RESEARCH PAPER

Virtual Reality for Shoulder Pain and Range of Motion After Neck Dissection Surgery

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ABSTRACT

Objective: The aim of this study was to investigate the therapeutic effect of virtual reality exercise on shoulder pain and range of motion after neck dissection. **Patients and Methods:** Sixty-eight patients of both genders had undergone neck dissection surgical intervention within one month prior to participating in current study and are suffering from shoulder pain and reduced range of motion, were randomly selected from Kasr Al-Aini Hospital, Cairo University. They were assigned into two equal groups (34 patients per group). The study was conducted between September 2024 and March 2025. Group (A): received virtual reality exercise via Xbox Kinect 360 console, a traditional physical exercise program, plus routine medical treatment (NSAIDS). Group (B): received traditional physical exercise, plus routine medical treatment (NSAIDS). Pain threshold was evaluating using a pressure algometer (PA) and shoulder range of motion (ROM)was measured using a goniometer were before and after intervention. **Results:** there was statistically significant improvement in treatment outcomes favouring Group A(p=0.001). **Conclusion:** It was concluded that virtual reality exercise using Xbox Kinect 360 console had significantly reduce shoulder pain and improves range of motion after neck dissection surgery compared to traditional treatment alone.

Keywords: Neck Dissection Surgery, Virtual Reality, Pain Threshold, ROM, Xbox Kinect.

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INTRODUCTION

Worldwide head and neck cancer accounts for approximately 900,000 cases and over 400,000 deaths annually (1). Most malignant tumors are head and neck squamous cell carcinomas (HNSCC). Treatment options include surgery, radiation therapy, and chemotherapy, or a com bination of these modalities. Approximately 50% of patients with locally advanced head and neck cancer will develop a recurrence (2). Distant metastases are present in about 10% of cases at the time of diagnosis, with an additional 20–30% devel oping during the course of the disease (3).

Neck dissection is an effective surgical procedure performed for the removal of cervical metastasis, unless it results in restricted arm/shoulder mobility with 17% incidence, thus could cause arm/shoulder pain and connective tissue fibrosis (4). Neck dissection is most commonly used in the management of cancers of the upper aerodigestive tract. It is used for malignancies of the skin of the head and neck area, the thyroid, and the salivary glands. The most aggressive form of this procedure is the radical neck dissection, whereby the accessory nerve, sternocleidomastoid muscle and internal jugular vein (in addition to lymph nodes) are excised (5).

After neck dissection reported complications might develop i.e., impaired shoulder mobility by up to 50% incidence, as well neuropathic impairments that might develop chronic ache, pain and skeletal musculature weakness by 18-23% occurrence incidences, which have negative impact on quality of life. Almost, the long-term post mastectomy shoulder pain is relatively explained as a result of disturbed kinematics of shoulder complex (6).

Postoperative pain in patients undergoing head and neck surgery is a major factor when aiming to improve functional recovery, reduce hospital stays, and increase quality of life (7). Major interventions, including bedside procedures, can also affect the experience of pain. Narcotic analgesics are an important part of postoperative pain management, but these have risks, including nausea, sedation, respiratory depression, and possible dependence **(8).**

Using virtual reality exercise (VRE) or exergaming is a novel and innovative technology that immerses individuals in a computer generated, multisensory, three-dimensional world wherein they interact with virtual environment **(9)**. VRE combines exercise and gameplay into a virtual environment with the intention of promoting greater physical activity among users. VRE is a valid method for targeting sedentary behaviours in children, adolescents and adults **(10)**.

Using virtual reality (VR), it is possible to give the user a virtual body that can be experienced as one ‘s own which can then be manipulated by the experimenter. This

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manipulation has been shown to have significant psychological and physiological implications and has potentially significant therapeutic potential. The virtual embodiment illusion requires three key components—firstly, the sense of body ownership (that the observed virtual body is the user`s body), the sense of self-location (that the user feels they are located in the virtual body), and the sense of agency (that the user feels control over the virtual body), each of which can be manipulated experimentally (**11**).

Recent studies have recommended repetitive exercises using virtual reality (VR) for functional recovery from upper extremity disorders (**12)** because the effectiveness of task-specific training improved when tasks were ordered in a random practice sequence using repetition and positive feedback. Many types of VR-based rehabilitation apparatus, from commercial video game equipment to robotics, are currently being developed and used. The RAPAEL Smart GloveTM (Neofect, Yong-in, Korea) is a VR rehabilitation tool designed for the distal upper extremities (**13).**

Hoffman et al are the first to use VR technology to relieve operative pain in burn patients during dressing changes. Subsequently, an increasing number of studies have examined the application of VR in the field of burns, mainly for pain management and psychological intervention during adjuvant therapy (**14).**

So, the aim of the study was to investigate the therapeutic effect of virtual reality exercise on shoulder pain after neck dissection.

MATERIAL AND METHODS:

Study design:

The study was designed as randomized, controlled trial, pre, and post-experimental design study. It was approved by the Research Ethical Committee of The Faculty of Physical Therapy, Cairo University (P.T.REC/012/006630).

Participants:

A total number of two groups of sixty-eight patients (thirty-four patients in each group) of both genders had undergone neck dissection surgical intervention, recently within one month prior participating in current study, and are suffering from shoulder pain and range of motion are selected randomly to participate in this study from Kasr Al-Aini Hospital. They were assigned into two equal groups; They were selected according to the following criteria: **Inclusion criteria:** Patient`s age ranged from 30-50 years old, all patients underwent neck dissection operation, recently, all patients suffered from shoulder pain and range of motion limitation, all patients were free of any comorbidities such as systemic or neurological diseases**. Exclusion criteria:** Patients with medical conditions that associated with shoulder range of motion after neck dissection are excluded, these conditions include hyperthyroidism, diabetes mellitus, parkinsonism, spinal cord injury, brain damage, congestive heart failure, anxiety, alcoholism and menopause. patients who received any treatment with a drug that was affecting sweating e.g. (thyroxin, anxiolytics) that is not stopped at least 4 weeks preceding the study, Patients with cardiac conditions such as arrhythmia, ischemic heart disease, low exercise tolerance, low respiratory reserve were excluded, patients who had sensory disorders, Patient who had fractures with nerve or vascular compromise, female patients who were pregnant and lactating.

Randomization

All participants agreed to an informed consent form before the beginning of the study, anonymity and privacy were guaranteed, and all the methods were done consistently with relevant laws and institutional rules. Participants were equally divided into two groups (control and study groups) equally by a computed randomization program.

Interventions

The subjects divided randomly into two groups equal in number, (group A) and (group B):

Study Group (A) were received virtual reality exercise, traditional physical exercise, plus routine medical treatment.

Control Group (B) were received traditional physical exercise, plus routine medical treatment.

For treatment:

Virtual reality exercise for Group A (study group); only was received virtual reality exercise in form of a series of kinect adventure games and designed for Xbox 360 kinect console. Virtual reality exercises will project onto a 24-inch screen LEDLit monitor. Each session was a series of 1-3 trials in a row of each of five kinect adventure shoulder aerobic exercises within 30-60 minutes, schedule three sessions per week over four weeks of the study. Initial familiarization session was conducted, then scoring system by explaining kinect recording system for users` movements through body mapping.

The exercise program conducted through virtual reality exercise training includes the following;

1. Active Shoulder Shrug Exercise

Active Shoulder Shrug Exercise: After familiarization with the non-immersive virtual reality (NIVR) system and trial sessions, participants were instructed to perform active bilateral shoulder elevations (shrugging). The exercise was guided by real-time visual and auditory feedback provided via the VR console**. (15).**

2. Active Scapular Retraction ("Blade Pinch")

Active Scapular Retraction Exercise: Following the familiarization phase, participants were instructed to perform active bilateral scapular retraction (retracting/pinching the shoulder blades backward). The performance was monitored and guided using interactive visual and auditory feedback through the NIVR setup**. (16).**

3. Codman's / Pendulum Exercise

Codman's (Pendulum) Exercise: Following system familiarization, participants performed circular pendulum movements with the affected upper extremity to promote active/assisted range of motion (ROM) in shoulder rotation. The movement trajectory was maintained using real-time visual and auditory feedback delivered by the VR console. **(17).**

4. Behind-the-Back Shoulder Internal Rotation

Behind-the-Back Shoulder Internal Rotation Exercise: Conducted in either a sitting or standing position, participants were instructed to perform active internal

rotation of the affected shoulder by moving the hand behind the back. The task was executed interactively under the guidance of visual and auditory feedback from the NIVR system **(18).**

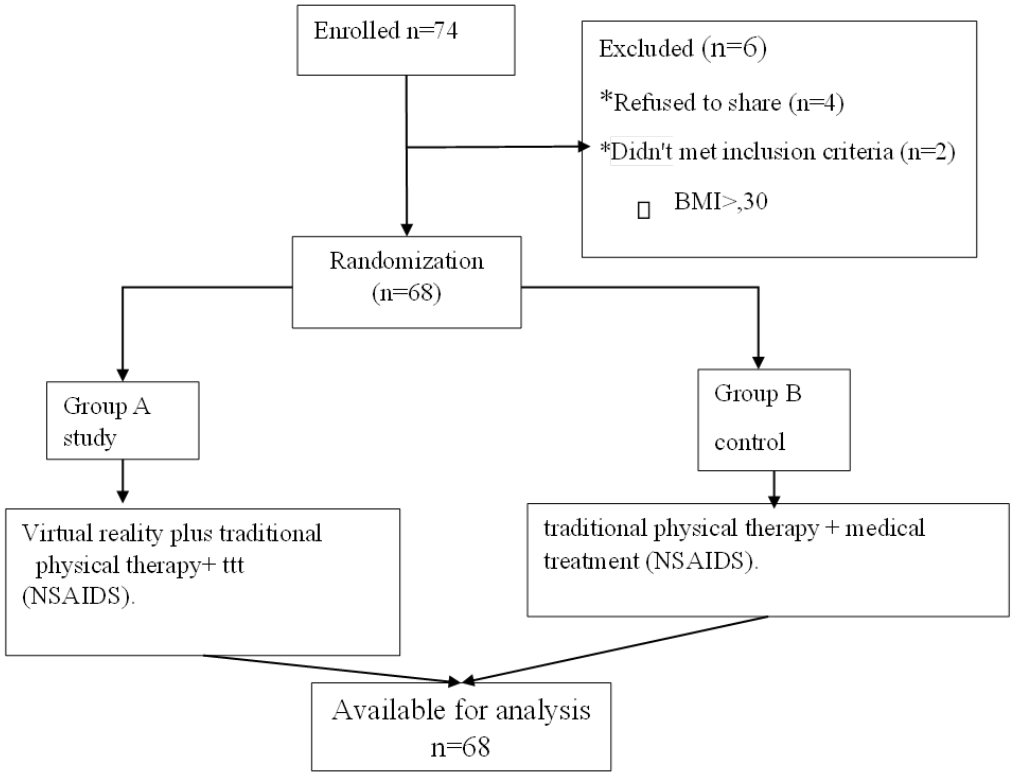
 Traditional physical exercise for Both group A& B;
Each participant in both groups (study and control groups) was received active ROM exercises for shoulder flexion, abduction, as well internal and external rotation. Traditional physical exercise protocol was involved the following;

Pendulum exercise: participant was bend over at waist then let his/ her arm hang down, using own participant body to initiate movement through swing affected arm gently forward and backward, then in circular movement.

Shoulder shrug: participant was actively shrug both shoulders upward.

Shoulder blade pinches: participant was instructed to pinch bilateral shoulder blades backward.

Hand-behind head reach exercise: participant was seated or supine then was instructed to clasp both hands and try to move both upper extremities behind head with elbows facing forward.



Flow chart of study participants

Outcome measures:

a- Shoulder Pressure pain threshold evaluation:

Pain was assessed to each patient using pressure algometer to indicate the pain threshold and therefore the level of pain that patient is suffering from, shoulder pain has lower pain threshold **(19).** The use of pressure algometer is reliable and valid **(20).** The most commonly used surface area of probes is 0.5 or 1 cm^2, the PA was placed perpendicular to the tissue surface and pressure will be applied steadily at a constant rate. Reported pressure application rates was ranged from 0.05 to 20 N/s. Ideally compression should be performed slowly enough to allow the subject time to react when pain is felt. When the subject reports feeling pain the action of pressure is stopped, or to avoid delay by the tester, through pressing a switch on an electronic PA **(21). b-Shoulder range of motion:**

The measurement of shoulder ROM (flexion, abduction and external rotation) was done before the start of first treatment session and after every two weeks of treatment **(22).**

The Goniometer placement:

The Axis of the goniometer was placed at the lateral arm and the moving arm parallel to moving limb.

Position of the patient: with the subject in the supine position.

For the goniometric measurements of internal rotation, the goniometer will be positioned with the fulcrum placed at the olecranon, the stable arm horizontal or vertical, depending on the specific procedure, and on the moving arm along the forearm with the processus styloideus ulnae as a reference point **(23)**.

Statistical tools and data analysis:

In this study, the obtained data was recorded.

These data were transferred into IBM card using IBM personal computer with statistical program to obtain the following statistical tools:

Descriptive statistics:

In this study, the descriptive statistics inform of mean, and standard deviation was calculated for all participants of the study to determine the homogeneity and central deviation.

-Analytic statistics:

In this study, the mean, standard deviation and standard error was calculated for all variables.

paired ―T" test was used to compare between data of the two groups.

Comparison was applied by student T test to compare between the independent means.
A value of $p<0.05$ was considered statistically significant. **(24).**

RESULTS:

The impact of treatment on pain pressure threshold:

There was statistically significant difference post-treatment (p= 0.001) in favor of group (A)

Table (1): Mean ±SD of PPT pre and post-treatment of both groups.

PPT (kg)	Group A	Group B	MD (95% CI)	P-value	η^2
Pre-treatment	2.6± 0.57	2.64 ± 0.53	-0.04 (-0.31, 0.22)	0.743	0.002
Post-treatment	3.54 ± 0.51	3.12 ± 0.54	0.42 (0.17, 0.66)	0.001	0.148
MD (95% CI)	-0.94 (-0.99, -0.88)	-0.48 (-0.53, -0.42)			
% of change	36%	18%			
P-value	0.001*	0.001*			

***MD:** mean difference, **CI**: Confidence interval, **P-value**: level of significance, **η^2:** partial eta square, *: significant*

The impact of treatment on shoulder range of motion:

- **Shoulder flexion:** there was statistically significant difference post-treatment (p= 0.001) in favor of group (A)

Table (2): Mean ±SD of shoulder flexion ROM pre and post-treatment of both groups.

Shoulder flexion ROM (degrees)	Group A	Group B	MD (95% CI)	P value	η^2
Pre-treatment	99.41± 15.84	95.94 ± 14.58	3.47(-3.9, 10.84)	0.351	0.013
Post-treatment	152.23 ± 12.42	133.59 ± 13.47	18.65 (12.37, 24.92)	0.001	0.348
MD (95% CI)	-52.82 (-55.44, -50.2)	-37.65(-40.26, -35)			
% of change	53%	39%			
P-value	0.001*	0.001*			

***MD:** mean difference, **CI**: Confidence interval, **P-value**: level of significance, **η^2:** partial eta square, *: significant*

- **Shoulder abduction:** there was statistically significant difference post-treatment (p= 0.001) in favor of group (A)

Table (3): Mean ±SD of shoulder abduction ROM pre and post-treatment of both groups.

Shoulder abduction ROM (degrees)	Group A	Group B	MD (95% CI)	P-value	η^2
Pre-treatment	102.15± 15.03	97.26 ± 14.48	4.88(-2.26, 10.03)	0.177	0.027
Post-treatment	156.62 ± 11.55	139.41 ± 11.4	17.21 (11.65, 22.76)	0.001	0.367
MD (95% CI)	-54.47 (-56.87, -52)	-42.15(-44.55, -39.7)			
% of change	53%	43%			
P-value	0.001*	0.001*			

***MD:** mean difference, **CI**: Confidence interval, **P-value**: level of significance, **η^2:** partial eta square, *: significant*

- **Shoulder external rotation:** there was statistically significant difference post-treatment (p= 0.001) in favor of group (A)

Table (4): Mean ±SD of shoulder external rotation ROM pre and post-treatment of both groups.

Shoulder external rotation ROM (degrees)	Group A	Group B	MD (95% CI)	P-value	η^2
Pre-treatment	42.62± 7.2	42.15 ± 7.23	0.47(-3.03, 3.97)	0.789	0.001
Post-treatment	76.5 ± 5.4	70.5 ± 6.24	6 (3.17, 8.83)	0.001	0.214
MD (95% CI)	-33.88 (-35.2, -32.56)	-28.35(-29.67, -27)			
% of change	79.5%	67%			
P-value	0.001*	0.001*			

***MD:** mean difference, **CI**: Confidence interval, **P-value**: level of significance, **η^2:** partial eta square, *: significant*

DISCUSSION:

The findings of the present study demonstrated that adding virtual reality (VR) exercises to conventional physical therapy significantly reduced shoulder pain following neck dissection surgery compared with conventional therapy alone. This improvement may be attributed to the immersive and interactive nature of VR, which promotes distraction from pain, enhances patient engagement, and stimulates cortical reorganization through repetitive task-oriented movements. Previous studies have suggested that

VR reduces pain perception by activating descending pain inhibitory pathways and increasing patient motivation during rehabilitation, thereby improving treatment adherence and clinical outcomes (25).

The significant improvement in shoulder range of motion observed in the current study may be explained by the ability of VR-based exercises to encourage repetitive, goal-directed upper-limb movements in an enjoyable environment. Such exercises facilitate active participation while reducing fear of movement, allowing patients to perform greater numbers of movement repetitions than with conventional therapy alone. This is consistent with motor learning principles and neuroplasticity mechanisms that contribute to restoring shoulder mobility following surgical intervention (26).

Shoulder dysfunction after neck dissection is commonly associated with spinal accessory nerve injury, postoperative pain, muscle weakness, and soft tissue fibrosis, all of which contribute to limited shoulder mobility and impaired function. Early rehabilitation is therefore considered essential for minimizing postoperative complications and enhancing functional recovery. The superior outcomes achieved in the VR group support the growing evidence that technology-assisted rehabilitation provides additional benefits beyond traditional exercise programs in patients recovering from head and neck cancer surgery (27).

Another explanation for the favorable results is the high level of patient motivation and adherence associated with virtual reality training. Unlike repetitive conventional exercises, VR provides immediate visual and auditory feedback, individualized task progression, and game-based activities that increase enjoyment and encourage active participation. Increased exercise adherence has been shown to improve rehabilitation outcomes by promoting greater movement intensity and repetition, both of which are essential for functional recovery after surgery (28).

The reduction in shoulder pain observed in the present study is consistent with the findings of **Pourmand et al.** (29), who reported that virtual reality-based rehabilitation effectively decreases pain intensity by providing immersive visual and auditory stimulation that diverts patients' attention from painful stimuli. This analgesic effect is believed to involve cognitive distraction and modulation of central pain processing, enabling patients to perform therapeutic exercises with less discomfort. Consequently, the integration of virtual reality into postoperative rehabilitation may facilitate earlier and more active participation in shoulder exercises following neck dissection surgery.

Also, a systematic review and meta-analysis study evaluated the effect of Virtual reality on neck pain and it showed a non-significant difference in pain intensity after applying VR, and there was a non-statistical difference in pain intensity at follow-up between the VR group and the control group (30).

Although the present study demonstrated that virtual reality combined with conventional physical therapy significantly reduced shoulder pain after neck dissection surgery, these findings are not consistent with those reported by **Massetti et al.** (31), who concluded that virtual reality did not produce significantly greater pain reduction than conventional rehabilitation in individuals with upper-limb musculoskeletal disorders. The discrepancy may be attributed to differences in patient characteristics, the duration and intensity of the intervention, the type of virtual reality system used, and the underlying pathology. Unlike the heterogeneous musculoskeletal conditions included in their review, the current study specifically investigated patients following neck dissection surgery, who may derive greater benefit from immersive rehabilitation because of postoperative pain and movement limitations.

Furthermore, **Coulter et al.** (32) found insufficient evidence to conclude that virtual reality provides additional clinical benefits over conventional exercise program for improving shoulder function in some rehabilitation settings. The authors emphasized that treatment effectiveness may depend on factors such as patient adherence, therapist supervision, and the selection of task-specific exercises. In the present study, participants completed supervised virtual reality sessions alongside conventional therapy, which likely enhanced compliance, exercise repetition, and motor performance, thereby explaining the more favorable outcomes.

In addition, the systematic review conducted by **Howard** (33) indicated that although virtual reality is a promising rehabilitation tool, the available evidence regarding its superiority over traditional therapy remains inconclusive because of methodological limitations, including small sample sizes, heterogeneous interventions, and inconsistent outcome measures. Conversely, the current study used a randomized controlled design with standardized assessment of shoulder pain and range of motion, which may have provided greater sensitivity for detecting treatment effects. Therefore, differences in study methodology and participant characteristics may explain the contrast between the present findings and those reported in earlier investigations.

CONCLUSION:

Integrating Xbox Kinect 360 Virtual Reality Exercise into a conventional physical therapy program along with standard medical management (NSAIDs) yields superior therapeutic benefits compared to traditional therapy alone in patients recovering from neck dissection surgery. The combined approach significantly elevates shoulder pain pressure thresholds and restores functional range of motion in flexion, abduction, and external rotation, serving as an effective interactive adjunct to oncological shoulder rehabilitation.

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