Annals of Physical and Rehabilitation Medicine xxx (2017) xxx–xxx

Available online at
ScienceDirect
www.sciencedirect.com

Elsevier Masson France
EM|consulte
www.em-consulte.com

Original article

Structured Wii protocol for rehabilitation of shoulder impingement syndrome: A pilot study

John-Ross Rizzo [a,b,c,1], Peter Thai [a,d,1], Edward J. Li [e], Terence Tung [a], Todd E. Hudson [a,b], Joseph Herrera [e], Preeti Raghavan [a,f,*]

[a] Rusk Rehabilitation, New York University School of Medicine, New York University, New York, USA
[b] Department of Neurology, New York University School of Medicine, New York University, New York, USA
[c] Department of Psychology and Center for Neural Science, New York University, New York, USA
[d] College of Medicine, SUNY Upstate Medical University, New York, USA
[e] Mount Sinai School of Medicine, New York, USA
[f] Department of Physical Therapy, Steinhardt School of Culture, Education, and Human Development, New York University, New York, USA

ARTICLE INFO

Article history:
Received 11 October 2015
Accepted 6 October 2016

Keywords:
Shoulder impingement syndrome
Shoulder pain
Rehabilitation
Gaming
Motivation

ABSTRACT

Objective: To determine the feasibility and efficacy of using a structured Nintendo Wii protocol to improve range of motion, strength, and quality of life in patients with shoulder impingement syndrome.
Methods: A total of 14 patients with shoulder pain were randomized to perform a structured Wii protocol ($n = 8$) or conventional therapy ($n = 6$). Pain-free shoulder range of motion, strength, shoulder pain and disability, and quality of life were assessed pre- and post-treatment.
Results: All 8 patients completed the Wii protocol, and 3 completed conventional therapy. The Wii protocol conferred significant improvements in shoulder range of motion, pain and disability, and quality of life but not strength, whereas conventional therapy conferred a significant improvement in strength.
Conclusions: As compared to conventional treatment, the structured Wii protocol implemented in this pilot study was a viable adjunct to therapy for shoulder impingement syndrome. Gaming may have a supplemental benefit by increasing motivation, pleasure, and/or adherence. Further investigation in larger cohorts is warranted.

1. Introduction

The annual prevalence and incidence of shoulder problems among adults is 2.4% and 1.5%, respectively [1]. Shoulder disorders represent approximately one-fifth of all disability payments for musculoskeletal disorders [2], with significant economic impact [3,4]. The most common shoulder disorder in general practice is shoulder impingement syndrome (SIS) [5], which is caused by compression of the rotator cuff tendons, most prominently the supraspinatus tendon and long head of the biceps along with their bursae in the subacromial space [6].

The primary risk factor for SIS is repetitive activity at or above the shoulder level, which may include work or recreational activities [7–9]. Age is an additional influencing factor because the incidence of SIS is increased among people older than 40 years [10]. The underlying mechanisms are thought to include inflammation and/or degeneration of the tendon(s) or bursa(e), dysfunctional scapulothoracic and glenohumeral mechanics, debilitated scapular and/or rotator cuff musculature, joint capsule irregularities, postural abnormalities of the neck and/or shoulder, and morphological abnormalities of the relevant skeletal elements [2]. Repetitive activity, particularly during overhead work, heavy lifting and forceful work, as well as working in an awkward posture increases the risk of shoulder disorders [8,9]. During arm elevation, the scapula must externally rotate, upwardly torque and tilt posteriorly [11]. Abnormal scapular kinematics is common in SIS [12] and may include reduced upward rotation and external rotation of the scapula, along with increased elevation and retraction of the clavicle [13], although increased upward rotation of the scapula has also been noted [14,15].

Shoulder pain and dysfunction secondary to SIS is often precipitated or exacerbated by an imbalance between the various muscle groups of the shoulder: the deltoids [16,17], the rotator cuff

* Corresponding author. 240 East 38th St., Suite 1774, 10016 New York, NY, USA. Tel.: +646 501 7754; fax: +212 263 2683.
E-mail address: preeti.raghavan@nyumc.org (P. Raghavan).
[1] Co-first authors.

http://dx.doi.org/10.1016/j.rehab.2016.10.004

(including the supraspinatus, infraspinatus, teres minor, and subscapularis) [18–21], and the scapular stabilizers (including the trapezius, serratus anterior, rhomboids, levator scapula, and pectoralis major) [22,23]. The relative difference in activation of specific muscles affects the biomechanics of the shoulder and may lead to changes in articulation between the glenoid fossa of the scapula and the humeral head [24]. These imbalances are often exacerbated by overhead activity, as subjectively reported [25]; however, objective evidence suggests that acromiohumeral distance may be shortest during activities closer to 90° [26]. Therapy for SIS involves restoring the balance between these muscle groups to optimize the kinematics of shoulder movement, minimize wear and tear, and decrease pain [27].

Therapeutic exercises for SIS focus on 3 goals. First, the scapular stabilizers must be strengthened to provide a stable skeletal scaffold for the rotator cuff muscles [28,29]. Second, imbalances between the rotator cuff muscles must be corrected. Typically the internal rotators are stronger than the external rotators, which must be addressed by strengthening the external rotators to create net neutral forces [30,31]. Third, after the rotator cuff muscles have been strengthened, coordination in compound shoulder movements, involving movements in multiple planes, must be improved [32,33]. Improvements in strength and coordination will then facilitate activities of daily living and broader functional goals.

A major obstacle in the treatment of musculoskeletal pain is compliance with and motivation to perform the prescribed exercise program [34–36]. Conventional therapy is effective as long as the patient remains engaged. The repetitive nature of the therapy may become tedious for patients who are unaccustomed to exercise, which can limit rehabilitation outcomes and recovery. "Gamification" of therapy (or game-based therapy) in rehabilitation is a strategy that can potentially address motivation and compliance and has been shown to increase compliance [37]. However, gaming, if not performed properly can also lead to injury [38].

We developed a structured protocol for game-based rehabilitation of shoulder movements using the Nintendo Wii system. The goal of this pilot randomized controlled trial was to examine the feasibility and efficacy of a structured Wii protocol and compare it to conventional therapy for improving pain-free shoulder range of motion (ROM), strength, and quality of life in patients with SIS.

2. Methods

2.1. Study design

2.1.1. Patients

All patients were recruited from the outpatient rehabilitation facilities at Mount Sinai Medical Center, New York, and informed consent was obtained as per the Institutional Review Board and the Declaration of Helsinki.

The inclusion criteria were:

- clinical diagnosis of SIS: subacromial bursitis and/or rotator cuff impingement with positive sign in 1 of 3 tests (Neer, Empty Can, and Hawkins);
- subjective pain relief on current medication regimen to be able to perform basic activities of daily living (self-reported), thereby suggesting the ability to participate in therapy;
- no neurological or cognitive disorders.

The exclusion criteria were:

- history of surgery or other significant injury to either upper extremity;
- presence of full thickness rotator cuff tear confirmed on MRI;
- presence of radicular pain and other neurological signs indicating nerve pathology;
- shoulder instability diagnosed by a positive apprehension test.

We recruited 15 patients who were pseudo-randomized in an alternating manner into the 2 treatment groups once they signed informed consent and completed baseline tests: 8 were allocated to the Wii group and 7 to the conventional therapy (control) group. However, after allocation, one control patient withdrew. After attrition, 8 patients remained in the Wii group (mean age 52 ± 25 years) and 3 in the control group (mean age 61 ± 23 years). Among the 6 patients randomized to the control group, one withdrew because of lack of interest during initial assessments, another because of a work-related injury, and a third because of dizziness after completing 3 weeks of therapy (Fig. 1).

2.1.2. ROM analysis

Maximum, active, pain-free, shoulder ROM in the frontal, sagittal and horizontal planes was assessed using Dartfish video analysis (Dartfish, Atlanta, GA) [39–41]. The patients wore dark clothes with reflective markers positioned over the shoulder and elbow joints at defined anatomical locations. Patients stood erect with their arms by their sides before starting each movement. The instructed movements and corresponding camera positions used for assessing ROM in each plane are detailed below. Three trials were recorded for each movement with the affected side only and the average ROM was obtained.

2.1.2.1. Frontal plane. The camera was positioned in front of and perpendicular to the patient at a distance of 2 m. Patients were asked to abduct their shoulder from the anatomical position to 180°.

2.1.2.2. Sagittal plane. The camera was positioned to the side and perpendicular to the patient at a distance of 2 m. Patients were asked to forward flex their shoulder from the anatomical position to 180°.

2.1.2.3. Horizontal plane. The camera was mounted on the ceiling and the patient stood directly below it. Patients were asked to first touch the opposite shoulder, then externally rotate the shoulder and extend the arm maximally to the side in the horizontal plane.

2.1.3. Strength testing

Strength was tested in the shoulder internal and external rotators as well as scapular stabilizers by using a digital scale that we validated in the laboratory for reliability (Balanzza, Miami, FL, USA model BZ100). The scale was affixed to a stable platform (a heavy height-adjustable table) and patients were asked to grasp the handle of the scale while pulling with maximum force for each of the outlined movements; the arm was positioned uniquely for each of the strength assessments as described below. Three trials were recorded for each movement with the affected side only and the average strength was obtained.

2.1.3.1. Internal and external rotator strength. Patients were seated upright in a chair with the elbow joint at 90° and the shoulder joint at 0° (i.e., the upper arm held close to the body). While grasping the handle of the scale, patients were instructed to internally and externally rotate their arm with maximum force as readings were taken.

2.1.3.2. Scapular stabilizer strength. Patients were seated upright with the elbow joint at 90°, the hand/wrist was at the side of the body, and the shoulder was extended and abducted 30° with neutral rotation (0° internal/external rotation). Patients were