Carpal tunnel syndrome (CTS) is a disorder of the upper extremity, with a reported prevalence of 3.72% in the US population. CTS includes a cluster of symptoms, including numbness and tingling in the median nerve distribution, waking at night, and variable pain. Although these symptoms are primarily attributed to compression of the median nerve at the carpal tunnel or an increase in the volume of its contents, many etiologies can be identified. Some authors have found that individuals with CTS usually experience pain symptoms in the neck and shoulder regions. Hurst et al found that the presence of arthritis in the neck may result in compression of the cervical nerve roots in people with CTS, whereas Pierre-Jerome and Bekkend found that individuals with CTS, compared to a control group, exhibited higher incidence of narrowing of the cervical foramen. These studies suggest that compromised neural foramen could potentially lead to nerve root compression, predisposing patients to develop CTS or aggravating existing symptoms of CTS through a secondary site of compression. Accordingly, it is possible that patients with CTS have impairments of cervical range of motion compared to healthy controls, exhibiting cervical spine lateral flexion away from the affected side.

A recent study showed that, compared to healthy control participants, individuals with moderate, unilateral CTS exhibited greater forward head posture and decreased cervical range of motion. To the best of the authors’ knowledge, no study has previously investigated differences in cervical range of motion between individuals with minimal, mild/moderate, and severe CTS, and healthy controls. The main purpose of this study was to investigate the differences in cervical range of motion in a healthy control group compared to a group of women with CTS and healthy controls. A corrected P value of less than .025 was used as threshold for significance (Bonferroni correction).

**STUDY DESIGN:** A case control, blinded study.

**OBJECTIVES:** To compare the amount of cervical range of motion in women with minimal, mild/moderate, and severe carpal tunnel syndrome (CTS) to that of healthy control participants. We also assessed the relationships between cervical range of motion and clinical variables related to the intensity and temporal profile of pain within each CTS group.

**BACKGROUND:** It is plausible that the cervical spine may be involved in individuals with CTS. No study has investigated the relationship between cervical range of motion and symptoms associated with CTS severity.

**METHODS:** Cervical range of motion was assessed in 71 women with CTS (18 with minimal, 18 with mild/moderate, and 35 with severe signs and symptoms) and in 20 similar, healthy women. Those with CTS were aged 35 to 59 years (mean ± SD, 45 ± 8 years) and those in the healthy group were aged 31 to 60 years (45 ± 8 years). An experienced therapist, blinded to the participants’ conditions, used a cervical range-of-motion (CROM) device to assess cervical range of motion. Mixed-model analyses of variance (ANOVA) were conducted to evaluate the differences in cervical range of motion among the 3 groups of patients with CTS and healthy controls. A corrected P value of less than .025 was used as threshold for significance (Bonferroni correction).

**RESULTS:** The mixed-model ANOVAs revealed that the individuals with CTS exhibited restricted cervical range of motion compared to healthy controls (P<.001), with no significant differences among the groups with minimal, mild/moderate, or severe CTS (P>.356). A significant negative correlation between pain intensity and cervical spine lateral flexion away from the affected side was identified: the greater the mean pain intensity, the lesser the cervical lateral flexion away from the affected side.

**CONCLUSIONS:** Women with minimal, mild/moderate, or severe CTS exhibited less cervical range of motion compared to women of a similar age, suggesting that restricted cervical range of motion may be a common feature in individuals with CTS, independent of severity subgroups, as defined by electrodiagnosis. Future research should investigate cervical range of motion as a possible consequence or causative factor of CTS and related symptoms. J Orthop Sports Phys Ther 2011;41(5):305-310. Epub 6 April 2011. doi:10.2519/jost.2011.3536

**KEY WORDS:** CTS, electrodiagnosis, median nerve, neck, wrist
with chronic minimal, mild/moderate, and severe CTS. Our hypothesis was that women with severe CTS would exhibit less cervical range of motion as compared to women with minimal or mild/moderate CTS and healthy women. A secondary aim was to investigate the relationship between cervical range of motion and the intensity and duration (chronicity) of the pain within each CTS group. We hypothesized that women with higher intensity of pain or a more chronic duration of the symptoms would exhibit less cervical range of motion.

METHODS

Participants

Consecutive women, with clinical and electrodiagnosis evidence of CTS, as determined by an experienced neurophysiologist from the Neurology Department of Fundación Hospital Alcorcón, were screened for eligibility criteria. To be included, patients had to exhibit at least 4 of the following 5 findings: pain and paresthesia within the median nerve distribution, increased symptoms at night (sensitivity, 0.73; specificity, 0.31),\(^6\) positive Tinel sign (sensitivity, 0.74; specificity, 0.91),\(^2\) positive Phalen sign (sensitivity, 0.88; specificity, 0.1.0),\(^2\) and self-perceived hand strength deficits. Symptoms had to have been present for a minimum of 6 months, and women with unilateral or bilateral symptoms were included.

Additionally, the electrodiagnosis examination had to reveal deficits of sensory and motor nerve conduction according to the standardized guidelines of the American Association of Electrodiagnosis, American Academy of Neurology, and the American Academy of Physical Medicine and Rehabilitation.\(^2\) Patients with minimal (abnormal segmental-comparative tests only), mild (abnormal median nerve sensory velocity conduction and normal distal motor latency) or moderate (abnormal median nerve sensory velocity conduction and abnormal distal motor latency), and severe (absence of median nerve sensory response and abnormal distal motor latency) CTS were included in the study.\(^6\) A median nerve sensory conduction velocity of less than 40 mm/s and a median nerve distal motor latency greater than 4.20 milliseconds were considered as abnormal.\(^1,2\) Sensory and motor conduction studies of the radial and ulnar nerves were conducted to rule out radial and ulnar nerve involvement.

Patients were excluded if they exhibited any of the following: (1) any sensory or motor deficit for the ulnar or radial nerve; (2) an age greater than 65 years; (3) previous carpal tunnel release or injection; (4) diagnoses of other cervical or upper extremity pathologies (eg, cervical radiculopathy, whiplash, lateral epicondylalgia); (5) history of neck, shoulder, or upper extremity trauma; (6) history of any systemic disease causing CTS (eg, diabetes mellitus, thyroid disease); (7) history of a systemic musculoskeletal medical condition (eg, rheumatoid arthritis, fibromyalgia); (8) active involvement with litigation or an intent to litigate at the time of the study; or (9) pregnancy. All participants were screened according to the American College of Rheumatology for the diagnosis of fibromyalgia syndrome.\(^6\)

The control group included healthy women who volunteered in response to a local advertisement and were excluded if they exhibited history of neck or upper extremity pain, fracture, or neurological disorder. The project was approved by The Local Human Research Committee of the Hospital Universitario Fundación Alcorcón. All participants signed an informed consent prior to their participation in the study.

Self-Report Measures

A 10-point numerical pain rating scale (NPRS),\(^14\) with 0 as no pain and 10 as maximum pain, was used to assess current level of hand pain, and worst and lowest level of hand pain experienced in the preceding week. The Spanish version\(^20\) of the Boston Carpal Tunnel Questionnaire (BCTQ)\(^15\) was also used to evaluate 2 domains: functional status, with a scale that assesses the ability to perform 8 common hand-related tasks, and symptom severity, with an 11-item scale that assessed pain severity, numbness, and weakness at night and during the day. Respondents answered each question on a 5-point scale, ranging from 1 as no complaint to 5 as severe complaint. The mean value of the scores was calculated for each domain, with higher scores indicating greater severity. The BCTQ has been shown to be valid, reliable, and responsive for patients with CTS.\(^6\)

Cervical Range-of-Motion Assessment

The cervical range of motion (CROM) device (Performance Attainment Associates, St Paul, MN) was used to measure cervical range of motion. Fletcher et al\(^11\) reported the CROM’s intratester reliability as ranging from 0.87 to 0.96 and a standard error of measurement of between 2.3° and 4.1°. A recent study\(^7\) found that the CROM device was as valid as the Fastrak motion analysis system, with good between-day reliability, ranging between 0.89 and 0.98, and standard errors of measurement across the 6 movements, ranging from 1.6° to 2.8°.\(^2\)

Cervical range of motion was assessed according to previously published guidelines.\(^10\) A therapist blinded to the participants’ condition recorded cervical range of motion in a single direction (flexion/extension, lateral flexion toward or away from the side of the CTS, and rotation toward or away from the side of the CTS), as well as total range of motion in 3 planes of movement (flexion, extension, lateral flexion, and rotation). In women with unilateral symptoms, each side was classified as affected or unaffected, and in those with bilateral symptoms the most painful side was classified as the affected side and the less painful side as the unaffected side. In the control group, the right side was considered the dominant side and the left side the nondominant side.

Cervical range of motion was evalu-
ated in a relaxed sitting position. Participants were asked to sit comfortably in a chair, with both feet flat on the floor, both hips and knees in 90° of flexion, and buttocks positioned against the back of the chair. The CROM device was placed on the top of the participant’s head, with the neck in a neutral position. Participants were asked to move their head as far as they could without pain in a standardized sequence: forward (flexion), backward (extension), right/left lateral flexion, and right/left rotation. Two measurements were recorded for each motion, and the mean was used in the statistical analysis.

**Statistical Analysis**

Data were analyzed with SPSS Version 17.0. Normal distribution of data was assessed with the Kolmogorov-Smirnov test ($P > .05$). Variables without a normal distribution of data (pain history and current, lowest, and worst level of pain intensity) were analyzed with nonparametric statistics, whereas data with a normal distribution (cervical range of motion) were analyzed with parametric statistics. For practical purposes, women with mild and moderate CTS were considered in the same group. Differences in clinical pain parameters and function (BCTQ) among the 3 groups with CTS were compared with the nonparametric Kruskal-Wallis test. For the main objective of the study, a 2-by-4 mixed-model analysis of variance (ANOVA) was used to evaluate the differences in cervical range of motion for lateral flexion and rotation motion, with side (the affected side in participants with CTS and the dominant/nondominant in controls) as the within-subject factor and group (minimal, mild/moderate, severe, and controls) as the between-subject factor. A 1-by-4 ANOVA, with group (minimal, mild/moderate, severe, and controls) as a between-subject factor, was used to evaluate the differences in cervical flexion and extension range of motion between groups. Finally, additional, separate 1-by-4 ANOVAs, with group as a between-subject factor, was used to evaluate the differences in the total range of motion (flexion/extension, lateral flexion, and rotation) between groups. Post hoc comparisons were conducted with the Bonferroni test. For the secondary objective of the study, the Spearman rho ($r_s$) test was used to analyze the association between cervical range of motion and pain clinical variables (pain history and current, lowest, and worst level of pain) within each CTS group. Although a $P$ value of less than .05 is generally considered statistically significant, because 2 related comparisons were conducted (flexion/extension and toward or away from the affected side for lateral flexion and rotation), a corrected $P$ value of less than .025 was used as threshold for significance.

**RESULTS**

**Demographic and Clinical Data**

Two hundred consecutive patients with CTS were screened for eligibility between June 2009 and June 2010. Seventy-one women presenting with CTS, aged 35 to 59 years (mean ± SD, 45 ± 8 years), satisfied all the eligibility criteria and agreed to participate. Of those excluded from the study, 45 had previous surgery, 50 previous steroid injections, 18 fibromyalgia, and 16 whiplash-associated disorders. Of the 71 patients who presented with CTS, 18 (25%) had minimal, 18 (25%) mild/moderate, and 35 (50%) severe CTS, with 38 (53%) having unilateral symptoms (24 right side, 14 left side) and 33 (47%) bilateral symptoms. There were no significant differences ($\chi^2 = 2.292$, $P = .459$) in the distribution of participants with unilateral or bilateral symptoms among groups classified by severity.

In the total sample, the mean ± SD duration of hand pain was 3.7 ± 3.0 years (95% confidence interval [CI]: 3.1, 7.1), the current level of pain was 5.2 ± 1.2 (95% CI: 4.9, 5.6), the worst level of pain experienced in the preceding week was 7.1 ± 1.1 (95% CI: 6.5, 7.6), and the lowest level of hand pain in the preceding week was 2.6 ± 1.1 (95% CI: 2.2, 3.1). The BCTQ functional status scale score of the total sample was 2.7 ± 0.7 (95%
CI: 2.5, 2.8), and the BCTQ symptom severity scale score was 2.8 ± 0.4 (95% CI: 2.7, 3.0). There were no significant differences in any of the pain-related measures and BCTQ scores among patients with minimal, mild/moderate, and severe CTS (TABLE 1).

In addition, 20 similar healthy women without upper extremity symptoms, aged 31 to 60 years (mean ± SD, 45 ± 8 years), were included. No significant differences (F = 0.609, P = .847) in age among groups were found.

Cervical Range of Motion in a Single Direction

The 2-by-4 mixed-model ANOVA revealed no significant interaction between group and side for lateral flexion (F = 0.066, P = .978) or rotation (F = 1.447, P = .231). The subsequent main effects analysis indicated significant differences among groups, but not between sides, for lateral flexion (group: F = 9.845, P < .001; side: F = 1.002, P = .315) and rotation (group: F = 4.563, P = .002; side: F = 1.384, P = .241). Post hoc analysis revealed that the 3 groups of patients with CTS had restricted cervical lateral flexion and rotation bilaterally, as compared to healthy controls (P < .01), with no significant differences among the groups with minimal, mild/moderate, or severe CTS (P > .119).

The 1-by-4 ANOVA revealed a significant difference among groups for cervical flexion (F = 29.102, P < .001) and extension (F = 18.471, P < .001) range of motion, with the 3 groups of patients exhibiting less cervical flexion and extension than healthy controls (P < .001). There was no difference among those with minimal, mild/moderate, or severe CTS (P > .346). TABLE 2 shows the cervical range of motion in individuals with minimal, mild/moderate, and severe CTS and healthy controls.

Total Cervical Range of Motion

The 1-by-4 ANOVA revealed significant differences between groups for flexion (F = 38.714, P < .001), lateral flexion (F = 5.772, P = .001), and rotation (F = 5.505; P = .002). Post hoc analysis revealed that the 3 groups of patients with CTS had less neck mobility than healthy controls (P < .01), with no differences among those with minimal, mild/moderate, and severe CTS (P > .343).

Correlation Between Cervical Range of Motion and Clinical Pain Features

Significant negative associations between current level of pain intensity and cervical range of motion in lateral flexion away from the affected side were identified in women with minimal (r = –0.493, P = .038), mild/moderate (r = –0.572, P = .013), and severe (r = –0.342, P = .044) CTS, such that, with greater pain intensity, there was less cervical lateral flexion away from the affected side. Range of motion for other cervical movements was not related to hand pain clinical features.

DISCUSSION

The results of the current study demonstrated that women with minimal, mild/moderate, and severe CTS exhibited less cervical range of motion, as compared to healthy, nonsymptomatic women of a similar age. These results suggest that restricted cervical range of motion is a common feature of women with CTS, independent of the level of CTS severity, as defined by electrodiagnosis. These results are consistent with previous results.10

In a meta-analysis of normative data of cervical range of motion, Chen et al9 reported the following 95% CIs for normative values for each movement:

| TABLE 2 | CERVICAL RANGE OF MOTION IN PATIENTS WITH CTS AND HEALTHY CONTROLS* |
|-------------------------------|-------------------|-------------------|-------------------|-------------------|
| Mininal CTS (n = 18) | Mild/Moderate CTS (n = 18) | Severe CTS (n = 35) | Healthy Controls (n = 20) |
| Flexion/Extension | | | |
| Flexion* | 45.3 (42.5, 48.1) | 478 (441, 514) | 44.2 (41.5, 46.9) | 62.2 (58.2, 65.7) |
| Extension* | 60.9 (54.0, 67.9) | 64.2 (59.6, 68.7) | 579 (53.6, 62.2) | 80.3 (76.2, 83.9) |
| Total* | 106.2 (94.2, 115.8) | 112.0 (106.0, 118.0) | 1021 (96.5, 1077) | 1425 (138.2, 146.9) |
| Lateral Flexion | | | | |
| Towards/dominant†‡ | 32.5 (28.5, 36.5) | 36.1 (27.2, 44.9) | 30.3 (27.9, 32.7) | 41.4 (36.3, 46.4) |
| Away from/nondominant†‡ | 36.2 (31.5, 41.0) | 40.9 (32.6, 49.2) | 34.2 (31.2, 36.6) | 44.1 (42.7, 45.6) |
| Total†‡ | 62.7 (62.4, 76.3) | 77.0 (60.1, 93.8) | 64.4 (60.0, 69.0) | 85.5 (80.1, 90.8) |
| Rotation | | | | |
| Towards/dominant†‡ | 70.1 (65.0, 75.3) | 71.1 (63.3, 79.0) | 677 (64.4, 71.0) | 80.5 (75.2, 85.2) |
| Away from/nondominant†‡ | 71.6 (66.4, 76.7) | 69.2 (62.6, 75.7) | 68.3 (65.5, 72.1) | 81.0 (76.3, 85.7) |
| Total†‡ | 141.7 (128.0, 154.9) | 140.3 (95.3, 157.1) | 136.0 (129.1, 142.8) | 161.5 (152.1, 170.8) |

Abbreviation: CTS, carpal tunnel syndrome.

*Data are mean (95% confidence interval) in degrees.
†Indicates significant differences between patients and controls (P < .001).
‡Towards and away from refer to the affected or most affected side for the 3 groups with CTS, dominant and nondominant was used for the control group.
flexion/extension: 116°, 150° (flexion: 48°, 69°; extension: 61°, 93°); lateral flexion: 76°, 108° (each side: 38°, 49°); and rotation: 86°, 136° (each side: 70°, 93°). Based on these data most, of the participants (97%) in the control group were in the upper 50% of the normative values and most of the women with CTS (90%) were below normative values. But the cervical range of motion of several of the women with mild/moderate CTS was within the lower value of the 95% confidence intervals of the normative values.

Because this study was not longitudinal, a cause-and-effect relationship could not be established with the current design. To determine whether restricted cervical range of motion is a consequence or cause/promoting factor of pain in women with CTS requires further investigation. Impairments in the cervical spine may be related to the theory of the “double crush” syndrome, which refers to the existence of dual compressive lesions along the course of a particular nerve.19 According to this theory, impingement of the brachial plexus in the cervical spine can result in a complex clinical presentation, by predisposing the median nerve to a second lesion, particularly at the carpal tunnel.19 In this case, the restricted cervical range of motion would be a clinical manifestation of the narrowing of the cervical foramen and, hence, a promoting factor for CTS.13,19 Conversely, it could also be possible that restricted cervical range of motion may be the consequence of pain-related fear-avoidance behaviors,12 although no studies have previously investigated fear-avoidance beliefs in patients with CTS. Nevertheless, whether restricted cervical range of motion is a cause or consequence of CTS, our study suggests that it is common in women with CTS.

We also found a significant correlation between the current level of hand pain intensity and the amount of cervical range of motion in lateral flexion away from the affected side, in that greater pain intensity was associated with less cervical lateral flexion away from the affected side. This finding may be related to the fact that CTS is a neuropathic condition, the symptoms of which cervical lateral flexion away from the affected side might increase.4,5

The results of the current study have implications for clinical practice. The co-existence of restricted cervical range of motion and CTS suggests that treatments targeted to the neck region may be helpful in the management of some patients with CTS. Nevertheless, clinicians should consider that median nerve compression within the carpal tunnel constitutes the main source/cause of this condition, and cervical nerve root compression may aggravate the existing entrapment condition. This hypothesis is illustrated by a case report20 in which the authors reported the improvement of a patient with CTS who, treated with a multimodal approach, including techniques directed at the neck, exhibited improvements in grip strength and a normalization of motor and sensory latencies of the median nerve.22 However, a cause-and-effect relationship cannot be inferred from a case report.

We acknowledge that there are limitations to the current study. As our sample was derived from 1 specialized hospital, future studies should include samples from the general population. As we included only women with CTS, the results of this study should not be applied to men with CTS. Additionally, our sample size was small, particularly for the group with minimal and mild/moderate CTS, and some of the nonsignificant results might, therefore, have been due to a lack of statistical power. Future studies that include greater sample sizes and patients from both genders are needed. Finally, the results of this study do not allow us to make inferences regarding the relevance of restricted cervical range of motion in the natural course of CTS. Future trials should investigate if physical therapy management directed at the cervical spine may change the symptoms and severity of CTS.

CONCLUSIONS

Women with minimal, mild/moderate, and severe CTS exhibited less cervical range of motion as compared to woman of a similar age, suggesting that restricted cervical range of motion may be a common feature of women with CTS, independent of severity subgroups defined on the basis of electrodiagnosis. Future research should investigate if restricted cervical range of motion is a consequence or causative factor of CTS and related symptoms.

KEY POINTS

FINDINGS: Women with minimal, mild/moderate, or severe CTS exhibited less cervical range of motion, as compared to controls, suggesting that restricted cervical range of motion is a common feature of women with CTS, independent of severity subgroups defined on the basis of electrodiagnosis.

IMPLICATIONS: Correction of impairments in the cervical spine may be helpful for the management of women with CTS.

CAUTION: We recruited women from 1 specialized hospital. The study design does not allow us to make inferences about a cause-and-effect relationship between cervical range of motion and CTS.

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