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A prospective, randomized, double blind, placebo controlled clinical trial assessing the effects of applying a force to C5 by a mechanically assisted instrument (MAI) on referred pain to the shoulder.

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Study Design: Randomized, prospective, double blind, placebo controlled clinical trial.

Objective: To determine the effects of applying a force to C5 of the spine by a mechanically assisted instrument (MAI) in patients with referred shoulder pain.

Summary of Background Data: Manipulating C5 of the spine is a chiropractic treatment for referred shoulder pain, there are no clinical trials evaluating its efficacy. Outcome measures were patient ranked questionnaires and independent examiner findings. One hundred and twenty five patients were diagnosed with referred shoulder pain of cervical origin; sixty five were in the treatment cohort and sixty in the placebo cohort

Methods: This was a prospective, randomized, double blind, placebo controlled trial assessing the effects of applying a force to C5 by a MAI to patients with referred shoulder pain. The treatment cohort had the MAI set at the maximum setting to transmit a force into the spine; the placebo cohort had the MAI turned off. Primary outcome measures were frequency and severity of extreme shoulder pain obtained via a patient reported questionnaire; secondary outcome measures were patient ranked pain and functional outcomes as well as examiner assessed range of motion and strength. Assessment procedures were completed at 24 weeks post treatment and data were analyzed with intent to treat protocol.

Results: There was a reduction in the frequency but not severity of extreme shoulder pain in the

treatment cohort, average ranking reducing from weekly to monthly ($p<0.05$). Patients treated with the MAI had 10 N ($p=0.04$) better internal rotation strength after 6 months post-treatment. No differences with any other outcome measures between the two cohorts at the 24 week study period.

Conclusion: The major effect of applying a MAI to the level of C5 of the spine in referred shoulder pain is improved shoulder strength for internal rotation in this randomized double-blinded clinical trial**.**

Key Words: C5 facet joints; referred shoulder pain; mechanically assisted instrument; cervical spine; randomized clinical trial; chiropractic; manipulation; shoulder; orthopedics; shoulder strength; cervical range of motion; supraspinatus; shoulder impingement; neck disability index; sclerotome; non-operative; functional restoration; inter-vertebral disc

Level of Evidence: 2

Introduction

Up to 20% of the adult population experiences shoulder symptoms at any one time [1]. Shoulder pain is the second most common musculoskeletal condition in the upper extremities [2]. Using the Maastricht Upper Extremity Questionnaire (MUEQ) who showed that one third of respondents had disorders of their cervical spine, 31% in the shoulder followed by upper arm (12%), lower arm (8%), elbow (6%), wrist (8%) and hand (11%) [2]. It has also been reported that 23% of patients that attend physiotherapy clinics [3] and 12% of patients that attend chiropractic clinics [4] have shoulder complaints.

Shoulder pain and neck pain are often interrelated. Grubb et al. showed using cervical discography that stimulation of the disc at C5/C6 elicited arm pain [5]. Bogduk et al. [6] have shown that neck and shoulder pain may arise from the C5/C6 facet joints and neck pain and headaches from the C2/C3 facet joints. Also, in experiments evaluating the distribution of pain from the cervical facet joint, Dwyer et al. [7] identified the C5/C6 facet joints, the authors found that the pain patterns for C5/C6 covered the shoulder above the level of the spine of the scapula. Bogduk defined referred pain as “pain perceived as arising from a body region topographically displaced from the site of the stimulus or disorder that produces the pain” [8]. The dorsal horn neuron simply relays its activation to the thalamus however the thalamic neurons cannot distinguish which particular dorsal horn neuron is responsible for the activation. Therefore, the further transmission of the stimulus from the thalamic neuron to the cortex is not precise. At best the cortex could infer that the stimulus arose somewhere in the pathway of the receptive field of the corresponding thalamic neuron that activated it. Feinstein et al., Inman and Saunders as well as Kellgren [7] completed studies that produced maps of patterns of referred pain from the cervical and thoracic

vertebral column. These maps indicate that referred pain follows a segmental pattern such that stimulation of progressively caudal levels in the vertebral column produces a progressively caudal distribution of referred pain. [7]. The term “sclerotome” has been adopted to describe the peripheral region in which referred pain from a given

vertebral segment is perceived [7].

The hypothesis that the facet joints and intervertebral discs of the cervical spine can be a source of referred pain to the shoulder and that this referred pain can be alleviated by a treatment consisting of manipulating C5, however there are no published clinical research trials testing or supporting this hypothesis. One method of “manipulating” C5 of the spine is to apply a force using a mechanically assisted instrument (MAI). The MAI (Figure 1) is a hand-held spring-loaded device that is activated by compressing a handle on the shank of the instrument. It delivers a force to a rubber tip which is attached to the end of a stylus. A force is applied to C5 using the MAI by placing the MAI on the skin at the level of C5 of the spine, in line with the column of the articular processes that contain the superior and inferior articular facets. These facets also articulate with inferior facet joints of C4 and the superior facet joints of C6 (on the side of pain). The MAI at this site delivers a force in a posterior to anterior direction. A literature search showed thirteen publications were related to shoulder and neck pain: 2 case reports, 3 case series and 8 randomized clinical trials.

These were either of low cohort numbers, there were no control cohorts, had a short time-frame of assessment and/or did not use a mechanically assisted instrument. The purpose of this study was to assess the effects of applying a force to C5 by a MAI on referred pain to the shoulder.

Materials and Methods

The study was approved by the South Eastern Sydney & Illawarra Area Health Service Human Research Ethics Committee (HREC) prior to patient recruitment. The outcome measures were analysed with Sigmaplot v 11 (Systat Software, Inc. Chicago IL, SPSS v21 IBM Inc., N.Y., U.S.A.) software using an intention to treat analysis. With an alpha=0.05/ beta 0.20 and the power at 0.8, level of significance at p=0.05, and the difference in means set at 2.39, expected standard deviation 3.6, the analysis indicated a sample size of 36 for each group. We therefore aim to recruit 40 patients to each group (to allow for dropouts) for a total enrollment of 80 patients. All subjects were assigned to one of two groups in a 1:1 ratio. Randomization was completed by preparing 40 cards with the word "treatment" written on them, and 40 cards with the word "placebo" written on them. Each card was then placed in an unmarked envelope and sealed. The envelopes were mixed, then placed in a box. This box was only accessible to the treating physician. On the day of the commencement in the trial the treating physician took out an envelope from the box and opened it to determine which cohort the patient was in. The card was then placed back in the envelope and the patient's name was written on it. The card was then placed in a separate storage compartment. The treating physician wrote the patient's name and to which cohort they were assigned in a dedicated notebook. The physician would refer to this notebook at each consultation to inform him of the patient's cohort. This notebook was then stored in a lockable file cabinet (separated storage compartment) which could only be accessed by that physician. As a double-blinded study it was explained to the patient by the treating physician that they

would not be told which cohort they were placed in. In addition the independent examiner was not aware which treatment the patient was receiving. Two hundred and two patients presenting with shoulder pain were recruited through newspaper advertisement, doctor mail-outs and referrals from other health professionals. Of these recruits 32 declined to participate, 45 did not meet the inclusion criteria as they were found to have pathology of their shoulder and/or cervical range of motion did not cause pain to their shoulder. This resulted in 125 patients meeting the

inclusion criteria and agreeing to participate in the trial. On the day of the commencement in the trial the treating physician took out an envelope from the box and opened it to determine which cohort the patient was in. There were 65 participants in the treatment cohort and 60 in the placebo cohort. Males totalled 68, of which 35 were in the placebo cohort and 33 in the treatment cohort. There were 57 females of which 25 were in the placebo cohort and 32 in the treatment cohort. The median age of the participants was 61 (range, 28-75 years) (Table 1) and the median duration of symptoms was 21 (range, 1-300 months) (Table 1).

The primary outcome measures were defined as patient-determined frequency and severity of shoulder pain at 24 weeks.

The secondary outcomes were defined as patient-determined: cervical pain on extension/rotation/lateral flexion, cervical pain on lateral flexion, stiffness on cervical

rotation, shoulder strength on internal rotation shoulder strength of supraspinatus impingement on internal rotation. All analyses were made using an intent to treat protocol.

The criteria for the diagnosis of referred shoulder pain were **(**1) 16-75 years; (2) their symptoms of shoulder pain had lasted least 2 weeks in duration; (3) they experienced shoulder pain upon movement of their cervical spine; (4) their shoulder pain was unaccompanied by shoulder pathology. The exclusion criteria included (1) worker's compensation or third party insurance claims and/or litigation in relation to the cervical spine; (2) concurrent facture of the cervical spine/upper limb; (3) concurrent infections of the spine/systemic infection; (4) inflammatory diseases of the spine and or upper limb-rheumatoid arthritis; (5) tumors or other destructive lesions of the cervical spine and or upper limb; (6) frank loss of sensory sensation to the affected upper limb, as tested via pin wheel/light touch; (7) any surgical intervention to the upper limb in the proceeding 12 weeks.

Treatment

Patients in both cohorts were placed in the prone position on a treatment table. The MAI was placed on the patient's skin at the level of C5 of the spine, at the level of the column of articular processes that contain the superior and inferior articular facets (on the side of pain). This was located by surface anatomy (Figure 1).

In the treatment cohort the MAI was set at the maximum setting (5 rings) depressed once causing a "click" sound to be heard transmitting a force into the spine in a posterior to anterior motion.

In the placebo cohort the MAI was not activated. Instead another MAI held in the practitioner's other hand was depressed once, so that the "click" sound of the MAI would be heard, but no force would be delivered to the cervical spine.

The above procedures were completed twice per week for 6 weeks, then once per week for 3 weeks. At 12 and 24 weeks there was no intervention. Assessments by an independent examiner were completed at 1/3/6/9/12 and 24 weeks. The frequency of treatment and time frames used is according to how these interventions are taught at tertiary levels.

Outcome measures

Evaluation consisted of assessments at initial (pre-treatment) appointment, 1 week 3 weeks, 6 weeks, 9 weeks, 12 weeks and 24 weeks post treatment. Independent examiner assessments were completed and recorded for muscle strength measured via a hand held dynamometer for internal rotation and supraspinatus; cervical range of motion assessments for stiffness and pain in flexion, extension, rotation, lateral flexion, extension/rotation/lateral flexion (Quadrant/Kemp's); shoulder impingement on internal rotation.

Statistical analysis

Parametric data consisting of active range of motion, grip strength and Orthopaedic Research Institute tests of maximal strength were analysed using Student's unpaired t-test for differences between cohorts at different time points with significance level $p<0.05$.

Mann-Whitney tests were used for non-parametric pain scores, internal rotation (hand–behind-back vertebrae levels) for differences between the cohorts (treatment v placebo) at different time points with significance level set at $p<0.05$. Two-Way ANOVA with

Bonferroni corrections was used to assess two factors (effects of time and treatment) between initial and different follow-up time points, with significance level set at $p<0.05$.

Chi-square analysis was used to assess dichomatous data, such as patient demographics and impingement signs.

Results

The MAI performance was assessed by a hand-held dynamometer, this indicated that at full setting it delivered a mean force of 5N +/- 0.2 N (Mean +/-SEM).

Primary outcome measures

The frequency of extreme shoulder pain in both cohorts experienced a significant improvement in the frequency of shoulder pain at 24 weeks, compared to pre-intervention levels. Mean +/- S.E.M., n=60 in the placebo cohort, n=65 in the treatment cohort. In the treatment cohort $p<0.05$ using Wilcoxon signed rank test between pre-treatment and 24 weeks. Mann-Whitney unpaired test showed no significant difference between the 2 cohorts at 24 weeks. Two-way ANOVA showed that time was the significant factor (Figure 2).

For the level of shoulder pain at rest both cohorts experienced a significant improvement in the intensity of shoulder pain at 24 weeks compared to pre-intervention levels. Mean +/- S.E.M., n=60 in

the placebo cohort, n=65 in the treatment cohort. In the treatment cohort $p<0.01$ using Wilcoxon signed rank test between pre-treatment and 24 weeks. Mann-Whitney unpaired test showed no significant difference between the 2 cohorts at 24 weeks. Two-way ANOVA showed that time was the significant factor (Figure 3).

Secondary outcome measures

Proportion of Patients Experiencing Cervical Pain on Extension/Rotation/Lateral Flexion (Quadrant/Kemp's) in the treatment cohort experienced a significant improvement at 24 weeks compared to pre-intervention levels. Mean +/- S.E.M., n=60 in the placebo cohort n=65 in the treatment cohort. In the treatment cohort $p<0.01$ between pre-treatment and 24 weeks with Chi square analysis. Chi square analysis at 24 weeks showed no significant difference between the two cohorts (Figure 4). For the proportion of patients experiencing cervical pain on lateral flexion the treatment cohort experienced a significant improvement in proportion of patients who experienced cervical spine pain in lateral flexion at 24 weeks compared to pre-intervention levels. Mean +/- S.E.M., n=60 in the placebo cohort, n=65 in the treatment cohort. In the treatment cohort $p<0.05$ between pre-treatment and 24 weeks with Chi square analysis. Chi square analysis at 24 weeks showed no significant difference between the two cohorts (Figure 5). The proportion of patients experiencing stiffness on cervical rotation in the treatment cohort experienced a significant improvement in proportion of patients who experienced cervical spine stiffness in rotation at 24 weeks

compared to pre-intervention levels. Mean +/- S.E.M., n=60 in the placebo cohort, n=65 in the treatment cohort. Chi square analysis showed the treatment cohort had a significant improvement $p<0.01$ between pre-treatment and 24 weeks. Chi square analysis at 24 weeks showed no significant difference between the two cohorts (Figure 6). For Shoulder Strength-Internal Rotation (Newtons) there was a significant difference in the two cohorts at 24 weeks, where treatment was a contributing factor. Shoulder Strength-Internal Rotation. Mean +/- S.E.M., n=60 in the placebo cohort, n=65 in the treatment cohort. Student's t-test showed no significant difference for the two cohorts between pre-treatment and 24 weeks. Two way ANOVA showed that the treatment cohort had a significant improvement at 6 months compared to pre-treatment. This improvement was due to the treatment itself $p= 0.04$ and not a temporal improvement $p<0.06$ (Figure 7). The proportion of patients with positive impingement on internal rotation at 24 weeks had a significant improvement in both cohorts compared to pre-intervention levels. Mean +/- S.E.M., n=60 in the placebo cohort, n=65 in the treatment cohort. In the treatment cohort $p<0.01$ using Chi square. Chi square analysis at 24 weeks showed no significant difference between the two cohorts (Figure 8).

Discussion

This trial was a prospective, randomized, double blind, placebo controlled clinical trial aimed to determine if there were any benefits in applying a force to the level of C5 of the spine twice per week for six weeks then once a week for three weeks by a mechanically assisted instrument (MAI) in

patients with referred pain to the shoulder. It was found that there was no effect on the intensity of pain, however, there were other improvements. In the treatment cohort at 24 weeks; the frequency of extreme shoulder pain decreased from weekly to monthly ($p<0.05$); the proportion of patients experiencing pain on cervical range of motion decreased by 30% ($p<0.01$) in extension/rotation/lateral flexion (Quadrant/Kemp's); the proportion of patients experiencing pain in cervical lateral flexion decreased by 20% ($p<0.05$); the proportion of patients that experienced stiffness in cervical rotation was reduced by 30% ($p<0.01$); the proportion of patients experiencing positive shoulder impingement on internal rotation decreased by 20% ($p<0.01$). Whilst all these outcomes improved in the treatment cohort, the only outcome measure that was statistically

significantly better in patients receiving the mechanically assisted instrument (MAI) compared with placebo, was shoulder strength in internal rotation at 24 weeks.

No deterioration in any parameters was detected in either cohorts, and there were no adverse reactions to the procedures reported. One patient had cervical fusion during the trial, this was pre-planned prior to their participation.

To our knowledge no other studies have evaluated the use of applying a force to C5 by a mechanically assisted instrument (MAI) in referred pain to the shoulder.

The strengths of our study was that it was a double blinded, placebo controlled trial. Both patient-reported and examiner-reported data were collected during the trial process and a single clinician with extensive experience in the use of the MAI applied the MAI treatment. The assessor was blinded as was the patient. This was a relatively large study for a single institution.

The limitations of the study was that although the numbers were large, more differences between cohorts may have been found with the use of larger sample sizes.

We were unable to determine if the pain is emanating from the intervertebral disc or facet joint or both. Providing only a clicking sound with no force application in the placebo cohort may not be an ideal sham intervention. An alternative may be adding another external force to another area of the cervical spine, however, this may also have confusing treatment effects. There may have also been inaccuracy of locating the C5 vertebral segment by surface anatomy.

Conclusion

The major effect of a mechanically assisted instrument (MAI) over placebo applied to the level of C5 of the spine two times per week for six weeks, then once a week for three weeks in patients who presented with referred shoulder pain was improved shoulder strength in internal rotation at 24 weeks.

There was no effect found on referred shoulder pain. The mechanisms for improved shoulder strength are unclear.

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Legends to Figures:

Figure 1: Positioning and Application of the Mechanically Assisted Instrument.

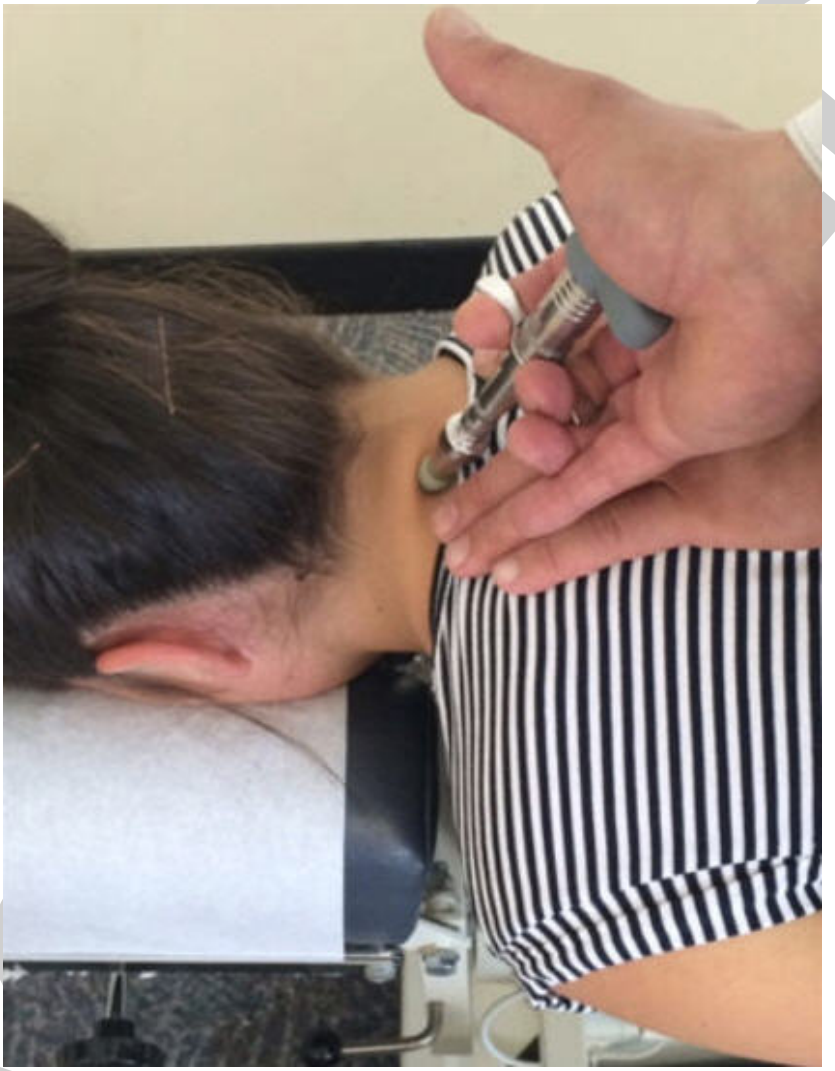

Figure 2: Frequency of Extreme Shoulder Pain.

Both cohorts experienced a significant improvement in the frequency of shoulder pain at 24 weeks compared to pre-intervention levels. In the treatment cohort $p<0.05$ using Wilcoxon signed rank test between pre-treatment and 24 weeks. Mann-Whitney unpaired test showed no significant difference between the 2 cohorts at 24 weeks. Two-way ANOVA showed that time was the significant factor.

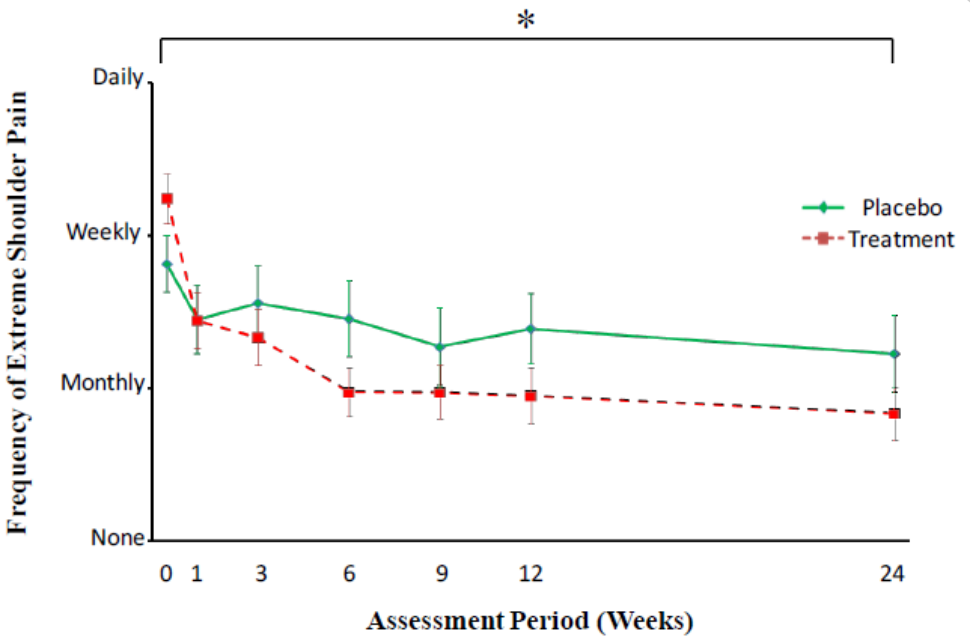

Figure 3: Level of Shoulder Pain at Rest.

Both cohorts experienced a significant improvement in the intensity of shoulder pain at 24 weeks compared to pre-intervention levels. In the treatment cohort $p<0.01$ using Wilcoxon signed rank test between pre-treatment and 24 weeks. Mann-Whitney unpaired test showed no significant difference between the 2 cohorts at 24 weeks. Two-way ANOVA showed that time was the significant factor.

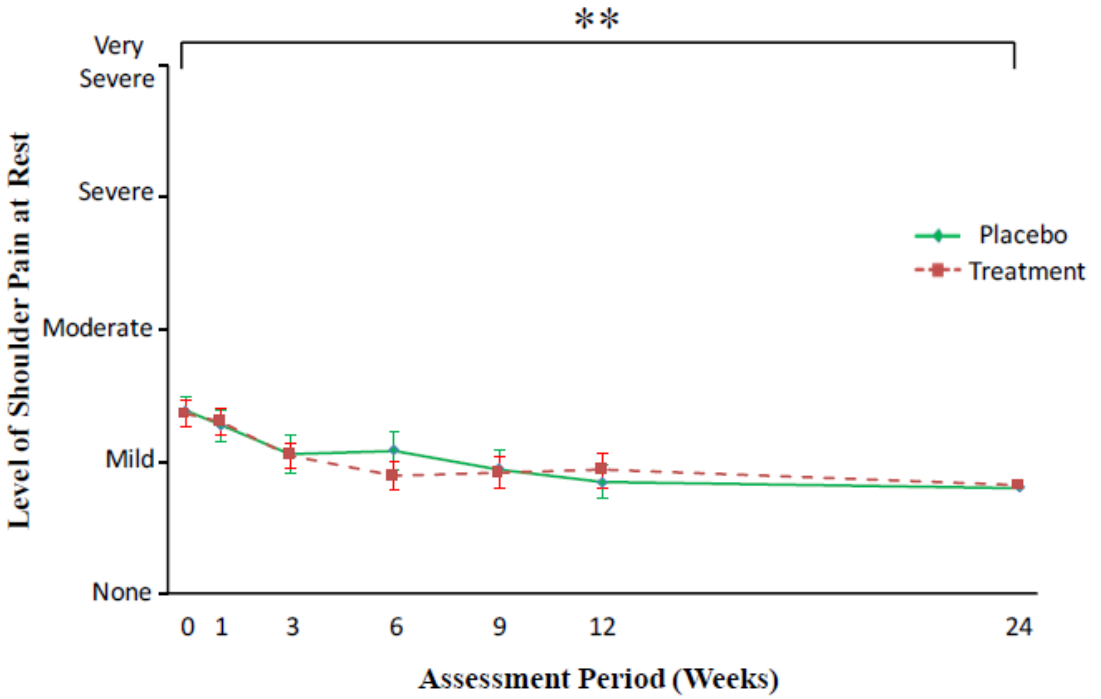

Figure 4: Proportion of Patients Experiencing Cervical Pain on Extension/Rotation/Lateral Flexion.

Treatment cohort experienced a significant improvement in the proportion of patients who experienced cervical spine pain in extension/rotation/lateral flexion at 24 weeks compared to pre-intervention levels. In the treatment cohort $p<0.01$ between pre-treatment and 24 weeks with Chi square analysis. Chi square analysis at 24 weeks showed no significant difference between the two cohorts.

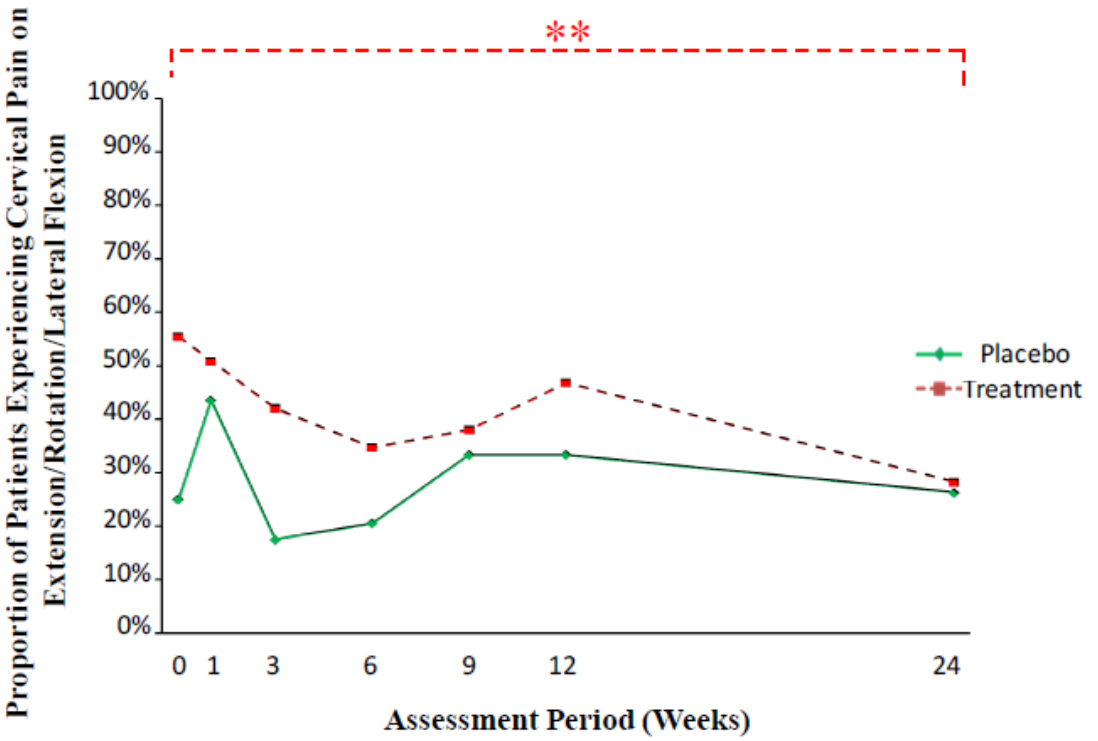

Figure 5: Proportion of Patients Experiencing Cervical Pain on Lateral Flexion.

Treatment cohort experienced a significant improvement in proportion of patients who experienced cervical spine pain in lateral flexion at 24 weeks compared to pre-intervention levels. In the treatment cohort $p<0.05$ between pre-treatment and 24 weeks with Chi square analysis. Chi square analysis at 24 weeks showed no significant difference between the two cohorts.

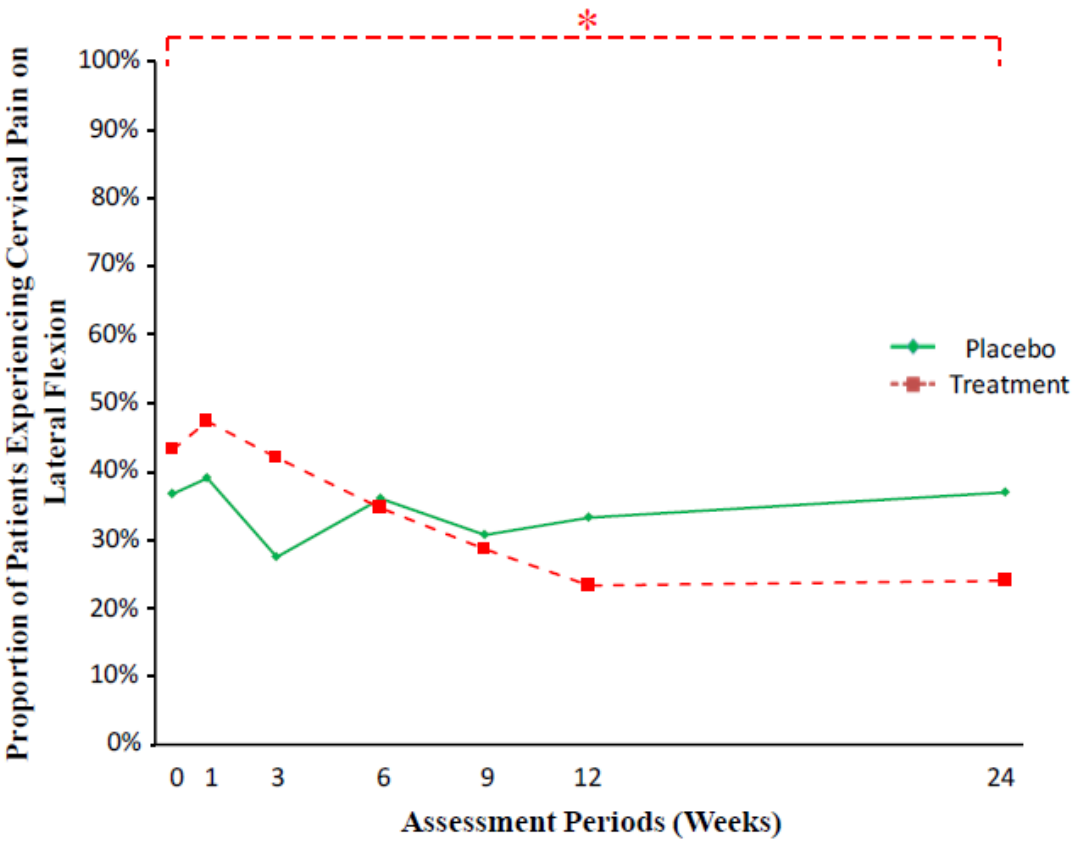

Figure 6: Proportion of Patients Experiencing Stiffness on Cervical Rotation.

Treatment cohort experienced a significant improvement in proportion of patients who experienced cervical spine stiffness in rotation at 24 weeks compared to pre-intervention levels. Chi square analysis showed the treatment cohort had a significant improvement $p<0.01$ between pre-treatment and 24 weeks. Chi square analysis at 24 weeks showed no significant difference between the two cohorts.

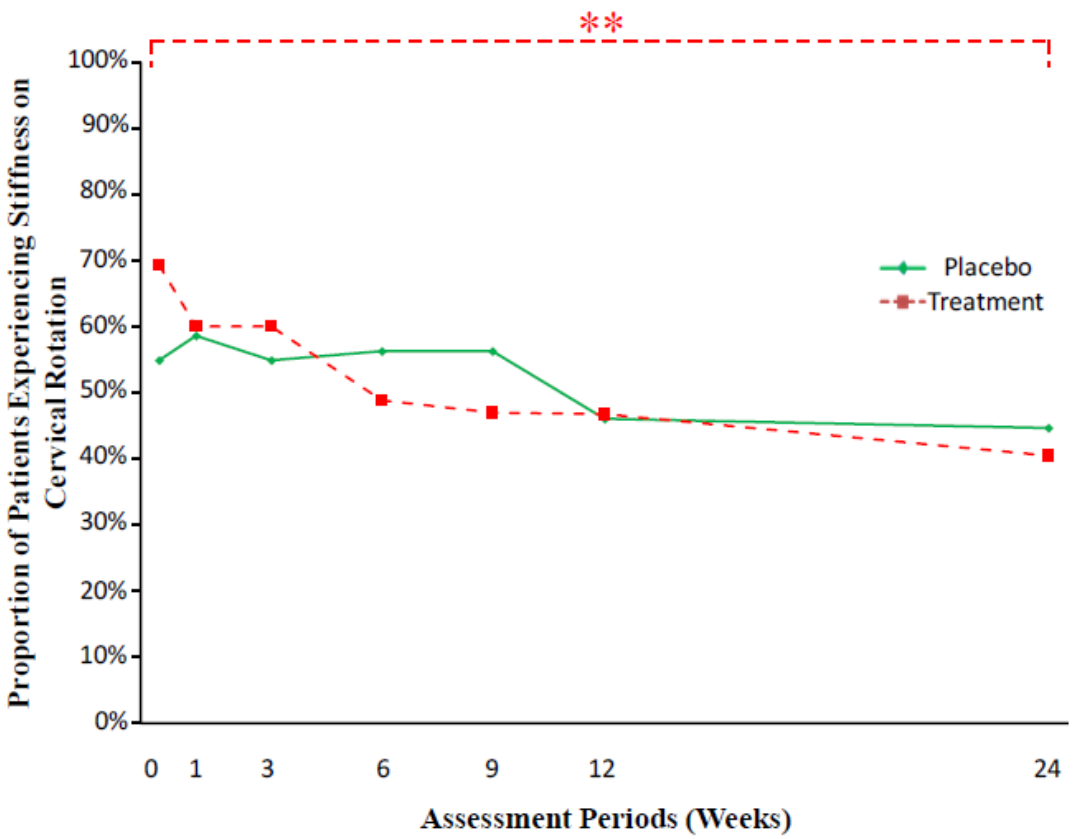

Figure 7: Shoulder Strength-Internal Rotation.

However there was a significant difference in the two cohorts at 24 weeks, where treatment was a contributing factor. Student's t-test showed no significant difference for the two cohorts between pre-treatment and 24 weeks. Two way ANOVA showed that the treatment cohort had a significant improvement at 6 months compared to pre-treatment. This improvement was due to the treatment itself p= 0.04 and not a temporal improvement p<0.06

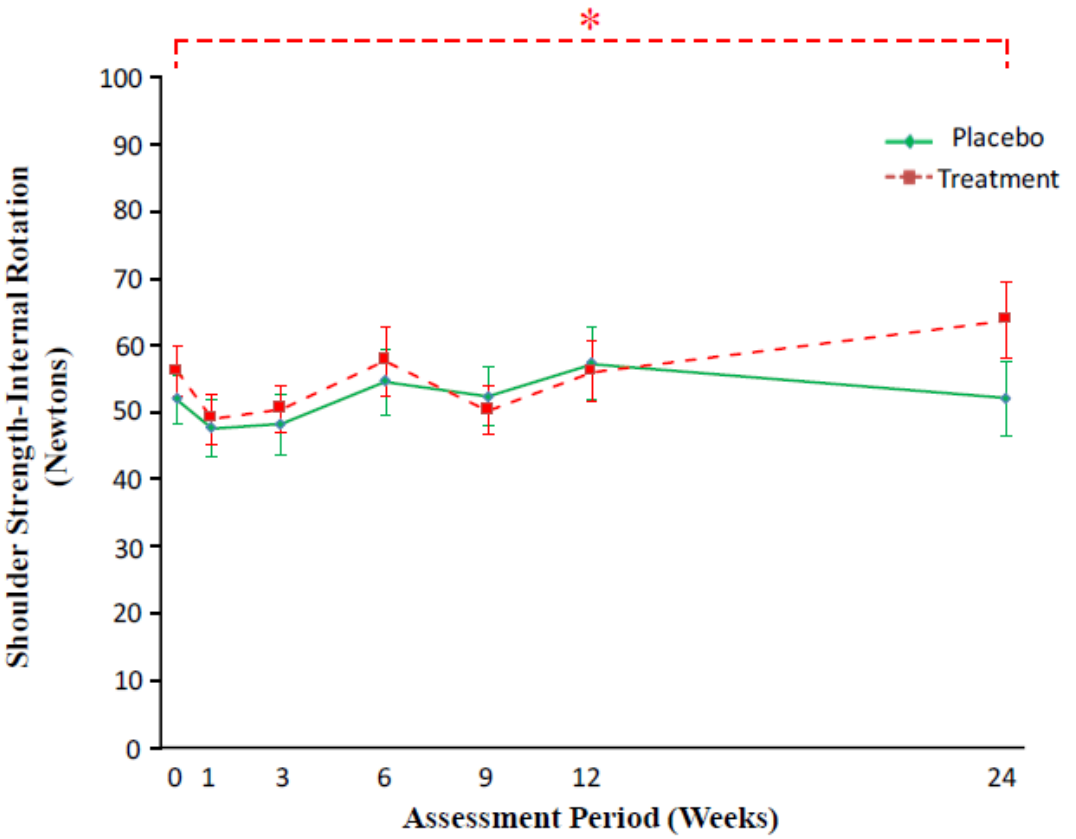

Figure 8: Proportion of Patients with Positive Impingement on Internal Rotation.

Both cohorts had a significant improvement in the proportion of patients with positive impingement on internal rotation at 24 weeks compared to pre-intervention levels. In the treatment cohort $p<0.01$ using Chi square. Chi square analysis at 24 weeks showed no significant difference between the two cohorts.

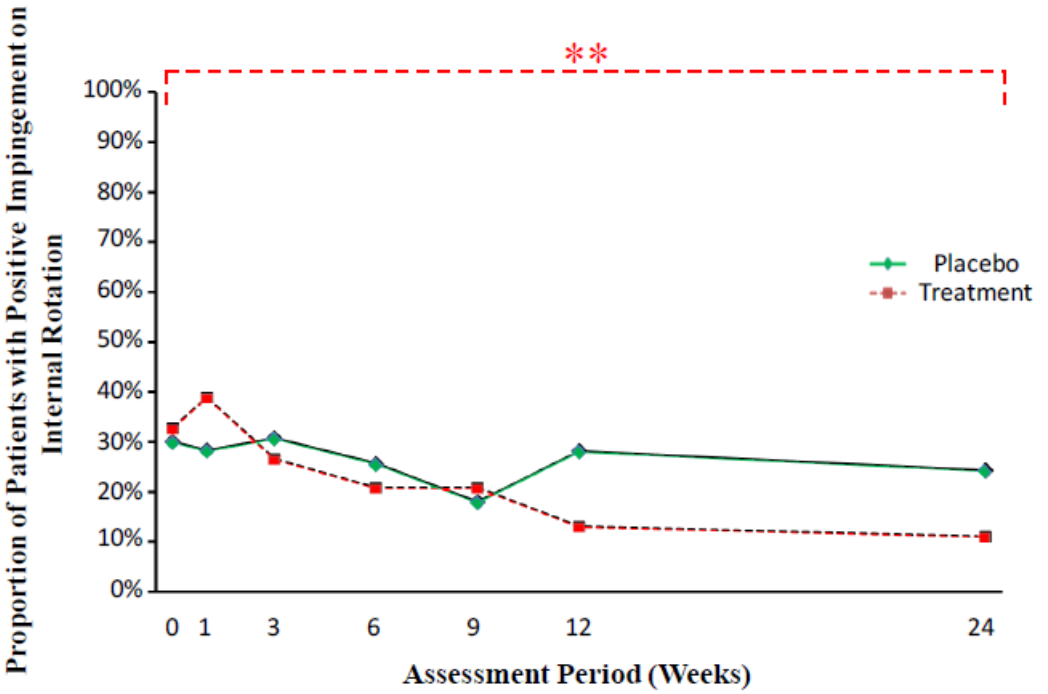

Table 1. Demographic data

No significant differences were found between the control and treatment cohorts

	Placebo Cohort	**Treatment Cohort**
Age	63 (37-75)	56 (28-75)
Gender **M : F**	35 : 25	33 : 32
Affected Shoulder **R : L**	42 : 18	37 : 28
Symptoms Duration **(Months)**	12 (1-300)	24 (1-288)