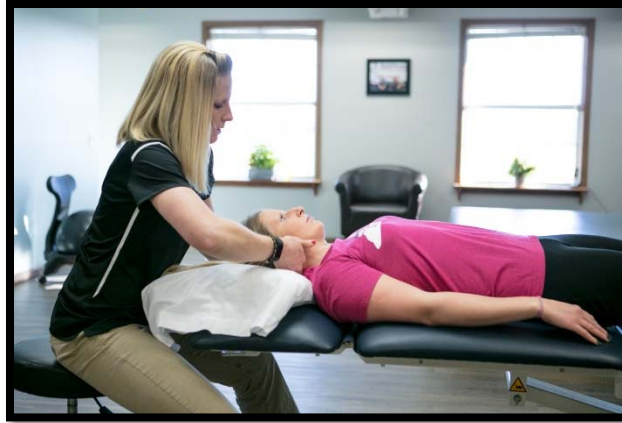




**Rehabilitation
& Performance**
INSTITUTE

The Cervical Spine



The Cervical Spine

ASSESS

Initial Observation

- Attitude and posture of the head and neck
- The way the person shakes hands, noting firmness of grasp and how they move their arm
- Full Standing Inspection:
 - Posterior: medial arch, calcaneal tendon for deviations, swelling, scars, popliteal fold, gluteal folds, PSIS, iliac crest, greater trochanters
 - Anterior: forefoot position, ankle mortise direction, anterior tibial tubercle, patellar direction, knee varus/valgus, greater trochanter, ASIS, rib cage, nipple level, sternum, position of the shoulders, neck and head position.
 - Lateral: recurvatum of the knee, position of the pelvis, lumbar, thoracic, cervical curves, position of the shoulder girdle and head.

AROM

- Habitual movements first, then do segment by segment with eyes open and then eyes closed.
- Note painful and pain-free ranges, speed, quality of movement, and aberrant patterns.
 - Flexion
 - Extension
 - Sidebending
 - Rotation
- Repeated movement patterns
 - Perform all cardinal planes of movement at least 10 times
- Combined movements
 - Flexion with SB
 - Flexion with SB one way and rotation to same side
 - Flexion with SB one way and rotation away
 - SB one way then extend
 - SB one way then extend and then rotate towards same side
 - SB one way then extend and rotate away

PROM

- Pt seated, ask about pain and feel for restrictions/ “end-feel”

- Flexion
- Extension
- SB
- Rotation
- Upper cervical extension, flex mid and CT area
- Lower cervical extension, flex upper cervical area
 - Can also do sustained positions if the above are negative. Hold 10 seconds
 - Overpressure to the upper and lower portions (one hand over the chin and the other on the back of the head)

Resisted Testing

- Test in 3 positions for each test. Start neutral and then in the most shortened and most lengthened position.
 - Flexion
 - Extension
 - Sidebending
 - Rotation

Palpation

- Anterior:
 - SC joint
 - SCM
 - TMJ-with opening and closing
 - Scalenes
- Posterior:
 - Occiput
 - Spinous processes-C2-T1
 - Facet joints
 - Transverse processes
 - Upper trapezii
 - Levator

Neuro Screen

- Myotomes
 - C1-rectus capitus anterior-chin tucks
 - C2-rectus capitus posterior-push chin up
 - C3-Scaleni-cervical SB
 - C4-Levator and trapezius-Press head back or shoulder elevation
 - C5-Deltoid-abuction of arm
 - C6-Bicep-elbow flexion
 - C7-Tricep-extend elbow, flexor carpi radialis-wrist flexion
 - C8-extension pollicis longus and brevis-thumb extension
 - T1-intrinsics-finger abduction/adduction
- Dermatomes
 - C1-Top of head
 - C2-Temporal & occipital regions of head
 - C3-Neck and posterior cheek
 - C4-Superior shoulder and clavicle

- C5-Deltoid patch & lateral arm
- C6-Lateral forearm, thumb and index finger
- C7-Posterior lateral forearm & middle finger
- C8-Medial forearm, ulna border & ring/little fingers
- T1-Medial side of forearm & upper arm
- Reflexes: C6-bicep reflex, C5-6-brachioradialis reflex, C7-8-triceps reflex

Special tests

- Compression
 - In flexion-bias for vertebral disk
 - In extension-bias for facet cartilage/entrapment
 - In slight flexion and side bending-bias for uncovertebral joints
- Vertebral Artery test-maximally rotate and extend head and hold for 20 seconds. Looking for nystagmus, dizziness, visual disturbances, headache, memory loss, runny nose
- Babinski Test
- Thoracic outlet tests
 - Adson Test
 - Scalene Relief test
 - Costoclavicular test
 - Pecotrals Minor test
 - Smiths test
 - Wright's Hyperabduction test
- Test Cluster for Radiating pain
 - Spurlings Test
 - Distraction test
 - ULTT A
 - Cervical rotation less than 60 degrees
 - If 4/4 are positive then Sn=.24 and Sp=.99
- Upper Cervical Ligamentous tests
 - Sharp Purser test-assess integrity of transverse ligament
 - Anterior glide of C2-tests for odontoid Fx
 - Alar Ligament test-assess integrity of alar ligament
- Special Testing for Cervical muscle endurance
 - Neck flexor endurance test
 - 24 seconds is normal for people with neck pain
 - Cranial cervical flexion test
 - Increase pressure from 26mmhg to 30 mmhg and hold 10 seconds

Specific Joint mobility tests

- May have to do all areas or just specific areas. Can do in both weight bearing and non weight bearing
- Cervicothoracic C6-T3: Flexion, extension, SB, and rotation
- Mid Cervical C2-6: flexion, extension, SB and Rotation
- Upper cervical-OA: Flexion, extension and SB
- Upper cervical-AA: Rotation
 - Refer to manual therapy section for appropriate performance of each

Remember to R/O TMD and other scalp/vestibular dysfunctions

SFMA Breakouts for Cervical Patterns:

| Cervical Flexion |
|---|
| Active Supine Cervical Flexion Test <ul style="list-style-type: none">- FN = Postural SMCD; consider c-s, t-s, shoulder |
| Passive Supine Cervical Flexion test <ul style="list-style-type: none">- FN = Active Cervical Flexion SMCD |
| Active Supine OA Cervical Flexion Test (20°) <ul style="list-style-type: none">- FN Bilateral = if PSCF is DN/DP then CF JMD/TED; if PSCF was FP, could also be SMCD (assess)- DN = OA Flexion JMD/TED possible cervical flexion JMD/TED |
| Possible cervical, thoracic and/or shoulder girdle SMCD effecting cervical flexion |

| Cervical Extension |
|---|
| Passive cervical extension (face perpendicular to the ground) |

| Cervical Rotation |
|--|
| Active Supine Cervical Rotation (80 degrees) <ul style="list-style-type: none">- FN: Postural SMCD; consider c-s, t-s, shoulder |
| Passive Supine Cervical Rotation <ul style="list-style-type: none">- FN: Active cervical rotation SMCD |
| C1-2 Rotation Test <ul style="list-style-type: none">- FN: if PSCR was DP = lower cervical JMD/TED- FN: If PSCR was FP = also could be cervical SMCD- DN: C1-2 JMD/TED and/or lower cervical JMD/TED |
| Possible cervical, thoracic and/or shoulder girdle SMCD effecting cervical flexion |

RESET THE SYSTEM

| Possible JMD/TED's from Cervical Flexion Breakout |
|--|
| General: A) Upper Cervical Flexion B) Lower Cervical Flexion |
| Specific Tissues: A) C1-2, sub occipitals, upper trap, multifidus B) C2-T1, upper trap, rhomboids, multifidus, levator scapula |

Cervical Spine Mobilizations

Occiput-Atlas (OA) (Biconvex on Concave)

- Distraction & Flexion



Stabilizing hand fixates on lateral aspect of transverse processes of C1 with thumb and index finger. Other hand holds patient's occiput as clinician's anterior shoulder rests on patient's forehead. Press down while rocking cranium upwards and keeping C1 fixated.

Atlanto-Axial (AA) (Biconvex on Biconvex)

- Flexion & Rotation (No sidebending)



Notice the change in hand and elbow direction for mobilization into rotation. Stabilizing hand thumb and index finger fixate the transverse processes of C2 to keep it from following C1 and occipital condyles. Use shoulder for leverage. Rotation occurs with axis through the patient's spinal cord.

Mid-Cervical Spine (C3-5)

- Side Glides (Various Positions)

Lower-Cervical Spine

- Seated Rotation



Make sure patient is sitting up straight and supported. Block segment below with lower arm. Hands should be as close together as possible. Can also use the patient's multifidi to extract impinged meniscoid from the facet by having them push INTO you during the mobilization.

Considerations:

- Mechanoreceptor= type I
- Mobilizing position= supine for upper, mid- c/s; seated for lower c/s, CT junction
- Hand placement= block with one hand on appropriate segment, designate a mobilizing hand
- Blocking: with sidebending block same side, with rotation block opposite side
- Coupling Motions in c/s
- Regional interdependence- make sure you look at the thoracic spine and mobilize/ manipulate accordingly

Arthrokinematics of the Cervical Spine to Consider:

- C5-6 has the most rotation; find C2 first to make sure you are on right segment

Manual Techniques to Reset Cervical Flexion Breakout:

| Purpose | Technique | Set Up | Direction of Force |
|---|-------------------------------------|---|---|
| Resolve upper cervical C1-2 flexion JMD | Upper cervical flexion mobilization | Pt in supine, therapists hand on occipital protuberance and blocking @ C2 | Superior with slight anterior tilt of the cranium on C2 |
| Resolve upper cervical flexion TED | Sub occipital release, UT ISTM, STM | Pt in supine | Dragging tips of fingers superiorly from C2/3 to base of cranium; various soft tissue techniques for UT |
| Resolve lower cervical flexion JMD | CT manipulation | Pt in sitting with hands behind head, therapist interweaves hands in patient's arms from behind | Patient inhales, on the exhale, 'scoop' and give a posterior-superior thrust |
| Resolve cervical flexion SCMD | MSF corrective | Pt in supine | With cook band or manual assistance, patient 'curls' up off the table/floor with an emphasis on "one segment at a time" |

Manual Techniques to Reset Cervical Extension Breakout:

| Purpose | Technique | Set Up | Direction of Force |
|-------------------------------|--|-------------------|---|
| Resolve TED of OA restriction | 1. Suboccipital release 2. STM/IASTM SCM and scalenes | Supine | 1. Distraction 2. In the direction of fibers or across fibers with rotation or sidebending |
| Resolve JMD of OA restriction | OA mobilizations | Supine | Distraction with AP mob to forehead |
| Resolve TED of C2-7 | STM/IASTM UT, SCM, cervical paraspinals | Supine or Prone | In the direction of fibers or across fibers |
| Resolve JMD of C2-7 | Anterior glide or upglide | Supine or Prone | PA or up and forward |
| Resolve TED of thoracic spine | STM to anterior limiting tissues | Supine | Various techniques |
| Resolve JMD of thoracic spine | Extension mobilization/manipulation | Prone | AP mobs |
| Resolve JMD of first rib | Anterior/medial mobilization/manipulation | Supine or sitting | Anterior/Medial glide |

Manual Techniques to Reset Cervical Rotation Breakout:

| Purpose | Technique | Set Up | Direction of Force |
|--------------------------------------|---|---|--|
| Resolve C1-2 cervical rotation JMD | Upper cervical rotation mobilization | Pt in supine, PT blocking C2 with other hand on occiput | With hand on occiput, therapist directs force on cranium in opposite direction of limited rotation |
| Resolve C2-T1 rotation JMD | Lower cervical UPA | Pt in supine, PT uses index finger to assess any lack of mobility throughout C2-7 w/ UPA; can lock out segment with extension, opposite rotation and side bending | Superior, medial and posterior; almost in the direction of the therapist's opposite shoulder |
| Resolve lower cervical JMD C7-T1 | Prone CT rotational manipulation | Pt in prone, therapist standing to the side of patient, take up the slack in the opposite UT | Use the thumb of the hand on the UT to direct force on T1 spinous process toward PT, have patient turn head toward therapist and gently direct a force in an superolateral direction at the occiput while maintaining a medial force with the thumb of the opposite hand |
| Resolve upper and lower cervical TED | STM / ISTM to sub occipitals, SCM, UT | Pt in supine or prone | Various techniques |
| Resolve cervical rotation TED / SMCD | PNF contract-relax and end range of cervical rotation | Pt in supine | Rotate head towards limited side, contract in opp. direction |

REINFORCE THE CORRECTION

Patient Education:

- Activity modification- ADLs/ ANLs
- Driving
- Sleeping positions/ hygiene
- Breathing
- Postural education
- Lifting mechanics
- TMJ positioning/ posture
- Nutrition and hydration
- **Stress management**
 - Increasing activity level through light exercise
 - Finding activities that patient can enjoy to decrease stress levels
 - Meditation / prayer

Suboccipital Release: put 2 tennis balls in a sock and place at the base of the skull. Practice diaphragmatic breathing and relax on sock for 5 minutes in a dark room.

Stretching: Levator scapulae, upper trapezius, suboccipitals.

Foam Rolling: thoracic extension over foam roller, thoracic spine paraspinal rolling

Functional Taping:

For Example- Kinesiotaping for Mechanical Neck Pain

- Can utilize kinesiotaping for mechanical neck pain by attaching base at C1-T2 without tension; having patient look down and away from side you are taping with paper off tension; have patient look down and apply web cut across two tails with 25% tension in middle of tape and tension free tails at C3-6

Reinforcement Techniques for Cervical Rotation Breakout:

| Purpose | Technique | Set Up or Directions |
|---|---|---|
| Reinforce upper cervical rotation | Supine cervical rotation w/ chin tuck | Direct patient to try to keep position of head while turning, aim to have chin finish over collarbone |
| Reinforce UT stretch | Active rotation w/ chin tuck at end range | Pt in sitting with hand of affected side under a chair, rotate the head away from the affected side until you are as far as possible then tuck chin to collarbone |
| Reinforce cervical rotation for SCMD | Cervical rotation with ABD or scapular retraction | Pt in supine or sitting, perform chin tuck with horizontal ABD and cervical rotation Supine scapular packing w/ KB or band |
| Reinforce cervical flexion/extension/rotation | UE rolling | Pt from supine to prone and prone to supine rolls upper body with use of single UE and cervical spine |

Reinforcement Techniques for Cervical Flexion Breakout:

| Purpose | Technique | Set Up or Directions |
|----------------------------------|--------------------------------------|---|
| Reinforce upper cervical flexion | Deep cervical neck flexor training | Supine chin tucks; ask the patient to make a double chin and then press the back of their head into the pillow/table |
| Reinforce lower cervical flexion | Quadruped segmental cat-camel | In quadruped, ask the patient to perform a segmental cat-camel with an emphasis at driving flexion and extension through CT junction while taking chin to chest |
| Reinforce cervical flexion TED | Seated cervical rotation and flexion | Ask the patient to sit in a chair with one hand placed under the chair, ask them to turn their head as far as they can away from the hand that is holding onto the chair and then try to touch their chin to their collarbone |
| Reinforce cervical flexion SMCD | UE rolling | Using only a single UE, patient rolls from supine <> prone |

Reinforcement Techniques for Cervical Extension Breakout:

| Purpose | Technique | Set Up or Directions |
|---------------------------------------|---|--|
| Increase OA mobility | OA self mobs with fist | Sitting position; fist under chin; push chin into fist; hold 3 seconds for 10 reps |
| Decrease suboccipital muscle guarding | Tennis ball self STM | Place tennis balls at occiput in supine |
| Improve first rib mobility | Self first rib mobilization with towel | |
| Improve thoracic spine mobility | 1) Foam rolling 2) Seated extension over chair | Supine with foam roll under thoracic spine and rolling up and down foam roll Seated with back of chair at thoracic spine and lean backwards |

RELOAD THE SOFTWARE

Once mobility is established at the dysfunctional joint, treat as a SMCD and reload the system so that the patient can utilize their new mobility in a functional manner.

| <i>Corrective Matrix Cervical Flexion</i> | | | | |
|--|--|---|--|---|
| <i>Posture</i> | Standing | Multi-segmental flexion @ wall with Cook band | Chin tuck @ wall | Resisted chin tuck |
| | Stacked Spine (Kneeling) | Tall kneeling or half kneeling cervical flexion with Cook band pull down | Tall kneeling chin tuck with KB hold | Half kneeling resisted chin tuck |
| | Suspended Spine (Quadruped) | Cervical flexion with Cook band behind patient | Quadruped chin tuck | Resisted chin tuck |
| | Supported Spine (Supine/Prone) | Multi-segmental flexion supine <> long sitting with Cook band | Supine deep cervical neck flexor training | Prone chin tuck with head hanging off table |
| | | Facilitate (Expresses Mobility) | Demonstrates (Expresses Competency) | Challenges (Expresses Motor Control) |
| <i>Corrective Matrix for cervical extension mobility</i> | | | | |
| <i>Posture</i> | Standing | Head back against ball on the wall – theraband external rotation of UEs then isometric into ball for cervical extension | Isometric cervical extension into ball on the wall | Band around back of head, chin tuck, and cervical extension |
| | Stacked Spine (Kneeling) | Kneeling band external rotation with UEs then cervical extension | Kneeling – towel around neck then extending back (can add rotation and SB) | Kneeling Theraband around back of head and extending |
| | Suspended Spine (Quadruped) | Quadruped band pull apart with cervical extension | Quadruped cervical extension | Quadruped cervical extension with band for resistance |
| | Supported Spine (Supine/Prone) | Upper body extension rolling – pattern assistance | Upper body extension rolling | Resisted upper body extension rolling |
| | | Facilitate (Expresses Mobility) | Demonstrates (Expresses Competency) | Challenges (Expresses Motor Control) |

| <i>Corrective Matrix for Cervical Rotation</i> | | | | |
|--|--|--|--|---|
| <i>Posture</i> | Standing | Standing cervical rotation w/ shoulder extension | Standing rotation | Cervical rotation with inverted KB hold or farmer's carry |
| | Stacked Spine (Kneeling) | Tall kneeling rotation w/ KB holds and end range breathing | Tall kneeling rotation | Cervical rotation w/ inverted KB hold |
| | Suspended Spine (Quadruped) | Quadruped cervical rotation with cook band | Quadruped cervical rotation | Resisted cervical rotation |
| | Supported Spine (Supine/Prone) | UE rolling w/ facilitation through cook band | UE rolling | Resisted cervical rotation |
| | | Facilitate (Expresses Mobility) | Demonstrates (Expresses Competency) | Challenges (Expresses Motor Control) |

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The Working Mechanism of Manual Therapy in Participants With Chronic Tension-Type Headache

Chronic tension-type headache (CTTH) is associated with cervical spine impairments, including restricted range of motion (ROM) of the cervical spine, reduced neck flexor endurance, and greater forward head posture.^{13,15,17,27,30} These associations

have led to the development of a biomechanical model for CTTH. According to this conceptual model, cervical dysfunction elicits headache through peripheral or central pain mechanisms; therefore, improvement of cervical dysfunction by physical treatment should reduce headache.^{5,18,19}

Based on this model, we conducted a randomized clinical trial (RCT) to determine the effectiveness of multimodal manual therapy, including mobilization of the cervical spine, isometric training of neck flexors, and posture correction. A reduction in headache days of 50% or greater was the

clinically relevant outcome.² A significant difference of 87.5% versus 27.5% in outcome was found in favor of manual therapy, compared to usual care by the general practitioner, in participants with CTTH.⁸

The extent to which specific elements (mobilization, isometric training of neck flexors, or posture correction) contribute to the effectiveness of manual therapy is unknown, and information about the working mechanisms of manual therapy in participants with headache is urgently needed.^{5,19} The biomechanical model mentioned above suggests that increased ROM of the cervical spine, increased neck flexor endurance, and a less pronounced forward head posture may offer potential explanations for the effect of manual therapy in reducing headache frequency. To explore the working mechanism of manual therapy, we investigated whether the above aspects of cervical spine function (cervical ROM, neck flexor endurance, and forward head posture) were mediators of the effect of manual therapy on headache frequency.

METHODS

Participants

FOR THE MEDIATION ANALYSES, WE used the combined data obtained from 2 studies, a multicenter, prag-

- **STUDY DESIGN:** Prospective longitudinal study.
- **OBJECTIVE:** To explore the working mechanism of manual therapy, we investigated whether 3 cervical spine variables were mediators of the effect of manual therapy on headache frequency.
- **BACKGROUND:** Manual therapy has been shown to reduce headache frequency in participants with chronic tension-type headache (CTTH). To what extent specific elements of treatment contribute to the effectiveness of manual therapy in CTTH is unknown.
- **METHODS:** One hundred eighty-two participants with CTTH participated in a prospective longitudinal study: 142 underwent manual therapy and 40 participants received usual care by their general practitioner. Regression analysis was performed according to the steps described by Baron and Kenny, and the proportion of mediated effect

was estimated for 3 potential mediators: (1) cervical range of motion, (2) neck flexor endurance, and (3) forward head posture. Outcome was defined as a 50% or greater reduction in headache days.

● **RESULTS:** Neck flexor endurance mediated 24.5% of the effect of manual therapy. Cervical range of motion and forward head posture showed no mediated effect.

● **CONCLUSION:** Increased neck flexor endurance appears to be a working mechanism of manual therapy. This finding supports isometric training of neck flexors in participants with CTTH. Trial registered with Netherlands Trial Register (TR 1074). *J Orthop Sports Phys Ther* 2013;43(10):693-699. Epub 9 September 2013. doi:10.2519/jospt.2013.4868

● **KEY WORDS:** chronic tension-type headache, manual therapy, working mechanism

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matic RCT (Netherlands Trial Register, TR 1074) and a parallel multicenter prospective cohort study of participants with CTTH who were recruited from 14 general practices in an urban area near Amsterdam, the Netherlands.⁸ From the pragmatic RCT, 82 participants were randomized either to a manual therapy group ($n = 41$) or to a control group ($n = 41$) that received usual care from a general practitioner. One hundred four participants who refused randomization because of a preference for manual therapy were entered into the cohort study. Participants in the cohort study fulfilled the same inclusion and exclusion criteria and received identical measurements and manual therapy as participants in the RCT.

To be included in the study, participants had to be between 18 and 65 years of age and to fulfill the criteria for CTTH according to the classification of headaches of the International Headache Society,²¹ which defines CTTH as headache occurring at least 15 days per month, on average, for a period of more than 3 months and lasting hours or being continuous in duration. Additionally, the headache had to have at least 1 of the following characteristics: (1) bilateral location, (2) pressing/tightening (nonpulsating) quality, (3) mild or moderate intensity not aggravated by normal physical activity such as walking or climbing stairs, and (4) only 1 of photophobia, phonophobia, or mild nausea, without moderate or severe nausea or vomiting.

Exclusion criteria were rheumatoid arthritis, suspected malignancy or brain tumor, and pregnancy. According to the International Headache Society classification²¹ of headache attributed to medication overuse, we excluded participants with an intake of triptans, ergotamines, or opioids on 10 or more days per month or of simple analgesics on 15 or more days per month on a regular basis for at least 3 months.² Participants were also excluded if they had received manual therapy in the 2 months before the study or were not able to read and write Dutch.

The selection and informed-consent procedures, baseline and follow-up mea-

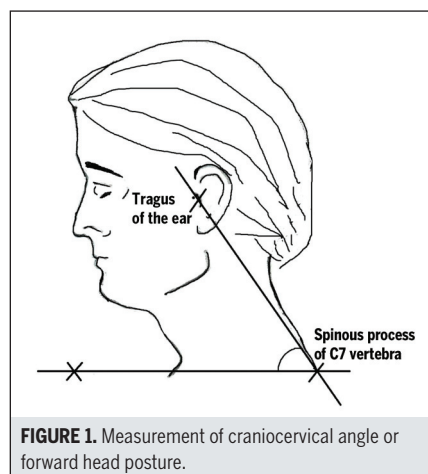


FIGURE 1. Measurement of craniocervical angle or forward head posture.

surements, and intervention protocol of this study have been previously published.⁷ The study protocol was approved by the Medical Ethics Committee of the VU University Medical Center in Amsterdam, the Netherlands.

Examination

Baseline measurements included a standardized history of headache, general health, a physical examination carried out by an independent research assistant, and several participant self-report measures. Expectations regarding treatment outcome were measured on a Likert scale ranging from 0 (no result) to 7 (good result).

Outcome Measures

As described by Andrasik et al,² we defined a 50% or greater reduction in headache days as the clinically relevant outcome (yes, 1; no, 0). To measure frequency of headache days, participants kept a headache diary to report their headaches during 2-week periods before the baseline and follow-up measurements. A 2-week period is sufficient to assess tension-type headache and is recommended for outcome measurement in headache research.^{2,6}

Potential Mediators

Cervical ROM was measured with the CROM device (Performance Attainment Associates, Lindstrom, MN) in degrees.

The active ROM in all directions (flexion, extension, right and left rotation, and right and left lateroflexion) was examined with the participant in a seated position. The intratester and intertester reliability of this measure have been shown to be good, with intraclass correlation coefficients (ICCs) of greater than 0.80.¹¹

Neck flexor endurance was assessed as the isometric strength of the neck flexors and scored as the number of seconds the patient could hold his or her head away from the table when lying on his or her back. This procedure has been described by Harris and colleagues,²⁰ and 2 studies have reported good to excellent intratester reliability of this test (ICC = 0.82-0.93).^{12,20}

Forward head posture was defined as the craniocervical angle between the horizontal line passing through C7 and the line extending from C7 to the tragus of the ear. This angle was measured using a lateral digital photograph with a digital camera (R707.5; Hewlett-Packard Company, Palo Alto, CA). The photograph was taken with the participant in a seated position. A smaller craniocervical angle indicates a greater forward head posture (FIGURE 1). The reliability of photographic measurement of the craniocervical angle is good (ICC>0.86).²⁹

Interventions

Manual therapy was applied by 4 manual therapists, who were trained in the treatment protocol in 2 two-hour sessions and received the treatment manual and patient booklets with home exercises. The manual therapists had an average of 10 years of experience, had worked at 3 different locations, and were members of the national association of manual therapists. Manual therapy was restricted to a maximum of 9 sessions (30 minutes each) during a period of 8 weeks, and had 3 goals.

The first goal was mobilization of the cervical and upper thoracic spine in all directions. The therapeutic procedures for these mobilizations consisted of low- and/or high-velocity mobilization and

home exercises. All mobilizations started with active mobilization (hands-off techniques), and, if necessary, the manual therapist proceeded with passive mobilizations (hands-on techniques). In addition to mobilization techniques, soft tissue techniques (muscle stretching and deep muscle frictions) could be used to reduce cervical muscular tension and pain.

The second goal was to train the neck flexor muscles in isometric strength. This training consisted of low-load neck flexor exercises, as described by Jull,²² using a stabilizer. In case a stabilizer was not available, the participants were instructed to pull their chin in (atlanto-occipital cervical flexion) and to hold this position (isometric contraction) for 10 to 20 seconds, while lying on their back in a horizontal position. These isometric exercises were also instructed in combination with retraction of the cervical spine in a sitting position. Participants were asked to perform these exercises at least twice a day.

The third goal of treatment was postural correction of the head and the cervical and thoracic spines. In an upright sitting position, the manual therapist instructed the participant to straighten the thoracic spine with a simultaneous retraction of the cervical spine. Neck flexor exercises were incorporated in all exercises of postural correction in sitting and standing positions. The manual therapists underlined the importance of this posture correction.

Depending on the participant's condition and outcomes, the manual therapist decided at each session which type of mobilizations or exercises to select for the treatment protocol. Besides posture correction exercises, participants were given advice about their workplace, especially those who performed sedentary work for at least several hours a day. Every participant received a booklet with a full description of all home exercises and written instructions by the manual therapist on type, frequency, and duration of the exercises. The participants were instructed by their manual therapist to

continue their exercises after their treatment period, focusing on retraction of the cervical spine and posture correction.

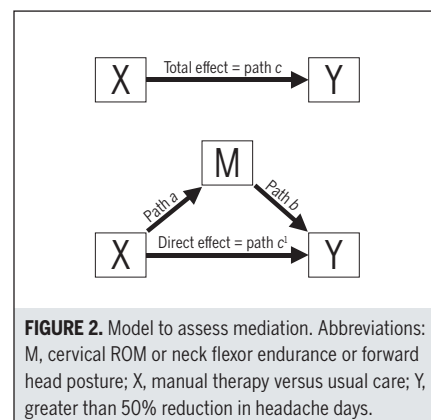
Participants in the control group were provided with usual care by their general practitioners. In 1 meeting, the general practitioners were informed to follow their national clinical guideline for the management of headache.²³ According to this guideline, the general practitioners provided information, reassurance, and advice, and discussed the benefits of lifestyle changes. If necessary, the general practitioners prescribed or changed analgesics or nonsteroidal anti-inflammatory drugs.

Statistical Analysis

Descriptive analysis was used to describe and compare the characteristics of participants of the trial and cohort study. Change was assessed as the change in score from baseline to the 8-week follow-up for cervical ROM (the sum of degrees for all directions), neck flexor endurance (seconds), and craniocervical angle (degrees).

FIGURE 2 shows the model used to analyze potential mediation between the independent variable treatment (manual therapy versus usual care), the mediator (cervical ROM or neck flexor endurance or forward head posture), and the dependent variable (50% or greater reduction in headache days).

According to the steps described by Baron and Kenny,⁴ 3 regression analyses were conducted. First, a logistic regression was performed to estimate the effect of manual therapy on outcome, with a 50% or greater reduction in headache days as the dependent variable, so that manual therapy had to be significantly related to a 50% or greater reduction in headache days (total effect, path *c*). Second, linear regression to estimate the effect of manual therapy on the mediator: manual therapy must be significantly related to the mediator (path *a*). Third, a logistic regression to regress the dependent variable on both the mediator and the independent variable was performed,



so that the mediator had to be significantly related to a 50% or greater reduction in headache days (path *b*). In this logistic regression, the direct effect (path *c'*) of manual therapy (manual therapy in the same model as the mediator) on the outcome (50% or greater reduction in headache days) had to be smaller than the total effect (path *c*).

The mediation effect was estimated by the product-of-coefficients method (path *a* times path *b*), and related confidence intervals (CIs) were calculated using bootstrapping techniques (2000 samples).²⁵ On the basis of the standardized coefficients, we also assessed the proportion of mediated effect: $(c - c')/c \times 100\%$. Analyses were done using SPSS (SPSS Inc, Chicago, IL) and Stata (StataCorp LP, College Station, TX) software.

RESULTS

BETWEEN JUNE 2007 AND MARCH 2009, a total of 204 participants were recruited, and follow-up measurements were completed in September 2009. **FIGURE 3** summarizes recruitment and retention of participants throughout the study. For all included participants (*n* = 186), the baseline characteristics are described in **TABLE 1**. Baseline characteristics, as well as expectations of treatment outcome, were similar between participants of the cohort study and the RCT. **TABLE 2** includes a description of the mean scores at baseline and 8-week follow-up and the change scores at 8 weeks of the

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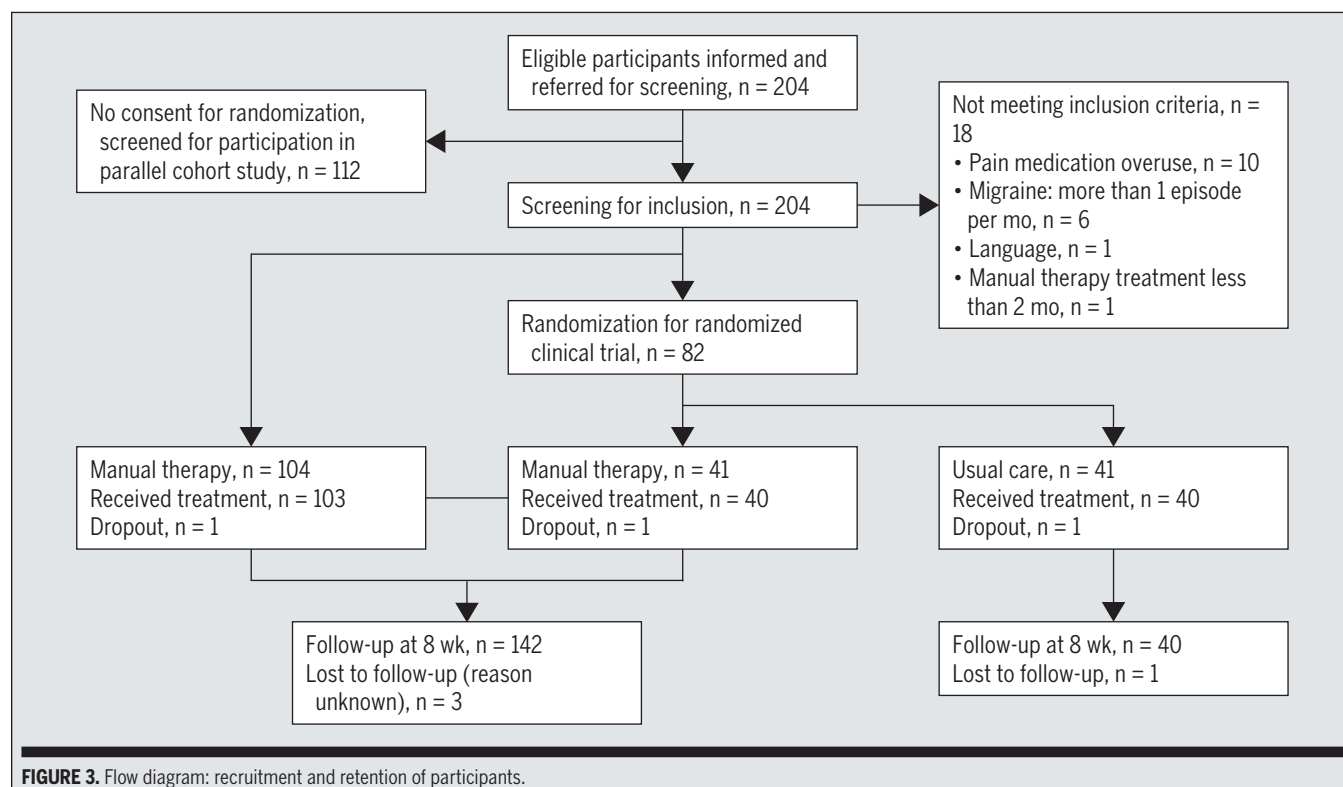


FIGURE 3. Flow diagram: recruitment and retention of participants.

TABLE 1

MANUAL THERAPY AND USUAL CARE PARTICIPANTS AT BASELINE REGARDING HEADACHE CHARACTERISTICS*

| | Manual Therapy (n = 145) | Usual Care (n = 41) |
|--|--------------------------|---------------------|
| Age, y ⁱ | 38.7 ± 11.6 (18-64) | 40.6 ± 11.3 (20-63) |
| Gender (male), % | 19 | 22 |
| Headache duration, y | 11.6 ± 11.1 | 13.1 ± 12.4 |
| Headache frequency over 2 wk, d | 11.5 ± 2.7 | 11.6 ± 2.8 |
| Expectation for treatment [‡] | 5.4 ± 1.5 | 5.2 ± 1.4 |

*Values are mean ± SD unless otherwise indicated.

ⁱValues in parentheses are range.

[‡]Likert scale (0 is no result, 7 is good result).

potential mediators (cervical ROM, neck flexor endurance, and forward head posture), as well as the results for the primary outcome measure (reduction in headache frequency) at 8-week follow-up. Data from 182 participants were available for mediation analysis. The results of the regression analyses are displayed in TABLE 3.

The analysis concerning cervical ROM as a potential mediator showed a significant total effect (path *c*) of manual therapy ($P < .05$) compared to usual care

on 50% or greater reduction in headache days. Manual therapy was also significantly related to change in cervical ROM (path *a*). Change in cervical ROM was not significantly related to a 50% or greater reduction in headache days (path *b*) (0.00; 95% CI: -0.01, 0.01). The direct effect (path *c'*) was not smaller than the total effect (path *c*) (odds ratio [OR] = 15.3; 95% CI: 6.3, 37.3 versus OR = 15.1; 95% CI: 6.5, 43.8). The results after bootstrapping showed that the mediated effect

was not significant and that the proportion of mediated effect was very small.

Concerning neck flexor endurance as a potential mediator, manual therapy was significantly related to change of this variable (path *a*) in the next regression analyses. Neck flexor endurance was also significantly related to a 50% or greater reduction in headache days (path *b*) (0.05; 95% CI: 0.02, 0.08). The direct effect of manual therapy on a 50% or greater reduction in headache days (OR = 9.5; 95% CI: 4.3, 25.8) was smaller than the total effect (OR = 15.1; 95% CI: 6.5, 35.9). The mediated effect after bootstrapping was significant (0.13; 95% CI: 0.06, 0.19). The proportion of mediated effect was 24.5%. In other words, the effect of manual therapy on a 50% or greater reduction in headache days partly depended on change in neck flexor endurance.

The mediation analysis for forward head posture showed that manual therapy was significantly related to change of this variable (path *a*). Forward head posture showed, however, no significant

relation to a 50% or greater reduction in headache days (path *b*) (0.05; 95% CI: -0.01, 0.11) and a minor reduction in direct effect (OR = 10.4; 95% CI: 4.1, 26.3) versus the total effect (OR = 11.5; 95% CI: 4.6, 28.8) of manual therapy on a 50% or greater reduction in headache days. The mediation effect (0.03; 95% CI: -0.02, 0.08) was not significant, and the proportion of mediated effect was small.

DISCUSSION

Main Findings

THIS STUDY WAS DESIGNED TO EXPLORE possible working mechanisms in manual therapy, using preselected potential mediators that reflect the goals of manual therapy. We found that increased neck flexor endurance mediated 24.5% of the effect of manual therapy on the reduction in headache days. Cervical ROM and forward head posture did not mediate the effect of manual therapy.

The present study monitored cervical ROM as an indicator of the effect of spinal mobilization consisting of high- and low-velocity thrust techniques and found no mediation effect of cervical ROM on manual therapy in reducing headache days. This finding further supports systematic reviews that have reported inconsistent and inconclusive effectiveness of physical treatments in tension-type headache aimed at mobilization.^{14,24,26} Considering these results and reported risks of cervical high-velocity thrust mobilization techniques,¹ clinicians should reconsider the use of these techniques in participants with CTTH.

The second goal of treatment was to increase neck flexor endurance with a specific training program. Increased neck flexor endurance mediated the effect of manual therapy on headache frequency. Previously, specific training of neck flexors was shown to be effective in reducing the number of headache days in CTTH.²⁸ Specific training of neck flexors appears to be a promising key element of treatment in participants with CTTH. As

| <div>TABLE 2</div> <div>MANUAL THERAPY AND USUAL CARE PARTICIPANTS: POTENTIAL MEDIATORS AT BASELINE AND 8 WEEKS AND OUTCOME AFTER TREATMENT*</div> | | |
|--|--------------------------|---------------------|
| Potential Mediators | Manual Therapy (n = 145) | Usual Care (n = 41) |
| Cervical range of motion, deg [†] | | |
| Baseline | 343.9 ± 53.7 | 335.9 ± 55.8 |
| 8 wk | 366.5 ± 52.2 | 344.9 ± 53.7 |
| Change after 8 wk | 21.6 ± 30.5 | 2.0 ± 31.4 |
| Neck flexor endurance, s | | |
| Baseline | 30.0 ± 25.3 | 28.9 ± 25.2 |
| 8 wk | 47.7 ± 24.8 | 30.4 ± 25.4 |
| Change after 8 wk | 17.3 ± 19.8 | 3.0 ± 17.3 |
| Forward head posture (craniocervical angle), deg | | |
| Baseline | 47.3 ± 7.5 | 44.8 ± 7.1 |
| 8 wk | 50.4 ± 8.0 | 47.0 ± 7.5 |
| Change after 8 wk | 3.3 ± 7.0 | 0.4 ± 6.7 |
| Primary outcome measure at 8 wk | | |
| Participants with a 50% or greater reduction in frequency of headache days, % | 85 | 28 |
| *Values are mean ± SD unless otherwise indicated. | | |
| †Total sum of all movements. | | |

the results of previous studies^{13,15,17,27,30} indicate that forward head position and decreased neck flexor endurance are associated with CTTH, we hypothesized that improvement of endurance of the neck flexors would contribute to maintaining an upright position of the cervical spine and to supporting the muscular stabilization of the upper cervical segments in this position. An explanation of why this mechanical approach may lead to a reduction of headache frequency may be found in the role of local muscle tenderness and peripheral and central sensitization in the pathogenesis of CTTH.⁵ Prolonged tenderness and trigger points in the suboccipital muscles are assumed to (1) increase myofascial pain sensitivity (peripheral sensitization) and (2) produce a continuous afferent input into the dorsal horn of the trigeminal nerve nucleus caudalis, sensitizing the central nervous system (central sensitization).^{3,5,9,19}

By increasing muscular stabilization of the cervical spine through training of neck flexor endurance, we intended to normalize afferent information from the upper cervical structures to the dor-

sal horn of the trigeminal nerve nucleus caudalis. In addition, neck flexor exercises can diminish tension and trigger points in the suboccipital muscles¹⁰ by stretching the suboccipital muscles during these exercises and thereby reducing peripheral and central sensitization. Our study, however, was not designed to directly identify which underlying neurophysiological mechanism could explain the effect of neck flexor endurance on reduction in headache days. Therefore, in future research, trigger points or algometry in the cephalic and extracephalic regions should be investigated as treatment mediators of the effect of exercise. Meanwhile, based on our findings, we recommend endurance training of neck flexors in the treatment of patients with CTTH.

The third goal of treatment was to decrease forward head posture by posture correction in sitting and standing positions. The correlation between increased forward head posture and chronic headache is frequently reported in the literature,^{13,15,17,27,30} indicating that forward head posture may be a potential mediator of manual therapy. However, a

TABLE 3

MEDIATION ANALYSIS: RESULTS OF LOGISTIC AND LINEAR REGRESSION ANALYSIS

| Mediator/Path, Regression Model | Dependent Variable | Independent Variable | Regression Coefficient* | Odds Ratio* | Mediated Effect*† | Proportion of Mediated Effect, % |
|----------------------------------|---------------------------------|--------------------------|-------------------------|------------------|----------------------|----------------------------------|
| Cervical ROM (n = 178)‡ | | | | | | |
| Path c, logistic | ≥50% reduction in headache days | MT versus UC | 2.72 (1.86, 3.75)§ | 15.1 (6.5, 43.8) | | |
| Path a, linear | Cervical ROM | MT versus UC | 19.31 (8.17, 30.45)§ | | | |
| Path b, logistic | ≥50% reduction in headache days | 1. Cervical ROM | 0.00 (-0.01, 0.01) | | -0.001 (-0.05, 0.05) | -0.33 |
| Path c', logistic | | 2. MT versus UC | 2.73 (1.84, 3.62)§ | 15.3 (6.3, 37.3) | | |
| Neck flexor endurance (n = 178)‡ | | | | | | |
| Path c, logistic | ≥50% reduction in headache days | MT versus UC | 2.73 (1.87, 3.58)§ | 15.1 (6.5, 35.9) | | |
| Path a, linear | Neck flexor endurance | MT versus UC | 14.49 (7.5, 21.49)§ | | | |
| Path b, logistic | ≥50% reduction in headache days | 1. Neck flexor endurance | 0.05 (0.02, 0.08)§ | | 0.13 (0.06, 0.19) | 24.5 |
| Path c', logistic | | 2. MT versus UC | 2.36 (1.45, 3.27)§ | 9.5 (4.3, 25.8) | | |
| Forward head posture (n = 143)‡ | | | | | | |
| Path c, logistic | ≥50% reduction in headache days | MT versus UC | 2.44 (1.52, 3.36)§ | 11.5 (4.6, 28.8) | | |
| Path a, linear | Forward head posture | MT versus UC | 3.24 (0.46, 6.02)§ | | | |
| Path b, logistic | ≥50% reduction in headache days | 1. Forward head posture | 0.05 (-0.01, 0.11) | | 0.03 (-0.02, 0.08) | 6.57 |
| Path c', logistic | | 2. MT versus UC | 2.34 (1.41, 3.27)§ | 10.4 (4.1, 26.3) | | |

Abbreviations: MT, manual therapy; ROM, range of motion; UC, usual care.

*Values in parentheses are 95% confidence intervals.

†Based on standardized coefficients.

‡Follow-up assessments not available for 8 participants (cervical ROM and neck flexor endurance) and for 43 participants (forward head posture).

§P < .05.

||The mediated effect was negative due to a positive effect of MT on cervical ROM and a negative effect of cervical ROM on a 50% or greater reduction in headache days.

decrease of forward head posture showed no significant mediated effect on manual therapy. These results do not support posture correction as an element of manual therapy in participants with CTTH. Our findings correspond to a previous noncontrolled study on 25 participants with CTTH receiving physical therapy, in which no relationship was found between neck mobility or forward head posture and frequency of headache.¹⁶

Study Limitations

To the best of our knowledge, this is the first study to investigate working mechanisms of the effectiveness of manual therapy in headache using mediation analysis. However, the sample size of the usual care group was small, which limited the statistical power of our analysis. Because of this limitation and to adjust

for overoptimism of the mediated effect, bootstrapping was performed. Furthermore, combining data from participants of a cohort and an RCT might have introduced a risk of bias, as cohort participants might have a stronger preference for manual therapy. We therefore compared patient characteristics and expectations regarding treatment outcome at baseline, which were very similar between both groups.

As our analyses could only partly explain the effect of manual therapy, other potential mediators, such as the presence of trigger points and pain sensitivity (see above) or time spent on treatment, could be evaluated as potential mediating variables. In our study, the time spent on treatment differed between the intervention groups due to a larger number of sessions (a mean of 6 versus 2 sessions)

and sessions of longer duration (30 versus 10 minutes) with manual therapy compared to usual general practitioner care. To evaluate the mediating effect of time spent on treatment, treatment protocols with identical mobilization or exercise regimes but differences in the duration or number of sessions should be investigated.

CONCLUSION

INCREASED NECK FLEXOR ENDURANCE appears to explain part of the working mechanism of manual therapy in participants with CTTH. The effect of manual therapy was not mediated by cervical ROM or forward head posture. We recommend isometric training of neck flexors in physical treatment of participants with CTTH. ●

KEY POINTS

FINDINGS: In a multimodule manual therapy treatment for participants with CTTH, neck flexor endurance contributed 25% to the total treatment effect of reducing the frequency of headache. Cervical ROM and forward head posture did not influence the total effect of manual therapy.

IMPLICATIONS: Because the increase of neck flexor endurance is related to a decrease of headache frequency, isometric training of neck flexors is strongly advised to be part of physical treatment for participants with CTTH.

CAUTION: The mediation analysis was restricted to participants with CTTH; therefore, the results cannot be generalized to other forms of headache.

REFERENCES

1. Albuquerque FC, Hu YC, Dashti SR, et al. Craniocervical arterial dissections as sequelae of chiropractic manipulation: patterns of injury and management. *J Neurosurg*. 2011;115:1197-1205. <http://dx.doi.org/10.3171/2011.8.JNS111212>
2. Andrasik F, Lipchik GL, McCrory DC, Witrock DA. Outcome measurement in behavioral headache research: headache parameters and psychosocial outcomes. *Headache*. 2005;45:429-437. <http://dx.doi.org/10.1111/j.1526-4610.2005.05094.x>
3. Ashina M, Bendtsen L, Jensen R, Sakai F, Olesen J. Muscle hardness in patients with chronic tension-type headache: relation to actual headache state. *Pain*. 1999;79:201-205.
4. Baron RM, Kenny DA. The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *J Pers Soc Psychol*. 1986;51:1173-1182.
5. Bendtsen L, Fernández-de-la-Peñas C. The role of muscles in tension-type headache. *Curr Pain Headache Rep*. 2011;15:451-458. <http://dx.doi.org/10.1007/s11916-011-0216-0>
6. Blanchard EB, Hillhouse J, Appelbaum KA, Jacard J. What is an adequate length of baseline in research and clinical practice with chronic headache? *Biofeedback Self Regul*. 1987;12:323-329.
7. Castien RF, van der Windt DA, Dekker J, Mutsaers B, Grooten A. Effectiveness of manual therapy compared to usual care by the general practitioner for chronic tension-type headache: design of a randomised clinical trial. *BMC Musculoskelet Disord*. 2009;10:21. <http://dx.doi.org/10.1186/1471-2474-10-21>

8. Castien RF, van der Windt DA, Grooten A, Dekker J. Effectiveness of manual therapy for chronic tension-type headache: a pragmatic, randomised, clinical trial. *Cephalalgia*. 2011;31:133-143. <http://dx.doi.org/10.1177/0333102410377362>
9. Chen Y. Advances in the pathophysiology of tension-type headache: from stress to central sensitization. *Curr Pain Headache Rep*. 2009;13:484-494.
10. Cummings M, Baldry P. Regional myofascial pain: diagnosis and management. *Best Pract Res Clin Rheumatol*. 2007;21:367-387. <http://dx.doi.org/10.1016/j.berh.2006.12.006>
11. de Koning CH, van den Heuvel SP, Staal JB, Smits-Engelsman BC, Hendriks EJ. Clinimetric evaluation of active range of motion measures in patients with non-specific neck pain: a systematic review. *Eur Spine J*. 2008;17:905-921. <http://dx.doi.org/10.1007/s00586-008-0656-3>
12. Edmondston SJ, Wallumrød ME, MacLéid F, Kvamme LS, Joebgas S, Brabham GC. Reliability of isometric muscle endurance tests in subjects with postural neck pain. *J Manipulative Physiol Ther*. 2008;31:348-354. <http://dx.doi.org/10.1016/j.jmpt.2008.04.010>
13. Fernández-de-las-Peñas C, Alonso-Blanco C, Cuadrado ML, Gerwin RD, Pareja JA. Trigger points in the suboccipital muscles and forward head posture in tension-type headache. *Headache*. 2006;46:454-460. <http://dx.doi.org/10.1111/j.1526-4610.2006.00288.x>
14. Fernández-de-las-Peñas C, Alonso-Blanco C, Cuadrado ML, Miangolarra JC, Barriga FJ, Pareja JA. Are manual therapies effective in reducing pain from tension-type headache? A systematic review. *Clin J Pain*. 2006;22:278-285. <http://dx.doi.org/10.1097/01.aip.0000173017.64741.86>
15. Fernández-de-las-Peñas C, Alonso-Blanco C, Cuadrado ML, Pareja JA. Forward head posture and neck mobility in chronic tension-type headache: a blinded, controlled study. *Cephalalgia*. 2006;26:314-319. <http://dx.doi.org/10.1111/j.1468-2982.2005.01042.x>
16. Fernández-de-las-Peñas C, Alonso-Blanco C, Cuadrado ML, Pareja JA. Neck mobility and forward head posture are not related to headache parameters in chronic tension-type headache. *Cephalalgia*. 2007;27:158-164. <http://dx.doi.org/10.1111/j.1468-2982.2006.01247.x>
17. Fernández-de-las-Peñas C, Pérez-de-Heredia M, Molero-Sánchez A, Miangolarra-Page JC. Performance of the craniocervical flexion test, forward head posture, and headache clinical parameters in patients with chronic tension-type headache: a pilot study. *J Orthop Sports Phys Ther*. 2007;37:33-39. <http://dx.doi.org/10.2519/jospt.2007.2401>
18. Fernández-de-las-Peñas C, Schoenen J. Chronic tension-type headache: what is new? *Curr Opin Neurol*. 2009;22:254-261. <http://dx.doi.org/10.1097/WCO.0b013e32832973ce>

19. Fumal A, Schoenen J. Tension-type headache: current research and clinical management. *Lancet Neurol*. 2008;7:70-83. [http://dx.doi.org/10.1016/S1474-4422\(07\)70325-3](http://dx.doi.org/10.1016/S1474-4422(07)70325-3)
20. Harris KD, Heer DM, Roy TC, Santos DM, Whitman JM, Wainner RS. Reliability of a measurement of neck flexor muscle endurance. *Phys Ther*. 2005;85:1349-1355.
21. International Headache Society. The International Classification of Headache Disorders: 2nd edition. *Cephalalgia*. 2004;24 suppl 1:9-160.
22. Jull G. Management of cervical headache. *Man Ther*. 1997;2:182-190. <http://dx.doi.org/10.1054/math.1997.0298>
23. Knuistingh Neven A, Bartelink MEL, De Jongh TOH, et al. NHG-standaard hoofdpijn. *Huisarts Wet*. 2004;46:411-422. http://dx.doi.org/10.1007/978-90-313-6614-9_21
24. Lenssinck ML, Damen L, Verhagen AP, Berger MY, Passchier J, Koes BW. The effectiveness of physiotherapy and manipulation in patients with tension-type headache: a systematic review. *Pain*. 2004;112:381-388. <http://dx.doi.org/10.1016/j.pain.2004.09.026>
25. MacKinnon DP, Fairchild AJ, Fritz MS. Mediation analysis. *Annu Rev Psychol*. 2007;58:593-614. <http://dx.doi.org/10.1146/annurev.psych.58.110405.085542>
26. Posadzki P, Ernst E. Spinal manipulations for tension-type headaches: a systematic review of randomized controlled trials. *Complement Ther Med*. 2012;20:232-239. <http://dx.doi.org/10.1016/j.ctim.2011.12.001>
27. Sohn JH, Choi HC, Lee SM, Jun AY. Differences in cervical musculoskeletal impairment between episodic and chronic tension-type headache. *Cephalalgia*. 2010;30:1514-1523. <http://dx.doi.org/10.1177/0333102410375724>
28. van Etteken H, Lucas C. Efficacy of physiotherapy including a craniocervical training programme for tension-type headache: a randomized clinical trial. *Cephalalgia*. 2006;26:983-991. <http://dx.doi.org/10.1111/j.1468-2982.2006.01163.x>
29. van Niekerk SM, Louw Q, Vaughan C, Grimmer-Somers K, Schreve K. Photographic measurement of upper-body sitting posture of high school students: a reliability and validity study. *BMC Musculoskelet Disord*. 2008;9:113. <http://dx.doi.org/10.1186/1471-2474-9-113>
30. Watson DH, Trott PH. Cervical headache: an investigation of natural head posture and upper cervical flexor muscle performance. *Cephalalgia*. 1993;13:272-284.



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