Cervical Proprioceptive Training in Treatment of Chronic Mechanical Neck Pain

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ABSTRACT

Introduction: *The existence of a tight coupling between gaze orientation and neck muscle activity has been well documented in humans. This coordination between eye and neck motor function strongly suggests that rehabilitation program based on eye-head coupling are more appropriate to facilitate neck proprioception rehabilitation, and subsequently reduce neck pain.* ***Purpose:*** *The purpose of this study was to clarify the importance of an eye-head coupling based rehabilitation program in the treatment of chronic mechanical neck pain.* ***Procedures:*** *A comparison was held between two groups of neck pain patients (A and B). Both groups received a traditional physical therapy program but group (B) received an eye-head coupling based rehabilitation program in addition. Treatment outcome was determined from: 1) scores of Neck Pain and Disability Scale (NPAD) as a self reported measure, 2) absolute angular error (AAE) in horizontal plane, and 3) absolute angular error (AAE) in sagittal plane.* ***Results:*** *The results showed a statistically significant decrease in the scores of (NPAD) scale in both groups (A and B) with greater decrease in group (B). No statistical significant decrease in the (AAE) in the group (A) in both horizontal and sagittal planes, while there was statistical significant decrease in the (AAE) in both horizontal and sagittal planes in group (B).* ***Conclusion:*** *It was concluded that combining a traditional physical therapy program with an eye-head coupling based rehabilitation program is important for improvement of chronic mechanical neck pain.*
Key Words: *neck pain, cervical, kinesthesia, eye-head coupling exercises, absolute angular error.*

INTRODUCTION

Neck pain and disability are prevalent throughout industrialized society[2]. It is the product of a fast, mechanical, full of tension life, lack of exercise, bad posture, and use of cushy pillows and soft beds. It may be also due to an injury. No specific cause can be pinpointed. Sometimes neck pain lasts for a few days and wears off on its own, but when it persists for a long time, it presents greater problems[3]. Neck pain is extremely common in the general population, it is costly in terms of investigations, treatment, individual suffering, and time lost from work[2]. In population surveys in the United Kingdom as many as 9% of adult males and 12% of adult females were experiencing some discomfort in the neck[5]. In another population survey 34.4% of the sample population, had experienced neck pain[2]. Neck pain is one of the most debilitating musculoskeletal problems. Neck pain problems are a significant source of disability to patients, but they have not been studied as extensively as low back pain problems[13]. Despite its frequency and unpleasantness, medical management of neck pain has been over shadowed by that of low back pain[15]. Protection against spinal injury requires proper anticipation of events, appropriate sensation of body position and reasonable muscular response[16]. Head orientation in space with respect to the trunk makes use of visual, vestibular and cervical proprioceptive cues[14]. Motion and stabilization of the spine are based on a complex reflex activation system in which the proprioceptive nerve endings in the annulus fibrosus of the intervertebral disc, the facet joints and paraspinal muscles initiate various reflex patterns[8]. A less consistent population of encapsulated nerve endings in facet joints were found in the thoracic and lumber spine compared with the cervical spine which means that the proprioceptive function in these regions is less refined than that in the cervical spine[11]. Restricted cervical movements and changes in the quality of proprioceptive information from the cervical spine region have been proved to affect voluntary eye movements[6]. Thus the aim of this study is to investigate the effects of an eye-head coupling based rehabilitation program on cervicocephalic kinesthesia and pain and disability in chronic mechanical neck pain patients.

MATERIALS AND METHODS

Subjects

A total of 40 patients with chronic mechanical neck pain participated in the study (Table 1). They were 23 females and 17 males, age ranging between 25 and 40 years. These patients were randomly assigned into two groups:

Group A: received a traditional physical therapy program.

Group B: received the same traditional physical therapy program as group A + an eye-head coupling based rehabilitation program.

All patients signed an informed consent form prior to participating in the study.

Table (1): General characteristics of study subjects.

General Characteristics		Number of Subjects
Sex	Male	17
	Female	23
Age	Min.	25
	Max.	40
	Mean	34.4
	S.D.	4.51

Inclusion Criteria:

1- Referred from an orthopedist with a diagnosis of chronic mechanical neck pain i.e. persisting for more than three months.
2- Age between 25 and 40years.

Exclusion Criteria:

1- Rheumatoid arthritis.
2- Ankylosing spondylitis.
3- Tumoral or infectious diseases.
4- Any given medications that can affect the results of the study.
5- Cervical spondylosis, disc prolapse or any sign of cervical radiculopathy or myelopathy.
6- Active or recent history of vestibular disorder or inner ear infection with associated balance\ coordination problem.
7- Any pathology or trauma related to the neck.
8- All potential sources of the patients complaints, which may go beyond just the physical sources were addressed or noticed.
9- Psychological and psychosocial factors which can play an important role in the patient's symptoms were taken into consideration.

Instrumentation

1- OB. Goniometer*.
2- Neck Pain and Disability Scale (NPAD).
3- Special goggles equipped with lenses that are opaque except for a clear central point of 0.5cm wide.
4- Ultrasonic device **.
5- Infrared lamp, 235-245 V., 250 W.
6- Mechanical traction.
7- Light beam pointer.

* 'Myrin' (OB Rehab Co AN LIC-Company s-17183 Solna, Sweden, Tfn 08-985370).
** (sonopuls 590), freq. 1 MHz., 10 W., 220-240 V. /50-60 Hz./ 0.35A, Enraf Nonius. Rontgenweg 1, P.O. Box 810, 2600 AV Delft. The Netherlands. Tel.: +31(0)152698400, Fax.: +31(0)152561686.

Evaluation Procedures

1- Evaluation of Pain Using (NPAD) Scale:

Subjective assessment of neck pain and disability was done in both groups twice, pre treatment and post treatment using the (NPAD) scale. Patients were instructed to respond to each item by marking along a 10-cm visual analogue scale that belongs to each item. Item scores ranged from 0 to 5, and the total score was a total of the item scores. The maximum total score equal 100 points, that indicating maximum neck pain and disability. The less the total score, the more is improvement in the neck pain and disability. As each item was describing the intensity of pain and its interference with the patient daily living, functional, emotional, social, recreational or vocational activities.

2- Evaluation of Kinesthetic Sensibility Using OB Goniometer:

Kinesthetic sensibility was tested in both groups twice, pre treatment and post treatment, by examining the ability of the patient to reproduce an angle at which the head had been placed before being moved i.e. active head repositioning. Active head repositioning was tested in two planes, horizontal plane and sagittal plane. All patients were had their vision occluded from the start of the experiment.

a) Horizontal Plane: The patient was instructed to concentrate in the pre-determined test angle for ten seconds, then he was asked to perform maximal rotation of the head to the left for approximately two seconds, then try to reproduce the test angle with a maximal precision without speed instruction. The primary outcome variable was the subject's absolute angular error (AAE). The AAE is the difference, ignoring the direction of the error, between the actual test angle and the subject's estimate of it.

After each trial the head was positioned in the initial test angle and no feedback in accuracy was given. Three trials were undertaken, with head repositioning after a rotation to the left. The same procedures were done for the head rotation to the right and three trials were taken, the AAE was calculated for each and the average of the six trials was taken as the mean kinesthetic sensibility in the horizontal plane. After five minutes of rest, new test angle was established for evaluation of active head repositioning in the sagittal plane.

b) Sagittal Plane: The patient was instructed to concentrate in the pre-determined test angle for ten seconds, and then he was asked to perform maximal flexion of the head for approximately two seconds, and then try to reproduce the test angle with a maximal precision without speed instruction. The primary outcome variable was the patient's AAE. After each trial the head was positioned in the initial test angle and no feedback in accuracy was given. Three trials were undertaken, with head repositioning after maximum flexion. The same procedures were done for the head extension and three trials were taken, the AAE was calculated for each and the average of the six trials was taken as the mean kinesthetic sensibility in the sagittal plane.

Treatment Procedures

Both groups received 3 sessions per week for a period of 4 weeks. The patient's expectations, questions, and goals were discussed at the beginning of the treatment. Two programs of treatment were used in this study:

- Traditional physical therapy program: applied for both groups (A&B).
- Eye-head coupling based rehabilitation program: applied for group (B) only.

Traditional Physical Therapy Program

This program was modified from Borenstein et al., 1996[1]; and Jordan et al., 1998[10]. It was applied to both groups, A and B, as following:

1- Infrared radiation for 15 minutes.
2- Pulsed ultrasonic therapy for 6 minutes duration with 1 W/cm² intensity, on the cervical paraspinal muscles.
3- Sustained traction with weight equal to 7% of total body weight was applied for 15 minutes with a 30° angle of pull.
4- Exercise program: It consisted of 3 stages; isometric exercises, stretching exercises, and postural exercises. First stage was started from the first session, and then each 4 sessions a new stage was added.

A- Isometric exercises (started from the 1st session):
  a. Isometric neck extension exercise.
  b. Isometric neck side bending exercise.
  c. Isometric neck flexion exercise.

B- Stretching exercises (added from the 5th session):
  a. Unilateral passive stretching for sternocleudomastoid muscle.
  b. Passive stretching for the short suboccipital muscles.

C- Postural exercises (added from the 9th session):
  a. Rotation postural exercise.
  b. Side bending postural exercise.
  c. Rotation-side bending postural exercise.
  d. Raise arm postural exercise.

Eye Head Coupling Based Rehabilitation Program

This program was modified from Revel et al., 1994. It consisted of 3 stages. First stage was started from the first session, and then each 4 sessions a new stage was added.

I- The First Stage (from 1st session):

Patient was in supine lying position. Therapist was standing behind the patient at the end of the bed holding the patient's head by his both hands. The patient was instructed to maintain his gaze on a fixed target while; therapist turned the patient's head passively and slowly. This exercise was performed 10 times.

II- The Second Stage (added from 5th session):

Patient was sitting in relaxed position, with good back support. Therapist was in standing position, observing movement of the patient's eyes.

i. Head Immobile: The patient was instructed to move his eyes at first slow then quickly as following:
a. Up and down. Performed 5 times.
b. Side to side. Performed 5 times.
c. Repeat a and b, focusing on finger: the therapist was standing in front of the patient and moving his finger in front of patient's eyes (up and down, then side to side); while patient's eyes following the movement of the therapist's finger.
d. Focusing on therapist's finger that started 3 feet away from face and moved toward the face up to 2 inches. Performed 5 times.

ii. Head Mobile: Patient was sitting in relaxed position with good back support. Therapist was standing in front of the patient, observing his head movements. The patient was instructed to move the head at first slow then quickly, with open eyes and then later with closed eyes as follow:
a. Bending forward and backward. Performed 5 times.
b. Turn from side to side. Performed 5 times.

III- The Third Stage (added from 9th session):

Patient was sitting in relaxed position with good back support. Exercises were performed with restricted peripheral vision using special goggles adjusted so that each patient would have clear foveal vision.

i. Active Movements of the Head (Rotations): Therapist was standing behind the patient, holding light beam pointer to move light beam slowly horizontally on the wall in front of the patient. Patient was instructed to follow the light beam. Five repetitions were performed.

ii. Automatic Movements of the Neck: Therapist was standing behind the patient, moving the patient's trunk in different unexpected directions. Patient was instructed to maintain his gaze on a fixed target while the therapist passively moved the trunk in different unexpected directions. Five repetitions were performed.

iii. Relocate The Initial Head Position: The patient was instructed to fix his gaze on a target for a few seconds and to memorize the head-neck position. Then, he closed his eyes, performed a maximal rotation of the head, tried to find the initial position and opened the eyes. If he could see the target that meant that he returned to original position, but if he couldn't see it that meant that he didn't return to the original position. The exercise was related to relocate as accurately as possible the initial head position. Five repetitions were performed.

RESULTS

Statistical Methodology

1- The mean and standard deviation of (NPAD) scale pre-treatment were compared with mean and standard deviation of (NPAD) scale post-treatment in each group (A&B) by using the paired t-test.

2- The mean and standard deviation of AAE at horizontal plane pre-treatment were compared with mean and standard deviation of AAE post-treatment in each group (A&B) by using the paired t-test.

3- The mean and standard deviation of AAE at sagittal plane pre-treatment were compared with mean and standard deviation of AAE post-treatment in each group (A&B) by using the paired t-test.

The 0.05 level was used as the maximum probability level denoting statistical significance ($P<0.05$).

Results of Neck Pain Measurements

Group A: Statistical analysis of this group was studied pre-treatment and post-treatment. The results showed a statistically significant decrease ($P<0.05$) in the scores of the (NPAD) scale (Table 2) (Figure 1).

Table (2): T-test of N.P.A.D. in group (A).

Time of evaluation	Min	Max	Mean	SD	2-tail probability	t-value
Pretreatment	63.2	76.7	72.52	3.605	0.0002 *	4.572 *
Posttreatment	30.9	76.1	59.92	10.991		

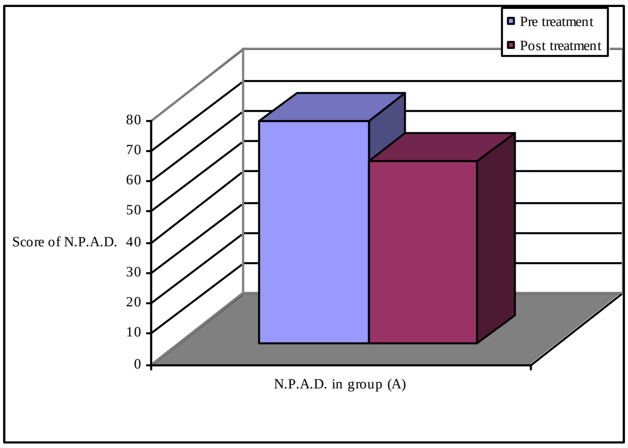

Fig. (1): N.P.A.D. in group A.

Group B: Statistical analysis of this group was studied pre-treatment and post-treatment. The results showed a statistically significant decrease (P<0.05) in the scores of the (NPAD) scale (Table 3) (Figure 2).

Statistical analysis of both groups revealed that the difference between NPAD score pretreatment and post-treatment was more significant in group (B) than in group (A) indicating more significant improvement in neck pain in group (B) than in group (A).

Table (3): T-test of N.P.A.D. in group (B).

Time of evaluation	Min	Max	Mean	SD	2-tail probability	t-value
Pretreatment	46.6	84.3	62.505	9.567	0.0001 *	4.833 *
Posttreatment	30	60.3	48.355	9.354		

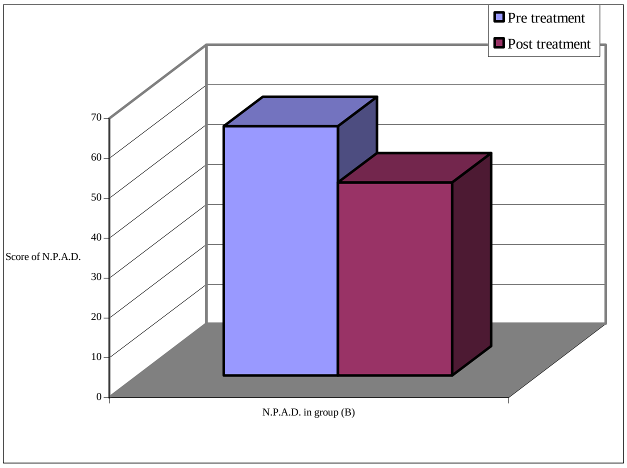

Fig. (2): N.P.A.D. in group B.

Results of Cervicocephalic Kinesthesia in Horizontal Plane

Group A: Statistical analysis of this group was studied pre-treatment and post-treatment. The results showed no significant difference between AAE pre-treatment and AAE post-treatment (P<0.05), (Table 4) (Figure 3).

Table (4): T-test of A.A.E. in the horizontal plane in group (A).

Time of evaluation	Min	Max	Mean	SD	2-tail probability	t-value
Pretreatment	5	11.16	8.297	1.503	0.122	1.614
Posttreatment	5.1	12.5	8.014	1.686		

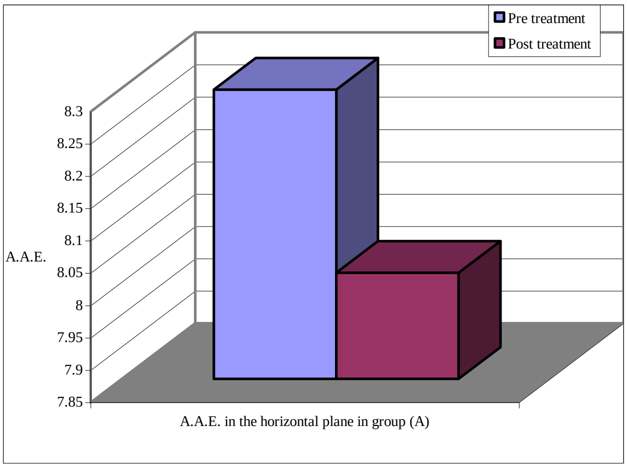

Fig. (3): A.A.E. in the horizontal plane in group A.

Group B: Statistical analysis of this group was studied pre-treatment and post-treatment. The results showed a statistically significant decrease between AAE pre-treatment and post-treatment (P<0.05), (Table 5) (Figure 4).

Statistical analysis of both groups revealed that the difference between AAE pretreatment and post-treatment was more significant in group (B) than in group (A) indicating more significant improvement in cervico-cephalic kinesthesia in the horizontal plane in group (B) than in group (A).

Table (5): T-test of A.A.E. in the horizontal plane in group (B).

Time of evaluation	Min	Max	Mean	SD	2-tail probability	t-value
Pretreatment	5.5	11.33	7.805	1.388	0.0002 *	4.421 *
Posttreatment	2	8	5.207	1.799		

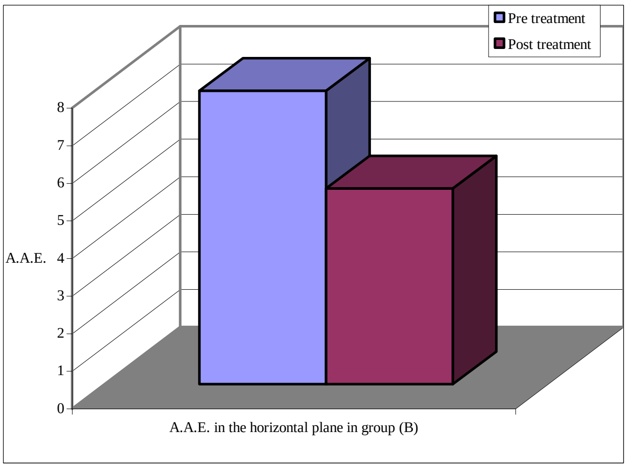

Fig. (4): A.A.E. in the horizontal plane in group B.

Results of Cervicocephalic Kinesthesia in Sagittal Plane:

Group A: Statistical analysis of this group was studied pre-treatment and post-treatment. The results showed no significant difference between AAE pre-treatment and AAE post-treatment (P<0.05), (Table 6) (Figure 5).

Table (6): T-test of A.A.E. in the sagittal plane in group (A).

Time of evaluation	Min	Max	Mean	SD	2-tail probability	t-value
Pretreatment	6.16	10.66	8.039	1.444	0.071	1.912
Posttreatment	5.66	9.66	7.533	1.148		

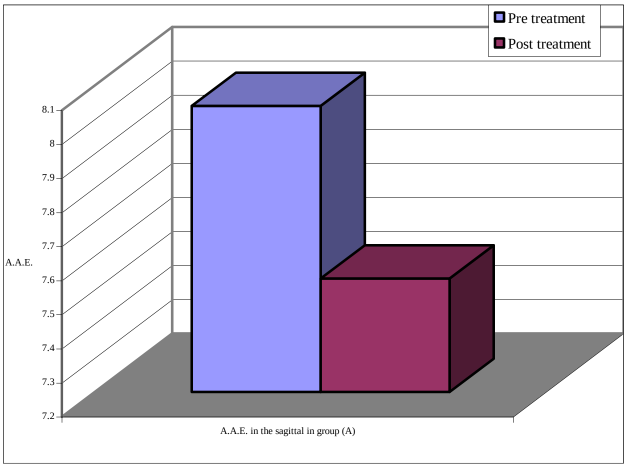

Fig. (5): A.A.E. in the sagittal plane in group A.

Group B: Statistical analysis of this group was studied pre-treatment and post-treatment. The results showed a statistically significant decrease between AAE pre-treatment and post-treatment (P<0.05), (Table 7) (Figure 6).

Statistical analysis of both groups revealed that the difference between AAE pretreatment and post-treatment was more significant in group (B) than in group (A) indicating more significant improvement in cervico-cephalic kinesthesia in the sagittal plane in group (B) than in group (A).

Table (7): T-test of A.A.E. in the sagital plane in group (B).

Time of evaluation	Min	Max	Mean	SD	2-tail probability	t-value
Pretreatment	4.66	10.83	7.596	1.503	0.0002 *	4.548 *
Posttreatment	2.5	11	5.493	2.026		

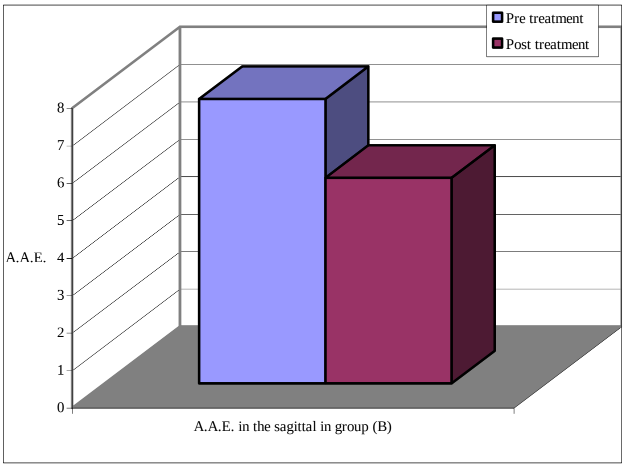

Fig. (6): A.A.E. in the sagittal plane in group B.

DISCUSSION

Generally, results of this study clearly showed the importance of combining an eye-head coupling based rehabilitation program with a traditional physical therapy program in treatment of chronic mechanical neck pain.

In Revel's[14] study, the absence of correlation between inaccuracy and pain intensity as well as direction of painful movement eliminates the hypothesis of cervical proprioceptive alterations due to nociceptive inputs. Cervicalgic subjects also showed an overshoot in horizontal plane repositioning movements. This overshoot could indicate the search for additional proprioceptive information coming from stretched antagonistic muscles constituting a type of overshoot by confirmation. Therefore, alteration in proprioceptive sensibility in patients with neck pain seems the most probable explanation. The cause could be an anatomic lesion of articular receptors due to a local trauma or degenerative arthropathy, or it could be due to purely functional alteration of tendinous and muscular proprioceptors related to neck muscle function disturbances[15].

In the current study, a statistically significant difference was found between the AAE of group A and that of group B in favor of group B, indicating a significantly more accuracy on active head repositioning experienced by patients in group B than in group A. This result was attributed to the effect of eye-head coupling exercises that provided to group B. The proprioceptive system of the neck, which is mainly involved in cervicocephalic kinesthesia has learning abilities and can be improved by rehabilitation techniques[15], which could explain the results of the current study.

Proprioceptive training was neglected in the traditional physical therapy programs for chronic neck pain. In the current study proprioceptive training (eye–head coupling exercises) was added to the traditional physical therapy program for group B.

Proprioceptors are responsible for providing afferent information regarding change in position and angular velocity of the spine to central nervous system (CNS), which controls tension of the neck muscles and react to those changes according to these information. If the change in position exceeds the limits of the normal movement, then the muscle groups activated by this reflex system will be thus capable of counteracting the applied external force. This feedback for the control of muscle actions then serves to counteract excessive strain of the passive structures and guard against injuries (Muller, 1983).

Ihara and Nakayama (1986)[7] reported that proprioceptive training could be considered as a method to shorten the time lag between neural proprioception and muscle response.

Johannsen et al. (1995)[9] reported different results when they compared the effectiveness of proprioceptive exercises with a strengthening program over a 3-month period. Their results suggested that proprioceptive and strengthening exercises produce a similar outcome from rehabilitation. However, there were flaws in the measurements taken, and therefore these results should be regarded with caution[4]. This controversy between the results of the current study and those of Johannsen et al. (1995)[9] can be attributed to the fact that they conducted their study on chronic low back pain patients, while the current study was conducted on chronic mechanical neck pain patients. And it has been proved by McLain et al. (1998)[11] that less consistent population of encapsulated nerve endings in facet joints were found in the thoracic and lumbar spine compared with the cervical spine which means that the proprioceptive function in these regions is less refined than that in the cervical spine.

APPENDIX

NPAD Scale

1. How bad is your pain today?
2. How bad is your pain on the average?
3. How bad is your pain at its worst?
4. Does your pain interfere with your sleep?
5. How bad is your pain with standing?
6. How bad is your pain with walking?
7. Does your pain interfere with driving or riding in a car?
8. Does your pain interfere with social activities?
9. Does your pain interfere with recreational activities?
10. Does your pain interfere with work activities?
11. Does your pain interfere with your personal care (eating, dressing, bathing, etc.)?
12. Does your pain interfere with personal relationships (family, friends, sex, etc.)?
13. How has your pain changed your outlook on life and the future (depression, hopelessness)?
14. Does pain affect your emotions?
15. Does your pain affect your ability to think or concentrate?
16. How stiff is your neck?
17. How much trouble do you have turning your neck?
18. How much trouble do you have looking up or down?
19. How much trouble do you have working overhead?
20. Do you spend more time than usual at home because of neck pain?

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الملخص العربي

تأثير تمرينات اقتران العين والرأس على الإحساس بالحركة في الاتجاه الرأسي العنقي في حالات الآلام العنقية الميكانيكية المزمنة

إن الطرق العلاجية التي تشتمل على التمرينات المستقبلات الحسية العميقة باستخدام تمرينات اقتران العين والرأس من الممكن أن تحدث تحسناً في الآلام العنقية الميكانيكية المزمنة . لقد كان الهدف من هذه الدراسة هو توضيح أهمية برنامج تمرينات اقتران العين والرأس على الإحساس بالحركة في الاتجاه الرأسي العنقي إذا تم استخدامه مع برنامج العلاج الطبيعي التقليدي في حالات الآلام العنقية الميكانيكية المزمنة . اشتملت هذه الدراسة على عينة مكونة من أربعين مريضاً بالآلام العنقية الميكانيكية المزمنة ولقد تراوحت أعمارهم بين 25 و 40 عاماً . وقد تم التأكد من خلو هؤلاء المرضى من الإصابة بخشونة أو تيبس أو روماتويد بالفقرات العنقية أو أي إصابة في مفصل الفك أو أي التهابات أو أورام عنقية أو انزلاق غضروفي عنقي أو أي مرض في الأذن الداخلية أو مرض أو إصابة تصيب العنق كما أشطرت على المرضي عدم تعاطي أدوية تأثر على نتائج البحث . وقد تم تقسيم المرضى عشوائياً إلى مجموعتين (أ – ب) حيث تلقت المجموعة (أ) برنامج علاج طبيعي تقليدي أما المجموعة (ب) فتلقت نفس البرنامج بالإضافة لبرنامج اقتران العين والرأس . وقد تحددت نتائج العلاج من خلال نتائج مقياس آلام وعجز الرقبة ونتائج الخطأ الزاوي المطلق في اختبار مدى حساسية الإحساس بالحركة في الاتجاه الرأسي العنقي عن طريق إعادة الوضع الفعال . وقد أظهرت النتائج وجود فروق ذات دلالة إحصائية في نتائج مقياس آلام وعجز الرقبة في كلتا المجموعتين قبل العلاج وبعد العلاج حيث كان هناك انخفاض في مستوى الألم في كلتا المجموعتين بعد العلاج مقارنتا به قبل العلاج لكن هذا الانخفاض كان ذا دلالة إحصائية أكثر بالمجموعة (ب) عن المجموعة (أ) أما نتائج الخطأ الزاوي المطلق في المستوى الأفقي فكانت أيضاً تشير إلى وجود انخفاض ذي دلالة إحصائية في المجموعة (ب) بعد العلاج مقارنةً به قبل العلاج في حين أن انخفاض في المجموعة (أ) لم يكن ذا دلالة إحصائية . وقد أشارت نتائج الخطأ الزاوي المطلق في المستوى الرأسي إلى وجود انخفاض ذي دلالة إحصائية في المجموعة (ب) بعد العلاج مقارنةً به قبل العلاج في حين أن الانخفاض في المجموعة (أ) لم يكن ذا دلالة إحصائية وبالتالي فقد أوضحت نتائج هذا البحث أن دمج برنامج العلاج الطبيعي التقليدي مع برنامج تمرين اقتران العين والرأس يكون أكثر فاعلية في تحسين الألم والعجز بالرقبة وتحسن الإحساس بالحركة في الاتجاه الرأسي العنقي .