

Bilateral Cervical Dysfunction in Patients With Unilateral Lateral Epicondylalgia Without Concomitant Cervical or Upper Limb Symptoms: A Cross-Sectional Case-Control Study

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1 **Bilateral cervical impairment in patients with unilateral lateral epicondylalgia without**
2 **concomitant cervical or upper limb symptoms: A cross-sectional case control study.**

3
4 INTRODUCTION

5 Lateral epicondylalgia (LE), also known as tennis elbow, is empirically considered a
6 tendinopathy of the extensor carpi radialis brevis origin. However, there is also clinical
7 recognition of a relationship between the cervical spine, radial nerve and LE. There are
8 findings of a greater prevalence of self-reported neck pain and cervicothoracic impairments in
9 patients with lateral elbow pain compared to an age-matched control population (Berglund et
10 al., 2008) as well as greater radial nerve mechanosensitivity of the affected arm in patients
11 with unilateral symptoms (Yaxley et al., 1993, Wright et al., 1994). Poorer long term
12 prognosis is predicted by self-reported neck pain, independent of high baseline pain intensity
13 (Smidt et al., 2006). Juxtaposed upon this is evidence of the effectiveness of manual therapy
14 directed toward the cervicothoracic spine in conjunction with elbow treatment, including
15 benefit in previously recalcitrant cases (Gunn et al., 1976), fewer treatment sessions (Cleland
16 et al., 2004) and greater improvement in short-term pain (Cleland et al., 2005). Interpretation
17 of the foregoing studies in a clinical context is difficult because it is often not clear whether
18 subjects were excluded if they had neck and upper limb symptoms additional to their LE
19 pain.

20
21
22 This study aimed to evaluate whether there are differences in manual examination of the
23 cervical and thoracic spine between healthy controls and LE subjects who did not have
24 additional (or concomitant) neck or upper limb symptoms. Secondly, the relationship
25 between spinal manual examination and radial nerve neurodynamic test responses was
26 examined in LE subjects, as well as the potential influence of pain severity, duration of
27 injury, age and gender.

28
29 METHODS

30 Design

31 This comparative study investigated the prevalence of abnormal findings from a clinical
32 examination of the cervical and thoracic spine and radial nerve in individuals with and
33 without unilateral LE. Data for the LE group was collected prior to enrolment into a
34 randomised controlled trial, the methodology for which is described in detail elsewhere
35 (Coombes et al., 2009).

36 Setting and subjects

37 All subjects were recruited from the greater Brisbane region of Australia through community
38 media advertisements. Eligibility was determined by a two stage process (telephone interview
39 and physical examination) by one researcher (BKC) and confirmed by a second researcher
40 (BV). Criteria for being included in the LE group was unilateral elbow pain over the lateral
41 epicondyle for longer than six weeks and aggravated by a combination of palpation, gripping
42 and resisted wrist and/or finger extension. Exclusion criteria were: recent injection or
43 physiotherapy; exacerbation of elbow pain with neck examination; sensory disturbance of the
44 hands; fractures; elbow surgery; malignancy or inflammatory disorders; pregnancy;
45 breastfeeding; or contraindication to injection. Healthy control subjects aged 35 to 70 with no
46 history of LE were included. All subjects were excluded if they experienced neck or other

47 upper limb symptoms necessitating treatment or preventing participation in usual work or
48 recreational activities in the preceding six months. Ethical approval was granted by the
49 institutional review board (University of Queensland) and informed written consent obtained
50 from all subjects.

51 Measures

52 The tests used in this study were selected because of their frequent use in clinical assessment
53 of the neck and upper limb. All testing was completed by a single physiotherapist with a post-
54 graduate degree in musculoskeletal physiotherapy who was not blinded to whether the subject
55 had LE or not. Spinal manual examination was performed on all subjects, while
56 neurodynamic function was evaluated in LE subjects only. Subjects were asked to rate the
57 level of elbow pain currently experienced at rest and the worst level of pain experienced
58 during the past week on 100mm visual analogue scales (VAS) with the following endpoints:
59 no pain (0mm) and worst pain imaginable pain (100mm).

60 *Manual examination*

61 Manual examination of the cervical and thoracic spine between C4 and T2 segments was
62 performed bilaterally on all subjects in prone lying. The examiner rated the mobility at each
63 site on a previously defined scale (Jull et al., 1994), ranging from 1 (severe hypomobility) to
64 7 (severe hypermobility), with 4 representing normal mobility. The participant verbally rated
65 any pain provoked by examination of each site on an 11-point numerical rating scale. A
66 positive response was defined if moderate to severe hypomobility or hypermobility was
67 present along with a pain response of three or greater (Zito et al., 2006). We based the criteria
68 for impairment on assessment of the quality and range of segmental motion as well as
69 provocation of pain, due to the qualitative nature of assessment of joint motion alone (Jull et
70 al., 1994, Hollerwoger, 2006, Jull et al., 1988). Responses at each site were scored and an
71 aggregate score, consisting of the sum of positive palpation sites, was then derived for further
72 analyses.

73

74 *Neurodynamic examination*

75 The upper limb neurodynamic test (ULNT) for the radial nerve was performed as previously
76 described (Butler, 2000), using the following sequencing: shoulder girdle depression, elbow
77 extension, shoulder internal rotation, pronation, wrist and finger flexion and shoulder
78 abduction to the end of range or until symptoms were produced. Once such a sensation was
79 provoked, structural differentiation between neurogenic and non-neurogenic sources of pain
80 was performed by the addition of sensitising movements at a site distant to the pain (shoulder
81 girdle elevation or cervical lateral flexion) while all other test components were maintained.
82 Based on a previous study evaluating the validity of the ULNT (Nee et al., 2012), the test was
83 considered positive if the following two criteria were present: (1) the subject's symptoms
84 were reproduced at least partially; (2) symptoms were altered by structural differentiation.
85 Moderate reliability (Kappa 0.44) has been reported for the radial nerve ULNT using the
86 above criteria (Schmid et al., 2009).

87

88

89 *Data management and analysis*

90 Statistical analysis was performed using SPSS 20 (IBM, Somers, New York, USA), with a
91 $P < 0.05$ significance level. Manual examination of the cervical and thoracic spine between
92 LE and control groups was compared using repeated measures analysis of variance, including
93 the within-subject factors of side (affected or unaffected) and level (C4-5, C5-6, C6-7, C7-T1
94 or T1-2) and the covariates age and sex. Control subjects were randomly allocated a

95 “matched affected arm” such that the control group had an equivalent proportion of dominant
96 sided arms as that observed in the LE group to account for any potential influence of hand
97 dominance (Coombes et al., 2012, Friedman, 1998). Linear and logistic regression models
98 evaluated the relationship between the aggregate score of spinal palpation sites and the
99 ULNT and potential associated factors of severity of pain and disability, age, sex and
100 duration. All variables were simultaneously entered into the model.

101

102

RESULTS

103 Analysis was possible using data from 164 subjects with LE and 62 controls without LE
104 (Table 1). Demographic characteristics (Table 1) including age, sex, body mass index,
105 manual occupation and sporting participation were not significantly different between groups.
106 LE subjects had an average (\pm standard deviation) duration of injury of 25.1 ± 29.8 weeks
107 (range six to 25weeks), with worst pain over the previous week and current resting pain
108 levels (VAS) of 61.9 ± 18.4 mm and 10.8 ± 13.4 mm respectively. This was the first episode
109 of LE in 76.4% of subjects. Putative causes included work (20.0%), sport (24.2%), overload
110 due to unusual activities (23.6%) and insidious onset (27.3%). The dominant arm was
111 affected in 71% of subjects.

112 Spinal manual examination responses for LE and control groups at each site are presented in
113 Table 2. Positive responses were most prevalent in LE subjects at C5-6 (18.9%) and C6-7
114 (17.7%) on the same side as their LE. Comparison of LE and control groups using repeated
115 measures analysis of variance found significant group by level ($P=0.02$) and group by side
116 ($P=0.04$) interactions, in the absence of a three-way interaction. Post hoc investigation of the
117 group by level interaction (Figure 1) confirmed that positive tests were significantly more
118 common in LE than control subjects at C4-5 ($P=0.01$), C5-6 ($P=0.002$) and C6-7 ($P=0.001$),
119 but not at C7-T1 or T1-2 levels ($P>0.05$). Post hoc investigation of the group by side
120 interaction (Figure 2) showed that positive tests were significantly more common in LE than
121 control subjects, at both the ipsilateral ($P=0.001$) and contralateral side ($P=0.02$) to the injury.

122

123 Evaluation of the number of positive palpation sites showed 36% of LE subjects had
124 impairment of at least one spinal palpation site, with one subject showing impairment at all
125 sites. Linear regression analysis revealed duration of injury was a significant predictor
126 (Standardised β 0.17, 95% CI 0.001 to 0.18; $P=0.03$), whereas pain levels, age or sex were
127 not associated with the total number of positive palpation sites. Subjects with more chronic
128 symptoms showed impairment at a greater number of sites than those with more acute
129 symptoms.

130

131 A positive ULNT was found in 41% of LE subjects. Logistic regression found severity of
132 elbow pain experienced at rest (OR 1.03, 95% CI 1.001 to 1.06; $P=0.04$) and the number of
133 positive palpation sites (OR 1.25, 95% CI 1.01 to 1.55; $P=0.04$) were significant predictors,
134 whereas worst pain level, duration, age and sex were not associated with neurodynamic
135 response. Subjects with higher resting elbow pain and impairment at multiple cervical or
136 thoracic spinal levels were more likely to have a positive ULNT.

137

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139

141 The results of this study indicate that cervical spine impairment, as determined by positive
142 findings on manual palpation, exists in LE subjects who do not have additional neck or upper
143 limb pain. Impairment was evident bilaterally at the cervical spine in unilateral LE, and
144 localised to the lower cervical spine (C4-7) but not the thoracic spine. A longer duration of
145 LE symptoms was associated with a greater risk of cervical spine impairment. Radial nerve
146 mechanosensitivity, as defined as reproduction of LE symptoms during ULNT and changed
147 by sensitisation manoeuvre, was associated with higher severity of elbow pain at rest and
148 more widespread cervical impairment, as inferred by a greater number of positive sites of
149 palpation.

150 With estimates ranging between 57 and 90% (Berglund et al., 2008, Waugh et al., 2004,
151 Vicenzino et al., 1996), the incidence of related cervical spine and radial nerve pathology in
152 the LE population has not been conclusively established. Differences in eligibility criteria,
153 examination procedure and criteria used to detect impairment provide strong sources of
154 heterogeneity between studies. Moreover, the presence of cervical impairment may be seen as
155 a differential diagnosis from true LE (Vicenzino et al., 1996) or as a sub-group thereof
156 (Figure 3). Within our LE population with mean duration of 25 weeks, a subgroup (36%) of
157 patients displayed impairment of at least one spinal palpation site or had a positive ULNT
158 (41%). Significantly larger rates were found by Berglund (2008) in their study of 31 patients
159 with lateral elbow pain (Berglund et al., 2008). A majority of subjects (70%) indicated pain in
160 the cervical or thoracic region on a pain drawing and 55% had pain (either locally or referred
161 to the elbow) on compression of the cervical vertebral foramina. Positive radial nerve
162 neurodynamic tests were found in 58% of patients, defined as pain in the forearm at less than
163 40 degrees of shoulder abduction. These differences may be explained by their more chronic
164 population (mean 36 months) or broader definition of lateral elbow pain, which included
165 cases in which elbow pain was reproduced by cervical examination, arguably a differential
166 diagnosis for LE. In another study, Waugh (2004) investigated 81 patients with unilateral LE
167 (mean duration 31 weeks), excluding those with concurrent upper quadrant symptoms not
168 directly related to their LE (Waugh et al., 2004). Symptomatic cervical signs, defined as at
169 least one active and passive accessory movement (C4-T1) provoking pain and displaying
170 abnormal end-feel, were found in 56% of cases. Consistent with results of our study, 41% had
171 a positive ULNT that reproduced their LE symptoms. In a novel study, Pienimaki (2011)
172 recruited 190 patients with unilateral medial or lateral epicondylitis, without exclusion
173 (Pienimaki et al., 2011). On pain drawing, 45% reported widespread pain over the neck or
174 upper limb, in addition to local elbow and/or forearm pain. Interestingly, widespread pain
175 was also relatively common (39%) in the subgroup without other diagnosed musculoskeletal
176 disorders (Pienimaki et al., 2011). In this population with chronic symptoms (mean duration
177 45 weeks), widespread pain was associated with female sex, long duration of symptoms, high
178 pain scores, sick leave and low levels of physical activity.

179 Our findings of cervical impairment in a subgroup of LE patients without concomitant neck
180 or other arm conditions, provides strength to the growing body of evidence inferring central
181 sensitisation mechanisms (Coombes et al., 2012, June 13, Lim et al., In press, Fernandez-
182 Carnero et al., 2009, Slater et al., 2005), whereby repeated nociceptor inputs from elbow
183 structures may trigger an increase in the excitability and synaptic efficacy of neurons in
184 central nociceptive pathways (Woolf, 2010). Convergence of afferent input from the lateral
185 elbow and C4-7 cervical segments may underlie the greater incidence of impairment at these
186 spinal segments, whilst receptive field expansion may explain the presence of bilateral
187 impairment in a unilateral condition. We propose that radiculopathy or somatic referral from

188 cervical structures is a less likely mechanism underlying findings in our population, due to
189 careful history taking and physical examination, although sub-clinical cases of referred pain
190 cannot be discounted. Another possible mechanism might be related to the generalised motor
191 impairment of the upper limb (Coombes et al., 2012, Alizadehkhayat et al., 2007, Bisset et
192 al., 2006) through which altered mechanical loading of the neck during upper limb activities
193 could plausibly promote the development of cervical impairment. Whilst causation cannot be
194 inferred from our cross-sectional study and the size of the associations detected on regression
195 analyses were small, the data lends some support to the notion that more widespread cervical
196 impairment is associated with chronicity. A weak but significant correlation was found
197 between cervical and neurodynamic assessments, indicating that whilst related they may
198 reflect different underlying mechanisms. Positive ULNT was similar in both acute and
199 chronic LE, but was associated with greater resting pain levels. Previous study of chronic LE,
200 did not find an association between positive ULNT and central hyperexcitability as measured
201 by nociceptive withdrawal reflex (Lim et al., In press). It is possible that radial nerve
202 mechanosensitivity represents a normal physiological response to greater pain severity at the
203 time of testing rather than one of augmented central hypersensitivity.

204 Before drawing clinical implications from this study, it is important to consider several
205 points. Firstly, the population studied was self-referred via community media announcements
206 as a part of a randomised controlled trial and underwent a thorough interview and
207 examination. The examination sought to exclude other comorbid upper limb or cervical
208 symptoms in the experimental sample. This needs to be considered in translation of the
209 findings into clinical practice, that is, the findings relate to a reasonably localised lateral
210 elbow and dorsal forearm pain state. Previous comparison of two LE populations, one of
211 which was recruited in a similar manner to ours, the other recruited from general practice,
212 found similar pain severity, age and history of elbow symptoms between the trials, supporting
213 the generalizability of findings (Bisset et al., 2007).

214 Secondly, we chose measures that are commonly used in clinical assessment of the upper
215 quarter. However, more confidence in the utility, relevance and importance of these
216 techniques would have been achieved if their reliability had been established in this
217 population and the examination was performed by an investigator blinded to the group or side
218 studied. A previous systematic review questioned the reliability of manual tests alone to
219 detect cervical spine dysfunction (Hollerwoger, 2006). However, the majority of studies
220 included in this review examined either segmental mobility or pain as an outcome. In
221 comparison, our study, along with that by Waugh (2004), defined spinal segments as
222 impaired if they exhibited abnormal motion and provoked pain (Waugh et al., 2004). In
223 addition, we examined multiple segmental levels, in an effort to highlight both the segmental
224 location and extent of spinal impairment. Secondly, while there is insufficient evidence in the
225 literature to support an isolated test of the radial nerve, we aimed to identify patients in whom
226 LE symptoms were at least partly related to the nerves in the neck and arm that had become
227 sensitive to movement. We defined a positive ULNT as reproduction of a patient's LE
228 symptoms and changed by structural differentiation (sensitisation manoeuvres), as
229 recommended in a recent review of the validity of ULNT (Nee et al 2012), consequently the
230 test was not performed in control participants as they did not experience such symptoms.
231 Previous studies have found a high rate of false positive tests in asymptomatic individuals
232 and recommended that reproduction of the patient's symptoms should be an integral part of
233 the diagnostic criteria (Davis et al., 2008).

234 This cross-sectional study of 222 subjects provides a valuable summary of spinal and
235 neurodynamic function and might assist in clinical decision making regarding use of physical

236 modalities for LE. Preliminary work has demonstrated the effectiveness of manual therapy
237 directed to the cervical spine in conjunction with elbow treatment for patients with LE
238 exhibiting cervical impairment (Cleland et al., 2005). Our results highlight patients with
239 longer duration of LE as potential candidates for spinal manual therapy and may explain the
240 greater hypoalgesic effect of cervical compared to thoracic spinal manipulation in this
241 population (Fernandez-Carnero et al., 2011). Secondly, results suggest that techniques to
242 reduce nerve mechanosensitivity may be of benefit in a subgroup of patients with more
243 severe resting pain. Whilst the effectiveness of neural tissue management has not been
244 addressed in LE, immediately clinically relevant benefits have been demonstrated in patients
245 with nerve-related neck and arm pain, using cervical manual therapy and a home exercise
246 program of nerve gliding exercises (Nee et al., 2012).

247 Differentiation of LE subgroups with cervical and neural impairment might be an important
248 prerequisite for effective treatment, and evaluation of their prognostic capacity is necessary.
249 It is important that future efforts are made to improve the reliability of measures of cervical
250 and neurodynamic impairment so that subgroups can be determined with improved veracity.
251 Careful exclusion of patients with referred pain or other concomitant neck or upper limb
252 conditions by this study provides a logical step for this field of interest.

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337 **Figure 1.** Results of spinal manual examination in lateral epicondylalgia (LE) and control (C)
338 subjects at each segmental level. Data illustrates the significant group by level interaction.

339

340 **Figure 2.** Results of spinal manual examination in lateral epicondylalgia (LE) and control (C)
341 subjects at the side ipsilateral and contralateral to injury. Data illustrates the significant group
342 by side interaction.

343

344 **Figure 3.** Cervical impairment may exist in a subgroup of patients with lateral epicondylalgia
345 or implicate a differential diagnosis.

346