocols, and outcome measures used.

The interpretation of the current findings, however, must be cautious owing to the methodological quality of the studies reviewed. The risk of bias assessment indicated that a majority of the studies had significant methodological limitations. For instance, the high risk of bias in domains like allocation concealment and participant blinding in certain studies may lead to an overestimation of the treatment effect.[22,24] The contradictory results, where some studies showed significant benefit and others did not, may be partly explained by this variation in methodological rigour. Therefore, the positive findings, particularly from studies with a high risk of bias, should be considered preliminary, and interpreted with caution (Figures 2-3).

The current review supports the analgesic benefits of VR therapy for AC, aligning with earlier findings.[16] However, a study investigating VR for knee osteoarthritis did not demonstrate significant pain improvement using the visual

analogue scale (VAS), suggesting potential differences in pain perception between shoulder and knee conditions, or the VR intervention itself.[25]

A key finding of the current review is the notable gap between the intended scope of the outcomes and the available literature. Although ADLs were predefined outcomes of interest, none of the included studies directly measured ADLs using validated tools specific to daily functioning. Outcomes assessed with DASH and SPADI questionnaires captured perceived disability related to functions without being direct measures of ADL performance. This underscores a critical gap in the current evidence base and highlights a vital area for future research.

The current systematic review has several limitations as it only reviewed studies published in the English language. Besides, due to the heterogeneity of the included studies and the lack of clinical trials, no meta-analysis could be conducted. The clinical trials were heterogeneous because of the numerous types of VR and clinical trial outcomes assessed. Secondly, the heterogeneity of the included studies made it challenging to generalise the results. Further, there was no clinical trial examining ADLs. Besides, there are different VR types used which could have influenced the therapeutic effect. The significant heterogeneity in VR interventions, dosage and comparator groups did not allow a quantitative synthesis or meaningful subgroup analyses. Future studies with more standardised protocols should opt for a more robust synthesis of the evidence. Finally, the generalisability and statistical power of the current findings is limited by the small sample sizes in the majority of the included studies, with 6(85.7%) studies having <50 participants.

Conclusion

VR appeared to have potential as a tool for the rehabilitation of FS patients. The evidence pointed towards possible benefits for pain reduction and EOM, but the results were inconsistent, and the field was limited by study quality and heterogeneity. The lack of focus on ADLs in the existing trials is a major gap. Therefore, more high-quality, standardised RCTs are needed to confirm VR's efficacy and establish optimal implementation protocols. Interventions like VR-assisted physical therapy and VR gaming appeared particularly effective, but the specific choice of VR intervention may depend on individual patient needs and preferences, and the resources available for rehabilitation programmes.

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Author Contribution:
AFQ: Drafting, quality assessment, data acquisition, analysis, interpretation, revision and final approval.
AA: Data extraction, screening, concept, design, data acquisition, analysis, interpretation, drafting and revision.
BF: Screening, quality assessment, concept, design and final approval.
SN: Drafting, quality assessment, concept, design and final approval.
RS: quality assessment, supervision, concept, design, data acquisition, analysis and final approval.
SMSAN: Co-supervision, drafting, revision and final approval.