In the name of God

Tehran University of Medical Sciences

Title:

Feasibility of VR-based rehabilitation of shoulder impingement syndrome in athletes

Introduction

The painful shoulder is the most common condition seen in sport injury clinics (1). Subacromial impingement syndrome is affected by scapular motion and position (2). Scapular dyskinesis is a potential impairment to optimum shoulder function which should be diagnosed and managed as an important part of treatment protocol (3, 4). Subacromial impingement syndrome is developed due to contraction of the anatomical structures passing through the subacromial fossa (5, 6). Problems in upper limb function in people with subacromial impingement syndrome decrease the quality of life and lead to functional disability in the patients (7-9). The majority of the investigations showed no significant difference in the outcomes between patients randomized to surgical decompression or conservative treatment (1). However, some studies reported better results after surgery, especially in the long term.

Recovery of restricted daily life tasks (such as personal care, dressing, and eating) is one of the main aims in physiotherapy and rehabilitation in subacromial impingement syndrome and currently, conventional physiotherapy and rehabilitation methods are main commonly used ones (10-12). Accordingly, the main purpose of this method is to reduce the pain, improvement in range of motion and also muscle strength. With the developing technology various virtual reality applications have initiated to take place in physiotherapy and rehabilitation programs in current years. These virtual reality applications are utilized to motivate the patients and keep their awareness in the rehabilitation. In addition, the diversity of virtual reality applications is increasing gradually so that participation of the patients and the attention to the treatment can be augmented. Hence in this study the effectiveness of game-based virtual reality in patient with subacromial impingement syndrome will be assessed.

Review of literature

In the study by Pekyavas et al in Turkey in 2017, thirty patients with SAIS were randomized into two groups which are Home Exercise Program (EX Group) (mean age: 40.6 ± 11.7 years) and Virtual Reality Exergaming Program (WII Group) (mean age: 40.33 ± 13.2 years). Subjects were assessed at the first session, at the end of the treatment (6 weeks) and at 1 month follow-up. The groups were assessed and

compared with Visual Analogue Scale (based on rest, activity and night pain), Neer and Hawkins Tests, Scapular Retraction Test (SRT), Scapular Assistance Test (SAT), Lateral Scapular Slide Test (LSST) and shoulder disability (Shoulder Pain and Disability Index (SPADI)). Intensity of pain was significantly decreased in both groups with the treatment ($p < 0.05$). The WII Group had significantly better results for all Neer test, SRT and SAT than the EX Group ($p < 0.05$). They concluded that virtual reality exer-gaming programs with these programs were found more effective than home exercise programs at short term in subjects with SAIS (13). In a comprehensive review by Berton et al in Italy search on PubMed, Medline, Cochrane, CINAHL, and Embase databases was conducted. This review was performed according to PRISMA guidelines. Studies published between 2015 and 2020 about remote virtual rehabilitations for orthopedic patients were selected. The Methodological Index for Non-Randomized Studies (MINORS) and Cochrane Risk-of-Bias assessment tool were used for quality assessment. Totally, 24 studies (9 randomized controlled trials (RCTs) and 15 non-randomized studies) and 2472 patients were included. Studies mainly concern telerehabilitation (56%), and to a lesser extent VR (28%), AR (28%), and gamification (16%). Remote virtual technologies were used following knee and hip arthroplasty. The included patients were between 40 and 60 years old and had a university degree. Remote virtual rehabilitation was not inferior to face-to-face therapy, and physical improvements

were demonstrated by increased clinical scores. Orthopedic virtual remote rehabilitation decreased costs related to transports, hospitalizations, and readmissions (14). Chen et al in Taiwan in 2016 imported games and virtual reality training to help participants train their shoulders in a relaxed environment. This study included the use of Kinect somatosensory device with Unity software to develop 3-dimensional situational games. The data collected from this training process can be uploaded via the Internet to a cloud or server for participants to perform self-inspection. The data can be a reference for the medical staff to assess training effectiveness for those with impairments and plan patient rehabilitation courses. In the training activities, 8 subjects with normal shoulder function demonstrated that the system has good stability and reproducibility. Six subjects with impaired shoulder underwent 6 weeks of training. During the third week of training, average performance stabilized. The t-test comparing 1-2 weeks to 3-4 weeks and 5-6 weeks showed significant differences (15). In study by Hayashi et al in Japan fifty-two healthy students participated in this randomized cross-over controlled trial. One VR-based task aimed to passively use the imagery of driving a car as a distraction intervention (the driving group), whereas the other VR-based task aimed to use exercise imagery (running) to actively engage the participants in movement (the running group). The mechanical pressure pain thresholds of the quadriceps and forearm and the heat pain threshold of the hand of each subject were

measured before, during, and after each VR task. The differences between the values at each time point and the differences between the groups were analyzed. The pressure and heat pain thresholds were significantly greater during VR task than those before VR task in both driving and running groups. The changes in the pressure pain thresholds that occurred during VR task were significantly higher in the running group than in the driving group. The difference between groups gradually declined after VR task. Conversely, there was no significant difference in the changes in the heat pain thresholds between the groups both during VR task and after VR task (16).

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Major objective:

Determination of the effectiveness of game-based virtual reality in patient with subacromial impingement syndrome

Minor Objectives:

1. Effectiveness of game-based virtual reality in patient with subacromial impingement syndrome by age
2. Effectiveness of game-based virtual reality in patient with subacromial impingement syndrome by sex
3. Effectiveness of game-based virtual reality in patient with subacromial impingement syndrome by duration of symptoms
4. Effectiveness of game-based virtual reality in patient with subacromial impingement syndrome by involvement side

Hypotheses:

1. Game-based virtual reality is effective in patient with subacromial impingement syndrome
2. Effectiveness of game-based virtual reality in patient with subacromial impingement syndrome is differed by age.
3. Effectiveness of game-based virtual reality in patient with subacromial impingement syndrome is differed by sex
4. Effectiveness of game-based virtual reality in patient with subacromial impingement syndrome is differed by duration of symptoms
5. Effectiveness of game-based virtual reality in patient with subacromial impingement syndrome is differed by involvement side

Methods and design:

In this case series study three consecutive patients with subacromial impingement syndrome in past 12 months admitted in a sport injury clinic in 2020 will be enrolled. The exclusion criteria are any visual or hearing problem, other neurological, orthopedic or rheumatic problems that may restrict, shoulder motion or cause pain, having a physical disability or uncontrolled chronic systemic disease, major trauma, treatment for shoulder problems within the last 6 months, and history

of epilepsy. The ethical approval will be received from ethical committee in Tehran University of Medical Sciences. A physician will applying the following evaluation parameters at the baseline, and at the end of 4-weeks treatment program, the same physiotherapist will be applying evaluation parameters. Primary outcome measures and applied evaluations are as below. The range of motion will be defined with 'goniometer', the pain with 'Visual Analogue Scale (VAS)', the disability with 'The Disabilities of the Arm, Shoulder and Hand (DASH)Questionnaire', the quality of shoulder function with 'Constant- Murley Score', the muscle strength with 'dynomometer', the pain threshold with algometer, the proprioception with Visual Auditory Joint Education Device, the kinesiophobia with 'Tampa Kinesiophobia Scale (TKS), the satisfaction of the treatment with 'Visual Analog Scale (VAS)'.The participants in the study will be rehabilitated for 5 times a week for 4 weeks, a total of 20 sessions (Duration of one session is 60 minutes). They will receive conventional physiotherapy and rehabilitation treatment program and game-based virtual reality exercises. In addition to the conventional physiotherapy and rehabilitation program, a 10-minute game-based virtual reality exercises will be applied. A game-based virtual reality device namedUSE-IT will be added to the rehabilitation program. Data analysis will be performed among subjects by SPSS (version 26.0) software [Statistical Procedures for Social Sciences; Chicago, Illinois, USA]. Chi-Square, Fisher, Independent-Sample-T, Mann-Whitney, and

Kolmogorov-Smirnov tests are used and will be considered statistically significant at P values less than 0.05.

Data collection methods and tools:

Data will be gathered by checklist including age, sex, time passed from symptoms, involved side. The outcomes will be assessed.

Data sampling and sample size:

Data sampling is with consecutive method and cases included 3 patients as a case series.

Data Analysis:

Data analysis will be performed among subjects by SPSS (version 26.0) software [Statistical Procedures for Social Sciences; Chicago, Illinois, USA]. Chi-Square, Fisher, Independent-Sample-T, Mann-Whitney, and Kolmogorov-Smirnov tests are used and will be considered statistically significant at P values less than 0.05.

Ethical Issues:

The ethical approval will be received from ethical committee in Tehran University of Medical Sciences. Helsinki Declaration will be respected across the study and informed consent form will be received from patients.

Limitations:

Small sample size that is due to case series design for the study and potentially it is negligible.

Variable Table:

	Variable	Type		Scale		Categorical		Definition	Tool	Measure
					Non-Continuous		Ordinal			
1	**Age**	■			■			**Age passed from life**	**Checklist**	**Year**
2	**Sex**	■				■		**Sexual phenotype**	**Checklist**	**Male/female**
3	**Duration**	■			■			**Definite months after initiation of symptoms**	**Checklist**	**Month**

4	Involved side							Affected side by disease	Checklist	Right/Left
5	Range of motion							Defined with ‘goniometer”	Checklist	Degree
6	Pain							Visual Analogue Scale (VAS)’	Checklist	Scale
7	Disability							The Disabilities of the Arm, Shoulder and Hand (DASH)Questionnaire’	Checklist	Scale
8	Quality of shoulder function							Constant- Murley Score	Checklist	Scale
9	Muscle strength							Measured by Dynomometer’	Checklist	Scale
10	Pain threshold							Measured by Algometer	Checklist	Scale
11	Proprioception							Visual Auditory Joint Education Device	Checklist	Scale
12	Kinesiophobia							Tampa Kinesiophobia Scale (TKS)	Checklist	Scale
13	Satisfaction of the treatment							Visual Analog Scale (VAS)	Checklist	Scale

Gantt Table

	Phase	Time																																	
	Proposal	1	■																																
	Data Sampling	8		■	■	■	■	■	■	■	■																								
	Statistical Analysis	1										■																							
	Final Report	1											■																						
	Article	1												■																					