The diagnostic validity of the cervical flexion–rotation test in C1/2-related cervicogenic headache

Mark Ogince*, Toby Hall, Kim Robinson, A.M. Blackmore

School of Physiotherapy, Curtin University of Technology, C/o 54 Bunya Street, Noranda, Perth, WA 6062, Australia

Received 8 March 2005; received in revised form 21 March 2006; accepted 27 June 2006

Abstract

This single-blind comparative group design aimed to investigate the sensitivity and specificity of the cervical flexion–rotation test in the diagnosis of C1/2-related cervicogenic headache.

This study tested 23 cervicogenic headache, 23 asymptomatic controls and 12 migraine with aura subjects, all aged 18–66 years. In stage 1, an experienced manipulative physiotherapist who did not partake in the flexion–rotation test procedure identified C1/2 dysfunction using passive segmental mobility tests in the cervicogenic headache group. Those with C1/2 dysfunction participated in stage 2. In stage 2, using the flexion–rotation test, subjects were tested by two experienced manipulative physiotherapists blinded to the subjects’ group allocation. Each therapist stated whether the test was positive or not based on the therapist’s interpretation of range of motion.

The sensitivity and specificity of the flexion–rotation test was 91% and 90%, respectively ($P<.001$), with an overall diagnostic accuracy of 91% ($P<.001$). The cervical flexion–rotation test significantly assists in the differential diagnosis of cervicogenic headache and in the identification of movement impairment at the C1/2 segment in patients with cervicogenic headache.

© 2006 Published by Elsevier Ltd.

Keywords: Sensitivity; Specificity; Manual examination; C1/2 segment

1. Introduction

Cervicogenic headache has been identified as a distinct subgroup by the International Headache Society (IHS) (Headache Classification Committee of the International Headache Society, 2004) and is caused by disease or dysfunction of structures in the neck (Edmeads, 2001).

The diagnostic criteria for cervicogenic headache outlined by the IHS include subjective features together with evidence of impairment of cervical function on physical examination. Such impairment includes atlanto-axial motion segment (C1/2 level) dysfunction (Hall and Robinson, 2004) identified by the flexion–rotation test.

Headache presents a diagnostic challenge due to similarities of signs and symptoms among the many types of headache (Nicholson and Gaston, 2001). In particular, distinguishing between cervicogenic headache and migraine is problematic (Lewit, 1977, Sjaastad and Bovim, 1991, Vernon et al., 1992; Blau and MacGregor, 1994).

The IHS subjective classification criteria are commonly used to classify cervicogenic headache however this process fails to identify the segmental source of pain, which is important for the application of manual therapy treatment. Radiological examinations are not effective (Jensen et al., 1990; Edmeads, 2001), and nerve block procedures are often impractical, particularly in the upper cervical region (Bogduk et al., 1985).

Impaired neck mobility is a diagnostic criterion in cervicogenic headache (Mersky and Bogduk, 1994; Sjaastad et al., 1998), however several studies have

---

*Corresponding author. Tel./fax: +61 8 9375 3224.
E-mail address: ogince.m@gmail.com (M. Ogince).
found that active cervical mobility is unreliable in differential diagnosis (Jull et al., 1988; Jensen et al., 1990; Treleaven et al., 1994; Sandmark and Nisell, 1995; Placzek et al., 1999; Hall and Robinson, 2004).

Conversely, manual examination has been shown to detect symptomatic cervical joint dysfunction in a number of studies of cervical headache (Jull et al., 1988; Jaeger, 1989; Jensen et al., 1990; Watson and Trott, 1993; Treleaven et al., 1994; Whittingham et al., 1994; Schoensee et al., 1995). Clinically, these tests, described by Maitland et al. (2001), are used as the current reference standard; however, they involve a high degree of skill on the part of the therapist.

Additionally, most external measures of cervical motion incorporate movements of both the upper and lower cervical regions simultaneously (Amiri et al., 2003). However, as cervicogenic headache has a primary involvement in the upper cervical segments, measurement of rotation purportedly biased to the upper cervical region could be a relevant clinical measure in the differential diagnosis of cervicogenic headache (Amiri et al., 2003). Furthermore, determining the dysfunctional cervical segment facilitates a more accurate treatment approach.

The cervical flexion–rotation test is an easily applied method of manual examination that is said to provide a means of determining the presence of joint dysfunction at the C1/2 level (Stratton and Bryan, 1994). The flexion–rotation test is conducted with the cervical spine fully flexed in an attempt to block as much rotational movement as possible above and below C1/2. The head is then rotated to the left and the right. If firm resistance is encountered and range is limited before the expected end range, then this is said to be significant, with a presumptive diagnosis of limited rotation of the atlas on the axis (Stratton and Bryan, 1994). Anecdotally, pain provocation during the flexion–rotation test is also a feature of a positive test result, however, pain is not a feature in asymptomatic subjects (Hall and Robinson, 2004).

It is deducible from the frequently reported overlapping characteristics seen with cervicogenic headache and migraine that in the clinical realm many cervicogenic patients are currently misdiagnosed as having migraine headache and migraine patients misdiagnosed as having cervicogenic headache (Sjaastad and Bovim, 1991). Consequently, it is likely that treatment is unsubstantiated and a poor prognosis will follow. Thus, there appears to be a need to identify physical tests that are valid, reliable and sensitive in assisting the diagnosis of cervicogenic headache.

Accordingly, the aims of this study were to determine the sensitivity and specificity of the cervical flexion–rotation test. An additional aim was to determine if a relationship exists between cervicogenic headache severity and the extent of restriction demonstrated by the flexion–rotation test.

2. Methods

2.1. Subjects

A single-blind comparative group design was used to determine differences between asymptomatic subjects, migraine with aura subjects and those with C1/2-related cervicogenic headache. Based on the previous findings of Hall and Robinson (2004), in order to detect a 10° difference of rotation with the cervical spine in flexion, with alpha at .05, power of 80% and a standard deviation of 8°, this study required at least 10 subjects per group. In total, 23 cervicogenic headache subjects (3 males, 20 females, mean age = 46 years), 23 asymptomatic controls (8 males, 15 females, mean age = 40 years) and 12 migraines with aura subjects (9 males, 3 females, mean age = 37 years) participated in the study. Subjects ranged in age from 18 to 66 years. This study had approval by the appropriate Human Research Ethics Committee.

3. Materials

The cervical range of motion device (CROM) (Performance Attainment Associates. 958 Lydia Drive, Roseville, Minnesota, USA. 55113) was modified to measure cervical rotation in a fully flexed cervical spine position. Two Velcro straps were fixed to the subject’s head, traversing the transverse and coronal planes, respectively (Fig. 1). The CROM goniometer was attached to the centre of the coronal Velcro strap to measure cervical rotation in maximal flexion (Fig. 1). The CROM and modified CROM have been shown to have good intratester and intertester reliability (Capuano-Pucci and Rheault, 1991; Hall and Robinson, 2004; Rheault and Albright, 1992). A headache questionnaire

Fig. 1. The cervical range of motion device (modified to measure cervical rotation in flexion) and the flexion–rotation test.
subjective diagnostic criteria as well as criteria outlined by the International Headache Society, 1988.

3.1. Procedures

Subjects were recruited from medical specialists and by advertisements. In response, 325 headache and 23 asymptomatic subjects expressed interest in participation. Using the IHS (Headache Classification Committee of the International Headache Society, 1988) subjective diagnostic criteria as well as criteria outlined by Sjaastad et al. (1998), Bogduk (1994) and Lord et al. (1994), telephone interviews were conducted to identify subjects with cervicogenic headache, migraine with aura headache and asymptomatic controls.

The inclusion criteria for the cervicogenic subjects were unilateral or side dominant headache without side-shift, (Sjaastad et al., 1998) headache associated with neck pain or reported stiffness (Bogduk, 1994; Sjaastad et al., 1998) neck symptoms preceding or co-existent with the onset of headache (Lord et al., 1994; Sjaastad et al., 1998) and pain precipitated or aggravated by specific neck movements or sustained posture (Headache Classification Committee of the International Headache Society, 1988). Additionally, passive segmental mobility tests reveal symptomatic C1/2 dysfunction (Maitland et al., 2001) as well as headache frequency at least an average of one per week and history of episodic semicontinuous or continuous headache for at least the previous 3 months. The exclusion criteria for the cervicogenic headache group were diagnostic criteria of headache that are not of cervical origin (Headache Classification Committee of the International Headache Society, 1988).

Asymptomatic subjects had no history of subjective features of cervicogenic headache, migraine, migraine with aura headache, episodic headache, and neck pain or stiffness. The following exclusion criteria related to all 3 groups; dizziness on cervical spine movement, inability to tolerate the flexion–rotation test position, failure to provide informed consent, insufficient fluency in English, known congenital fusion, history of cervical surgery, cervical or cranial trauma, rheumatoid arthritis and Downs Syndrome.

The inclusion criteria for the migraine with aura group were based on the IHS classification (Headache Classification Committee of the International Headache Society, 1988). The exclusion criteria for this group were neck pain, discomfort or stiffness.

Of the 325 symptomatic subjects interviewed, 82% reported overlapping cervicogenic and migraine symptoms and were rejected from the study. The remaining symptomatic subjects consisted of 12 migraine with aura and 46 cervicogenic subjects. As a sample of convenience 23 cervicogenic, 23 asymptomatic and 12 migraine with aura subjects who matched the criteria were recruited into the study. Telephone interviews and the allocation of subjects to their respective groups were conducted by the principal investigator who did not partake in the flexion–rotation test procedures.

Cervicogenic headache subjects were required to attend a preliminary session to determine the presence of C1/2 dysfunction. This was defined as stage 1. Thereafter, all subjects attended a single session for data collection, defined as stage 2. Prior to the start of the study all subjects were required to provide informed consent.

In stage 1, an experienced teacher of manipulative physiotherapy, with 12 years experience who did not take part in the flexion rotation test procedure, identified 23 out of 34 cervicogenic headache subjects with C1/2 as the dominant level of dysfunction using passive segmental mobility tests. This method of assessment has been shown to be a valid means of identifying the symptomatic cervical level in a previous study (Jull et al., 1988). These 23 subjects were then allocated to the cervicogenic headache group. The flexion–rotation test was not used in this part of the assessment. Segmental mobility was assessed using passive accessory and physiological intervertebral movements (PAIVMs and PPIVMs) as described by Maitland et al. (2001). In congruence with the clinical setting, assessing segmental dysfunction using PAIVMs and PPIVMs served as the reference standard in this study.

In stage 2, using the flexion–rotation test subjects were tested by two experienced manipulative physiotherapists who had 16 and 13 years postgraduate manipulative therapy experience and were blinded to the subjects’ group allocation. The flexion–rotation test was conducted with the subject relaxed and recumbent. The cervical spine was fully flexed with the occiput resting against the examiner’s abdomen (Fig. 1). The head was then rotated to the left and right. Each therapist was required to interpret the flexion–rotation test results and state whether the test was positive or not, based on the therapist’s interpretation of range of motion. The range of motion was considered limited when the therapist determined a firm end feel and based on the therapists’ interpretation there was a minimum of a 10° reduction from the expected range. Pain provocation during the flexion–rotation test was not tested in this study. Thereafter, the goniometer was fixed and the flexion–rotation test was repeated twice in each direction, with one therapist ascertaining range in reverse order and measurements recorded on each occasion. An interval of 30s elapsed between each trial. Additionally, each therapist was blinded to each other’s interpretation and recordings.

At the time of assessment, cervicogenic and migraine subjects completed a headache questionnaire (Niere and Robinson, 1997) detailing their history of headache frequency, intensity and duration. This questionnaire
has been shown to be reliable and enables an index of headache severity to be calculated (Niere and Robinson, 1997). Additionally, the intensity of headache at the time of the assessment was determined on a 10 cm visual analogue scale (VAS). The results of the questionnaire and VAS were used to determine if the degree of restriction of rotation in flexion was related to the severity of the headache symptoms in the cervicogenic headache group.

3.2. Statistical analysis

All data were analysed using SPSS Version 11.0 statistical software (SPSS, Inc., Chicago, IL). In all cases alpha was set at the .05 level. An analysis of variance (ANOVA) and planned orthogonal comparisons were used to analyse range of rotation with the cervical spine in flexion between the 3 subject groups. An ANCOVA was used to determine whether age and gender accounted for the difference in range of rotation with the cervical spine in flexion between the 3 groups. The sensitivity and specificity of the flexion–rotation test were analysed using cross tabulation and were determined with a receiver operating characteristic (ROC) curve. To calculate the sensitivity and specificity the migraine with aura and asymptomatic groups were combined and then compared to the cervicogenic headache group. The frequencies used to calculate sensitivity and specificity are given in Table 1. The dichotomous variables used to determine the sensitivity and specificity were the therapists’ identification of the presence or absence of C1/2 dysfunction and thereby cervicogenic headache. The ROC curve was created with the flexion–rotation range of motion values. The inter-tester reliability of the flexion–rotation test was calculated from a cross-tabulation using kappa.

A variable headache severity index was calculated using the method described by Niere and Robinson (1997). The greater the score on the headache severity index the greater the severity of headache. To determine the relationship of the headache severity index score and the VAS score to the range of rotation in flexion, Pearson’s correlation analyses were used.

4. Results

The average range of unilateral rotation for both sides was 39° (SD = 6.9), 39° (SD = 6.5) and 20° (SD = 11) for the migraine with aura, asymptomatic and cervicogenic headache groups, respectively. For the cervicogenic headache group the average range of unilateral rotation refers to the most restricted side. The difference between groups was significant (P < .001) (Fig. 2). The results indicate that the range of rotation was significantly reduced in the cervicogenic headache group when compared to the migraine with aura and asymptomatic subjects (P < .001). There was no significant difference in range between the migraine with aura subjects and asymptomatic subjects (P = .971) (Fig. 2). There was a significant negative correlation between age and ROM (r = -.404, P = .002), and the difference in ROM between males (M = 35.1, SD = 9.2) and females (M = 29.7, SD = 13.7) was close to significance, t(52) = 1.76, P = .084. Therefore, age and gender were both included as covariates in an ANCOVA, and a significant result on ANCOVA (P < .001) revealed that neither age nor gender accounted for the differences between groups.

Sensitivity is the test’s ability to obtain a positive test when the target condition is really present (Portney and Watkins, 1993). Specificity is the test’s ability to obtain a negative test when the condition is really absent (Portney and Watkins, 1993). Positive predictive value is the likelihood that person who tests positive actually has the disease and negative predictive value is the probability that a person who tests negative is actually disease-free (Portney and Watkins, 1993). A positive likelihood ratio indicates the increase in odds favouring the condition given a positive test result and a negative

<table>
<thead>
<tr>
<th></th>
<th>Cervicogenic headache</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive</td>
<td>Negative</td>
</tr>
<tr>
<td>Cervical flexion</td>
<td>21/21*</td>
<td>3/4*</td>
</tr>
<tr>
<td>Rotation test</td>
<td>2/2*</td>
<td>32/31*</td>
</tr>
<tr>
<td>Total</td>
<td>23/23*</td>
<td>35/35*</td>
</tr>
</tbody>
</table>

*Therapist 1/Therapist 2.
The sensitivity, specificity, positive and negative predictive values as well as likelihood ratios of the cervical flexion–rotation test

<table>
<thead>
<tr>
<th>Therapist 1</th>
<th>Therapist 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity (%)</td>
<td>91.3</td>
</tr>
<tr>
<td>Specificity (%)</td>
<td>91.4</td>
</tr>
<tr>
<td>Positive predictive value (%)</td>
<td>87.5</td>
</tr>
<tr>
<td>Negative predictive value (%)</td>
<td>94.1</td>
</tr>
<tr>
<td>Positive likelihood ratio</td>
<td>10.65</td>
</tr>
<tr>
<td>Negative likelihood ratio</td>
<td>0.095</td>
</tr>
</tbody>
</table>

The ROC curve indicated that the test value, which provides the highest sensitivity and the lowest 1-specificity, is 32° (cut-off score). That is, if the flexion rotation-test value is less than or equal to 32° the test is positive.

In examining the relationship between the headache severity index score and the range of rotation in flexion, there was no significant correlation $r_{(23)} = .24$, $P = .27$. Additionally, when examining the relationship between severity of headache at the time of assessment on a VAS to range of rotation in flexion, there was no significant correlation $r_{(23)} = -.09$, $P = .960$.

5. Discussion

This study found the range of cervical rotation in flexion was significantly reduced in the presence of C1/2 dominant cervicogenic headache when compared to a control group of either asymptomatic or migraine with aura. These results concur with Hall and Robinson (2004) who evaluated the flexion–rotation test comparing only cervicogenic headache subjects and asymptomatic controls. Hall and Robinson (2004) demonstrated that the average range of unilateral rotation to each side was 28° and 45° for the cervicogenic and asymptomatic groups, respectively. This study showed that average range of unilateral rotation was 20° and 39° for the cervicogenic and asymptomatic groups, respectively. Additionally, the range of rotation in flexion in asymptomatic controls is comparable with Amiri et al. (2003) who found the average range of unilateral rotation was 42°.

This study also found there was no difference in range of flexion between the migraine with aura and the asymptomatic subjects. Migraine with aura has been described as a disturbance of brain function or a neurovascular event (Sanchez-del-Rio and Reuter, 2004) and consequently does not involve impairment of the cervical spine. Hence, this result was not unexpected and helps to confirm the lack of cervical involvement in headache with aura patients.

The results of this study suggest that the clinical method purported to bias rotation to the upper cervical region is an accurate and reliable clinical measure in the identification of dysfunction at the C1/2 level and in the differential diagnosis of cervicogenic headache. Thus, in accordance with Amiri et al. (2003) it would be reasonable to recommend that the flexion–rotation test be used in the assessment of patients with C1/2 dysfunction, for purposes of differential diagnosis and assessment of treatment outcomes.

This is the first study to establish the sensitivity and specificity of the cervical flexion–rotation test in cervicogenic headache diagnosis. The average sensitivity and specificity was 91% and 90%, respectively, with an
overall diagnostic accuracy of 91%. This indicates that the cervical flexion–rotation test has very high accuracy in determining the presence of C1/2 involvement in cervicogenic headache and for headache differential diagnosis. Furthermore, the average kappa statistic of .81 suggests excellent therapist agreement (Landis and Koch, 1977). Bogduk (1997) concludes that for most good clinical tests in physical examination, the kappa value should range between .4 and .6. This study has also determined a range of 32° as the cut-off value at which the flexion rotation-test is deemed positive. This enables the clinician to confidently interpret the results of the test in clinical practice. Consequently, these results help to establish the flexion–rotation test as a reliable measure that assists in differential headache diagnosis and determining the presence of C1/2 dysfunction.

It is important to note that at the time of testing each therapist interpreted the flexion–rotation test results by stating whether the test was positive or not, based on the therapist's interpretation of range of motion. That is, the range of motion was considered limited when the therapist determined a firm end feel and based on the therapists interpretation there was a minimum of a 10° reduction from the expected range. Since it is impractical to use a CROM device in the clinical environment this method more accurately reflects those used by physiotherapists in the clinical environment.

In contrast to Hall and Robinson (2004), this study found that the severity of cervicogenic headache is not related to the degree of restriction of rotation with the cervical spine in maximal flexion. Given that the sample of cervicogenic headache subjects was similar in both studies it appears that this difference may be due to alternative factors. Silberstein et al. (2001) contend that many patients are not good observers of their own complaints, even when those complaints are chronic. Certainly, the authors observed that whilst subjects completed the questionnaire they expressed difficulty in recalling the intensity, frequency and duration of symptoms. This may have skewed the results of the questionnaire and thus account for the different results in this study.

Using the VAS to assess the influence of intensity of headache on range of rotation at the time of testing, this study indicated that the severity of headache at the time of assessment is not related to the degree of restriction with the cervical spine in flexion. Clearly, this appears to be advantageous as the diagnostic accuracy of the flexion–rotation test is not influenced by the patient's head pain at the time of assessment.

When comparing the cervicogenic (n = 23) and asymptomatic groups (n = 23), we were only able to recruit 12 subjects in the migraine with aura group (n = 12). This sample corresponds to Ziegler and Hassanein (1990) who showed that at most, only 30% of the migraine population have migraine with aura. Of the symptomatic subjects interviewed, 82% reported overlapping cervicogenic and migraine symptoms and thus were rejected from the study. This data corresponds with Sjaastad and Bovim (1991), Fishbain et al. (2001) and Nicholson and Gaston (2001) who report frequent overlapping characteristics seen with cervicogenic and migraine patients. This study’s population was limited to cervicogenic and migraine with aura patients who have symptoms characteristic of no overlap. Based on the study sample, it appears that those who participated represent a small percentage of the symptomatic population who present in the clinical setting.

The study’s case control design and spectrum bias is by no means a limitation, as in order to determine the diagnostic accuracy of physical test the subjects must represent either a purely positive disease state, that is, cervicogenic headache or symptoms manifest of a disease free state. Thus, this study has demonstrated the cervical flexion–rotation test significantly assists in C1/2 cervicogenic headache diagnosis when the subjective criteria follow those of the IHS. Consequently, this study sets the groundwork for future studies to evaluate the cervical flexion–rotation test on a subject population whose symptoms overlap cervicogenic and migraine headache.

The authors acknowledge a number of limitations of the study. In particular, the use of a single assessor to identify C1/2 dysfunction using manual diagnosis. At the time of this study no credible alternative reference standard was available for determining the segmental level of involvement for the high cervical spine. The only other potential reference standard, double blind anaesthetic blocks, has not been attempted in the high cervical spine. In addition, selection bias was unavoidable in obtaining a large sample size. Not all subjects presenting with the relevant condition were included in order of entry neither was the selection random.

6. Conclusion

This study has demonstrated that the cervical flexion–rotation test is extremely reliable and has high sensitivity and specificity in detecting the presence of C1/2 rotation restriction in patients with cervicogenic headache. The cut of value for a positive test is range of rotation less than 32°. The flexion–rotation test is a simple, non-invasive test that can be easily applied in the clinical setting.

Acknowledgements

The authors thank Mr. Wim Dankaerts for assisting with the testing procedures. The authors also acknowl-


deck the School of Physiotherapy at Curtin University of Technology for providing assistance to present the research findings at the WCPT Conference in Barcelona 2003 as well as the Australian Physiotherapy Association WA Branch for awarding the MJ Rosen Scholarship to present this research at the Annual Conference of the APTA in Chicago 2004.


References


