

The association between the static posture of the cervical spine and cervicogenic headache

Peter Keith Farmer

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Declarations

I hereby certify that the work embodied in this thesis is the result of original research and has not been submitted for a higher degree to any other University or institution.

Signed

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Table of Contents

Declarations	i
Acknowledgements	ii
Table of Contents	iv
List of Tables	vii
List of Figures.....	viii
Abbreviations and list of terms.....	ix
Abstract x	
Chapter 1 Introduction.....	1
1.1 Background	1
1.2 Aims	4
1.3 Hypotheses	5
1.4 Null Hypotheses.....	5
1.5 Structure of the thesis.....	6
Chapter 2 Literature Review	7
2.1 Overview	7
2.2 Headache diagnosis.....	9
2.2.1 Theorised mechanisms of tension type headaches.....	11
2.2.2 Theorised mechanisms of migraine	12
2.2.3 Theorised mechanisms of CEH	12
2.3 Aetiology of Cervicogenic headache	13
2.3.1 Articular system	15
2.3.2 Dura mater	20
2.3.3 Neural system.....	20
2.3.4 The muscular system.....	22
2.3.5 Summary of CEH aetiology	22
2.4 Cervicogenic headache (CEH) diagnosis.....	24
2.4.1 International Headache Society diagnostic criteria.....	25
2.4.2 Cervicogenic Headache International Study Group (CHISG) diagnostic criteria	26
2.5 CEH diagnosis: Using diagnostic blocks or clinical signs?.....	28
2.5.1 Using diagnostic blocks for CEH diagnosis	28
2.5.2 Using clinical signs for CEH diagnosis	30
2.6 Evidence that a combination of clinical signs may be needed in CEH diagnosis ..	31
2.7 Posture.....	33
2.8 Why investigate posture?	36
2.9 Abnormal posture and different headache types.....	38
2.9.1 Postural assessment in headache.....	38
2.9.2 Postural assessment in headache: sagittal plane	39
2.10 Postural assessment in headache: horizontal plane.....	52
2.10.1 Measuring C1 horizontal plane posture	53
2.10.2 Measuring C2 horizontal plane posture	53
2.10.3 Factors complicating C2 horizontal plane assessment.....	55

2.10.4 Research investigating horizontal plane posture at C2 in headache patients.	59
2.10.5 Horizontal plane measurement techniques for C2	62
2.11 Why is assessing posture in CEH important?	66
2.12 Proposed methods for analysing posture in the upper cervical spine	69
2.13 Palpation assessment of posture in CEH	71
2.14 Radiographic assessment of posture in CEH	76
2.15 Summary	78
Chapter 3 Method	80
3.1 Overview	80
3.2 Study design.....	81
3.2.1 Rationale for study design	82
3.3 Sample Size.....	84
3.4 Recruitment.....	85
3.5 Inclusion and exclusion criteria	87
3.5.1 CEH group inclusion and exclusion criteria	92
3.5.2 Control group inclusion and exclusion criteria.....	96
3.6 Data collection	97
3.6.1 Postural palpation assessment.....	97
3.6.2 Radiograph method and measurement.....	101
3.7 Data analysis	112
3.7.1 Participant physical characteristics	112
3.7.2 Postural palpation assessment.....	112
3.7.3 Radiographic examination	113
3.7.3.1 Reliability of the radiographic measurement.....	113
3.7.3.2 Investigating the association between CEH and spinal posture.....	113
3.7.3.3 Sub-group analysis based on headache distribution	114
3.7.4 Statistical analysis.....	115
Chapter 4 Results	116
4.1 Overview	116
4.2 Physical characteristics of participants	116
4.3 CEH group characteristics	118
4.4 Using palpation to assess cervical spinal posture	121
4.5 Radiographic measurement of cervical spinal posture	122
4.5.1 Reliability of the radiographic measurements	123
4.5.2 Analysis of associations between posture and CEH using the radiographic measurements.....	124
4.5.3 Correlations between the measured spinal postural variables on radiographs	126
4.5.4 Logistic regression analysis of radiographic measurements.....	127
4.6 Sub-group analysis based on headache distribution	128
4.6.1 The effect of age or gender differences on the sub-group analysis	129
4.6.2 Findings of sub-group analysis	130
Chapter 5 Discussion.....	131
5.1 Principal Findings	131
5.2 Population	132
5.2.1 Participants.....	132

5.2.2 Examiners	133
5.3 General cervical lordosis.....	133
5.4 Upper cervical spinal posture.....	139
5.5 Clinical implications	140
5.5.1 Reliability of cervical postural palpation assessment	140
5.5.2 The association between static cervical spinal posture and cervicogenic symptoms	144
5.5.3 Understanding the association between CEH and general cervical lordosis ..	146
5.5.4 Does an increased cervical lordosis differentiate CEH from other headache types or ‘normals’?	149
5.5.5 Association between the distribution of the headache and posture	151
5.5.6 Relationship between upper cervical posture and general cervical posture ..	153
5.5.7 Reliability of radiographic measurements	154
5.6 Limitations	155
5.6.1 The order of the palpation and radiographic assessments	155
5.6.2 CEH subgroups	157
5.6.3 Patient position in the postural palpation assessment	157
5.6.4 Posture may alter when CEH patients are not experiencing symptoms	158
5.7 Future Research	159
5.7.1 Cervical lordosis in other headache types.....	159
5.7.2 Investigating the nature of the association between CEH and posture	160
5.7.3 Investigating the link between upper cervical flexor function and posture ...	161
5.7.4 Does the postural presentation vary in subgroups of CEH patients?.....	161
5.7.5 Investigating other components of posture	163
5.7.6 Determining the specificity of the palpation for reproduction of familiar headache.....	164
5.7.7 Assessing the reliability of postural palpation in different patient positions.	165
5.8 Summary and Conclusions	165
Reference List.....	168
Appendix A Ethics approval letters.....	179
Appendix B Recruitment flyer	182
Appendix C Research Information Statement.....	183
Appendix D Phone Call Screening Questionnaire.....	187
Appendix E Examiner Recording Sheet for Palpation for Reproduction of Familiar Headache.....	189
Appendix F Examiner Recording Sheet for Postural Palpation Assessment ...	190
Appendix G Data for postural palpation assessment	191

List of Tables

Table 4. 1 The age and gender characteristics of the participants in the cervicogenic headache (CEH) and control groups.	117
Table 4. 2 Number of CEH participants reporting reproduction of their familiar headache with palpation at each cervical level.	119
Table 4. 3 The age and gender of the participants with CEH separated into sub-groups based on the distribution of their reported headache reproduced by palpation.	120
Table 4. 4 Kappa scores and standard error for the agreement between physiotherapy examiners for each of the spinal postural variables assessed with postural palpation....	121
Table 4. 5 Intraclass correlation coefficients (ICC) (2,1) and 95% confidence intervals (CI) of the cervical spinal postural variables measured on radiographs.	123
Table 4. 6 Descriptive statistics, normality tests and comparisons of radiographic postural variables between participants in the cervicogenic headache (CEH) and control groups.	125
Table 4. 7 Pearson's correlation between the radiographic measures of cervical spinal posture for the whole sample and for the CEH group.	126
Table 4. 8 Associations between the radiological measurements of the cervical spinal postural variables and the likelihood of experiencing CEH.	127
Table 4. 9 Characteristics of the CEH, control and headache distribution sub-groups. .	129
Table 5. 1 Comparison of general cervical lordosis (C2-C7 Cobb angle) measurements (degrees) between the present study and Harrison et al. (2004).	135

List of Figures

Figure 2. 1 Illustration of the convergence of inputs from the trigeminal nerve with the inputs from the cervical region (muscle, joints and skin) onto the second-order neurones in the trigeminocervical nucleus (Goadsby & Bartsch, 2008).	10
Figure 2. 2 Illustrates the proposed ‘ideal’ static posture in the sagittal plane with the line of gravity aligned with the atlanto-occipital junction (AOJ), cervicothoracic junction (CTJ), thoracolumbar junction (TLJ) and lumbosacral junction (LSJ) (Boyle et al., 2002).	34
Figure 2. 3 Illustration of the craniovertebral angle measurement method. The craniovertebral angle is the angle between the horizontal line passing through C7 and a line extending from the tragus of the ear to the tip of the C7 spinous process (Fernandez-de-Las-Penas, Cuadrado, & Pareja, 2007).	41
Figure 2. 4 Illustration of the upper cervical lordosis radiographic measurement method. The acute angle between the two lines is measured in degrees to indicate the upper cervical lordosis (Johnson, 1998).	49
Figure 2. 5 Illustration of the C2-7 Cobb angle radiographic measurement of general cervical lordosis. The acute angle between the two perpendiculars is measured in degrees to indicate the general cervical lordosis (D.E. Harrison et al., 2000).	50
Figure 2. 6 Illustration of the posterior tangent method for radiographically measuring the cervical lordosis. The C2-C7 posterior tangent is the acute angle between two lines: one line connecting the posterior-superior point on C2 and the posterior-inferior point on C2, and the second line connecting the posterior-superior point on C7 and the posterior-inferior point on C7 (D. E. Harrison et al., 2000).	51
Figure 2. 7 Represents a typical C2 vertebra viewed in the horizontal plane.	54
Figure 2. 8 Represents a deviation of the C2 spinous process to the left with C2 viewed in the horizontal plane.	56
Figure 2. 9 Represents a rotation of the C2 vertebra to the right with C2 viewed in the horizontal plane.	57
Figure 2. 10 Represents an asymmetrical bifid C2 spinous process with the right tip being more prominent, viewed in the horizontal plane.	58
Figure 2. 11 Demonstrates the technique for measuring C2 spinous process deviation from the midline using an AP X-ray (the distance in millimetres between the lines indicates the deviation of the C2 spinous process from the midline) (Gradl et al., 2005).	64
Figure 2. 12 Demonstrates the distances measured in the odontoid lateral mass interspace technique (Iannacone et al., 1990).	65
Figure 3. 1 Flow chart demonstrating the sequencing of the recruitment process for potential participants and the assessments performed on participants.	86
Figure 3. 2 Example of upper cervical lordosis measurement on a radiograph.	107
Figure 3. 3 Example of a general cervical lordosis measurement (Cobb C2-C7 measurement) on a radiograph.	109
Figure 3. 4 Example of a C2 spinous process deviation measurement on a radiograph.	111

Abbreviations and list of terms

C2	Axis (second cervical vertebra)
CEH	Cervicogenic headache
CI	Confidence intervals
DevL	Deviated left
DevR	Deviated right
GCL	General cervical lordosis
ICC	Intraclass correlation coefficient
RotL	Rotated left
RotR	Rotated right
SPD	Spinous process deviation
UCL	Upper cervical lordosis

Abstract

Research previously investigating cervical posture reports an association between cervical spinal posture and tension type headaches and migraines but no association between cervicogenic headache (CEH) and cervical spinal posture. These reports lead to the competing conclusions that there is either no association between CEH and abnormal posture or that the methods used to assess posture in the previous studies did not isolate the specific postural variables that are associated with CEH.

The present study used a single blind, age and gender matched, comparative measurement design to evaluate the differences in cervical spinal posture, measured on cervical radiographs, between asymptomatic participants (control group) and participants who had cervicogenic headache (CEH). There were two main objectives of the present study. The first was to determine if radiographic assessment can identify differences in sagittal plane posture and C2 spinous process alignment in the horizontal plane in individuals with CEH compared to controls. The second was to determine whether physiotherapist examiners could determine the presenting posture of the cervical spine using a palpation assessment.

The association between CEH and measures of cervical spinal posture using cervical radiographs were studied in 30 CEH participants and 30 age and gender matched control participants. The cervical spine postural variables assessed were general cervical lordosis (GCL), upper cervical lordosis (UCL) and C2 spinous process alignment. Differences between postural variables between the two groups were determined using paired t-tests

(matching participants by age and gender) or the non-parametric equivalent where appropriate. Logistic regression determined the postural variables which increased the likelihood of experiencing CEH. The same postural variables of these same participants were also assessed by two experienced physiotherapy examiners using palpation. Kappa was used to determine reliability of physiotherapist palpation assessment.

The results of the present study did not identify any postural variables that could differentiate the CEH from the control participants using radiographs (GCL $p = 0.06$, UCL $p = 0.10$, C2 deviation $p = 0.77$). The logistic regression analysis did, however, demonstrate that there was a statistically significant association between increased general cervical lordosis, as measured on radiographs, and an increased likelihood of experiencing CEH ($p = 0.042$). This association was not found for UCL ($p = 0.09$) or C2 deviation ($p = 0.74$). The present study also found that experienced physiotherapy examiners were unreliable at determining the postural presentation of the cervical spine (Kappa GCL = 0.15, UCL = 0.19, C2 = 0.04, 95% CI GCL = -0.07 - 0.37, UCL = -0.02 - 0.42, C2 = -0.10 - 0.18).

These results suggest that GCL may be an important clinical characteristic to identify in the assessment or management of CEH. However, physiotherapist palpation alone is not recommended to assess GCL, as therapists were unreliable in this study. These results suggest that increased GCL increases the likelihood of experiencing CEH. Therefore, future assessment and management strategies for this condition should consider including assessment of cervical lordosis.

Chapter 1 Introduction

1.1 Background

Posture is a factor that is considered by many health care professionals, including physiotherapists, chiropractors, osteopaths and medical practitioners, to be an important component of the clinical presentation of their patients. Many clinicians routinely analyse their patient's postural presentation (Christensen & Hartvigsen, 2008). As with other components of the clinical examination, the aim of postural assessment is to identify factors that may be associated with mechanical dysfunction and presenting symptoms. Musculoskeletal clinicians commonly use treatment strategies that aim to alter posture (Keating et al., 2005). Assessment and treatment of posture is common despite there being very little evidence that altered posture is associated with symptoms, or that treatment strategies can improve posture related symptoms (Christensen & Hartvigsen, 2008; Refshauge & Gass, 2004).

Cervicogenic headache (CEH) is one of the more commonly presenting musculoskeletal conditions that has been reported to be associated with abnormal posture (Jull, 1997; Richardson, 2009). CEH is a specific type of headache where the symptoms originate from a mechanical dysfunction in the cervical spine but the pain is perceived in the head (Bogduk & Govind, 2009). Abnormal posture has been proposed to be either an aggravating factor or the underlying cause of CEH (Jull, 1997; Richardson, 2009).

However, research previously investigating cervical posture in CEH has not demonstrated an association between the two (Dumas et al., 2001; Zito, Jull, & Story, 2006). These reports lead to the competing hypotheses that there is either no association between CEH and abnormal posture or that the methods used to assess posture in these previous studies did not isolate the specific postural variables that are associated with CEH.

This study aims to analyse the association between abnormal cervical posture and CEH using cervical radiographs. There have been no previous studies identified that have used radiographic assessment of posture in CEH. Radiographic measurement techniques were used as they have been found to reliably measure cervical postural variables (Cote, Cassidy, Yong-Hing, Sibley, & Loewy, 1997; Johnson, 1998). Radiographs also make it possible to measure upper cervical spine posture using specific landmarks which are not visible using visual or photographic methods (Gradl, Maier-Bosse, Penning, & Stabler, 2005; Johnson, 1998). Measurements of upper cervical spine posture were included as it is generally accepted that the upper cervical spine is the primary region in the neck from which CEH symptoms originate (Bogduk, 2001; Narouze, Casanova, & Mekhail, 2007; Ward & Levin, 2000).

This study also aims to determine if physiotherapist palpation is a reliable form of assessment of posture in the cervical region. The analysis of palpation as a method to determine postural presentation was included as it has been recommended that a thorough assessment of upper cervical spinal posture ideally requires combining the results both of

a palpation assessment and a radiographic assessment (Jende & Peterson, 1997; Maitland, Hengeveld, Banks, & English, 2005). This advice assumes that both assessment methods are reliable. No research has been identified that has assessed the reliability of palpation assessment for cervical spinal posture.

Determining the reliability of palpation assessment is also important as patients sometimes present to physiotherapists without cervical radiographs and in this situation knowing the reliability of cervical palpation assessment would help the physiotherapist decide whether performing this method of postural evaluation is appropriate. Further, if cervical palpation assessment of posture is shown to be reliable then it may be appropriate to modify advice recommending the use of cervical radiographs for postural assessment.

1.2 Aims

The specific aims of the present study were to:

- Evaluate the inter-rater reliability of physiotherapist examiners in assessing the horizontal plane posture of the C2 vertebra using palpation
- Evaluate the inter-rater reliability of physiotherapist examiners in determining the presenting postural characteristics of the overall sagittal curve of the cervical spine
- Evaluate the inter-rater reliability of physiotherapist examiners in determining the presenting postural characteristics of the sagittal curve of the upper cervical spine
- Determine if there is an association between altered C2 spinous process position measured using an antero-posterior (AP) open mouth X-ray view and CEH
- Determine if there is an association between altered general cervical lordosis measured using a lateral X-ray view and CEH
- Determine if there is an association between altered upper cervical lordosis measured using a lateral X-ray view and CEH.

1.3 Hypotheses

1. Trained and experienced physiotherapists can use palpation to consistently determine the presenting postural characteristics of the cervical spine for the variables assessed
2. Radiographic assessment can identify statistically significant differences in the C2 spinous process alignment in the horizontal plane in individuals with CEH when compared to controls
3. Radiographic assessment can identify statistically significant differences in the sagittal plane posture in individuals with CEH when compared to controls.

1.4 Null Hypotheses

1. Trained and experienced physiotherapists cannot use palpation to consistently determine the presenting postural characteristics of the cervical spine for the variables assessed
2. Radiographic assessment does not identify any statistically significant differences in the C2 spinous process alignment in the horizontal plane in individuals with CEH when compared to controls
3. Radiographic assessment does not identify any statistically significant differences in the sagittal plane posture in individuals with CEH when compared to controls.

1.5 Structure of the thesis

This thesis is structured in a traditional format. The following four chapters are the literature review, method, results and discussion chapters. The hypotheses being investigated can be separated into two distinct components. These two components are firstly the investigation of the reliability of palpation assessment to determine cervical posture and secondly the radiological assessment of posture in CEH. The literature review provides a background for the two hypotheses being investigated in the present study. The method, results and discussion chapters also separate these two components. Further, the discussion chapter then amalgamates the results of the two components of the present study to determine the limitations and clinical implications of these findings, potential directions for future research and conclusions.

Chapter 2 Literature Review

2.1 Overview

Headaches are a common condition that is often a major cause of disability. The prevalence of headaches is high with an estimated 46% of the adult population having a currently active headache disorder (Stovner et al., 2007). The level of disability caused by headaches is not only determined by their prevalence but also by the severity and/or frequency of the symptoms. It has been reported that in adults that have experienced headaches in the last 12 months there is a 50% incidence of at least one severe headache episode and a 75% incidence of recurrent headache symptoms (Cady, Schreiber, Farmer, & Sheftell, 2002). Quality of life is more negatively affected in individuals with recurrent headache types than in those with less recurrent headaches (Stovner et al., 2007). This suggests that research should focus on individuals with recurrent headache types.

Recurrent headache types can be separated into two major categories: primary headaches and secondary headaches. Primary headaches are not associated with another disease, whereas secondary headaches are caused by an associated disease process (Ahn, Mun, Kim, Oh, & Han, 2008). Migraine and tension type headaches are the two most common forms of recurrent headache and these are both considered primary headaches. The third most common form of recurrent headache is cervicogenic headache (CEH) and it is a type of secondary headache (Sjaastad & Bakketeig, 2008). CEH are reported to account for 15-20% of recurrent headaches (Haldeman & Dagenais, 2001).

CEHs are considered a secondary headache because the pain is perceived in the head but is referred from a primary source in the neck (Bogduk & Govind, 2009). The quality of life burden for CEH patients has been reported to be substantial and comparable to that experienced in migraine and tension type headaches (van Suijlekom, Lame, Stomp van den Berg, Kessels, & Weber, 2003). A recent epidemiological study on headaches reported that CEH has a prevalence of 4.1% in the general community (Sjaastad & Bakketeig, 2008). The combination of the prevalence and quality of life burden in patients with CEH suggests there is substantial disability associated with CEH in the community. The proposition that the neck can be the cause of headaches is still, however, controversial (Antonaci, Bono, Mauri, Drottning, & Buscone, 2005). This controversy suggests that further research into CEH is required. Improving knowledge of the factors associated with CEH is expected to both improve the ability to provide an accurate diagnosis and also to provide an improved basis for future assessment and treatment of this condition.

2.2 Headache diagnosis

Correctly diagnosing the type of headache that a patient is experiencing is important as this diagnosis often determines the type of treatment that is provided (Hanten, Olson, & Ludwig, 2002; Lucas, Macaskill, Irwig, Moran, & Bogduk, 2009). The difficulty in establishing CEH as a diagnosis is largely due to difficulties in distinguishing this headache type from tension-type headache and migraine without aura (Gadotti, Armijo, & Magee, 2008; Haldeman & Dagenais, 2001; Martelletti & van Suijlekom, 2004). Achieving a CEH diagnosis requires an ability to discriminate between the different headache types. This discrimination process is based on the generally accepted assumption that each headache type is caused by a different underlying mechanism (Fernandez-de-las-Penas, 2008; Hall, Briffa, & Hopper, 2008). The ability to discriminate headache types is also based on the secondary assumption that there will be a different pattern of clinical signs associated with each different underlying mechanism.

The challenge in distinguishing CEH from tension-type headache and migraine stems from the similar neuroanatomical pathways taken by the nociceptive signals that produce these headaches (Goadsby, 2009). Nociceptive signals are information regarding tissue damage that is transmitted along nerves to the spinal cord and the cortex of the brain (Bogduk, 1991). The nociceptive signals in each of these headache types are proposed to originate from different structures but in each case they have been proposed to converge onto the trigeminocervical nucleus in the spinal cord (Fernandez-de-las-Penas, Cuadrado, Arendt-Nielsen, Simons, & Pareja, 2007; Goadsby & Bartsch, 2008) (Figure 2.1).

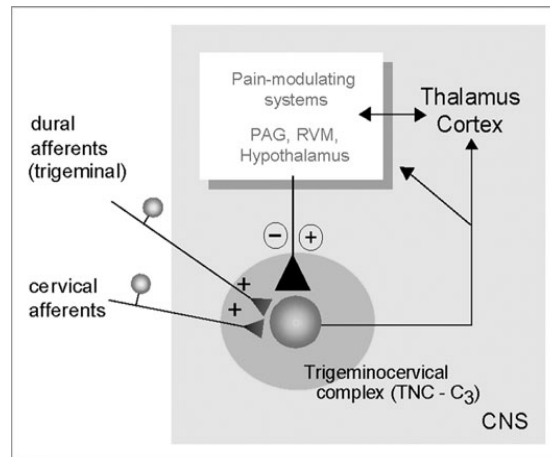


Figure 2. 1 Illustration of the convergence of inputs from the trigeminal nerve with the inputs from the cervical region (muscle, joints and skin) onto the second-order neurones in the trigeminocervical nucleus (Goadsby & Bartsch, 2008).

The trigeminocervical nucleus is a collection of relay neurones that transfer nociceptive information from cervical structures and from structures in the head supplied by the trigeminal nerve to the pain processing regions of the brain (Bartsch & Goadsby, 2003). The common pathway taken by the nociceptive signals in these three common headache types suggests that there may not be a completely different mechanism underlying these headaches. Despite different hypothesised origins of the nociceptive signals in each of these headache types, the symptoms are all believed to result from a sensitisation of the trigeminocervical nucleus (Bartsch, 2005). The degree of sensitisation of the trigeminocervical nucleus is reported to be affected by the intensity and duration of the nociceptive input, the descending influences from the brain (either inhibiting or facilitating the nociceptive signals) and from further processing in the brainstem,

thalamus and cortex (Goadsby & Bartsch, 2008). Pain, including the pain experienced in headaches, is theorised to occur only following the central nervous system processing of nociceptive signals (Merriskey, 1986). Therefore, the expression of each of these different headache types has been proposed to be due to an interplay between central nervous system processing and trigeminocervical nucleus sensitisation processes (Goadsby & Bartsch, 2008).

The primary difference between the three main types of recurrent headaches, migraine, tension-type and CEH, is proposed to be the different original source of nociceptive signals that results in the sensitisation of the trigeminocervical nucleus (Goadsby & Bartsch, 2008). The theorised mechanisms for the generation of the nociceptive signals with these three recurrent headache types are described below.

2.2.1 Theorised mechanisms of tension type headaches

The cause of tension type headache pain is not completely understood, however a theory has been proposed that tension type headaches are associated with trigeminocervical nucleus sensitisation from muscular trigger points. This theorised mechanism is based on an association that has been demonstrated between tension type headaches and referred pain from ‘trigger points’ in muscles of the head, neck and shoulders (Fernandez-de-las-Penas & Schoenen, 2009). Trigger points are defined as hyperirritable areas within a taut band of skeletal muscle that is painful on compression and which usually results in pain referring or spreading to areas other than the compressed point (Fernandez-de-las-Penas,

Cuadrado, Arendt-Nielsen et al., 2007; Lucas et al., 2009). These trigger points have been found in the muscles supplied by the upper cervical or trigeminal nerves that have a direct neurological connection to the trigeminocervical nucleus (Fernandez-de-las-Penas, Cuadrado, Arendt-Nielsen et al., 2007).

2.2.2 Theorised mechanisms of migraine

Migraine headaches are believed to be predominantly due to a neuro-vascular disorder in the brain (Goadsby, Lipton, & Ferrari, 2002). The migraine symptoms are hypothesised to occur due to an inflammation of the meningeal vascular structures (Bo et al., 2009). These vascular structures are innervated by the trigeminal nerves (Goadsby et al., 2002). The nociceptive activity that is generated as a result of the inflammation of the vascular structures is theorised to result in migraine symptoms through a sensitisation of the trigeminocervical nucleus through the trigeminal nerves (Goadsby & Bartsch, 2008).

2.2.3 Theorised mechanisms of CEH

CEH are proposed to be due to nociceptive impulses generated in the cervical region that then pass along the upper cervical spinal nerves and into the trigeminocervical nucleus in the spinal cord (Bartsch & Goadsby, 2003). The upper cervical spine is generally accepted to be the primary region in the neck that is the source of CEH symptoms due to the direct connection between the upper cervical nerves and the trigeminocervical

nucleus (Bogduk, 2001; Narouze et al., 2007; Ward & Levin, 2000). A persistent stream of nociceptive impulses or a single strong noxious stimulus along the upper cervical nerves causes a sensitisation of the trigeminocervical nucleus (Goadsby & Bartsch, 2008). The lower cervical spinal levels have been reported to be more likely to be associated with symptoms in the neck or shoulder girdle (Cooper, Bailey, & Bogduk, 2007).

2.3 Aetiology of Cervicogenic headache

By definition, CEH occurs because of nociceptive input originating from the cervical region (Bogduk & Govind, 2009). CEH diagnosis, therefore, needs to be based on establishing a cervical source of nociceptive input (Goadsby & Bartsch, 2008). One difficulty in diagnosing CEH stems from an inability to determine whether the trigeminocervical nucleus has been sensitised by sources other than the cervical spine. Sensitisation of the trigeminocervical nucleus can also occur from persistent trigeminal nociceptive input or from changes in the central nervous system pain modulation system (Figure 2.1). Pain and symptoms that are very similar in nature to those experienced with CEH can, therefore, be experienced in headaches where the primary cause is not from the cervical region. This can make differentiating CEH from other headache types difficult.

The perception of pain in the head in CEH is believed to occur because of the convergence of the upper cervical nerves and the trigeminal nerves from the head into the trigeminocervical nucleus (Goadsby, 2009). The trigeminal nerve is the largest of the

cranial nerves and it carries motor supply to the muscles of mastication and transmits sensory information from the face, oral and nasal cavities, and most of the scalp (Woolfall & Coulthard, 2001). The convergence of the nerves from these two regions (the cervical region and the head) onto the trigeminocervical nucleus, when combined with a sensitisation of the trigeminocervical nucleus, is believed to be the neuro-anatomical basis of CEH (Bartsch & Goadsby, 2003; Martelletti & van Suijlekom, 2004; Piovesan et al., 2001).

Almost every structure and pathology in the cervical spine has been implicated as a possible aggravating factor or cause of CEH (Haldeman & Dagenais, 2001). Structures innervated by the C1, C2 or C3 spinal nerves are proposed to be associated with CEH via trigeminocervical nucleus sensitization as the upper cervical spinal nerves are the only cervical nerves that directly connect into the trigeminocervical nucleus (Bartsch & Goadsby, 2003). These upper cervical spine (C1-C3) nerves have been reported to innervate joints (the atlanto-occipital joint, medial and lateral atlanto-axial joints and the C2-C3 zygapophyseal joints), the C2-C3 disc, muscles (including the sub-occipital muscles, upper trapezius and sternocleidomastoid muscles), the upper cervical spinal dura mater and the vertebral arteries (Fleming, Forsythe, & Cook, 2007). All of these would thus be possible sources of CEH symptoms. However, CEH symptoms have also been shown to be associated with lower cervical spondylosis, as well as with injury to lower cervical discs and joints (Diener, Kaminski, Stappert, Stolke, & Schoch, 2007; Jansen & Sjaastad, 2007; Kawabori, Hida, Yano, & Iwasaki, 2009; Michler, Bovim, & Sjaastad, 1991). The generation of CEH from lower cervical pathology has been proposed to

indicate that pain afferents from the lower cervical nerve roots may also converge on to the trigeminocervical nucleus (Diener et al., 2007).

Some structures have been proposed as likely sources of CEH symptoms. Providing evidence of a definite association between CEH and these structures would be expected to provide a more specific direction for the assessment and treatment of this condition. The specific structures that have been proposed to primarily contribute to the symptoms in CEH include the articular system, dura mater, nerves and the muscular system (Bartsch & Goadsby, 2002; Fernandez-de-las-Penas, 2008; Fleming et al., 2007; Goldberg, Schwartzman, Domskey, Sabia, & Torjman, 2008). Evidence to support the theories about these cervical structures proposed to be most likely involved in CEH is discussed below.

2.3.1 Articular system

One common theory is that CEH is predominantly related to 'joint dysfunction' in the cervical spine (Fernandez-de-las-Penas, 2008; Paluzzi, Belli, Lafente, & Wasserberg, 2006). The type of joint dysfunction that contributes to CEH is currently under debate with joint hypomobility and hypermobility both having been proposed by different authors to be associated with CEH (Ogince, Hall, Robinson, & Blackmore, 2007; Rozen, Roth, & Denenberg, 2006). There is also debate about the cervical joint level that is most commonly associated with CEH (Cooper et al., 2007; Hall, Briffa, Hopper, & Robinson, 2010). The following section examines the research that has focussed on the articular system in CEH.

Joint hypomobility or hypermobility?

CEH has been reported in one study to be associated with a reduction in mobility at the C1-C2 joint (Ogince et al., 2007). In this study a passive segmental mobility test was used to determine the C1-C2 dysfunctional level and then a flexion-rotation test was performed to assess the range of movement at the C1-C2 level. The passive segmental mobility test was based on the methods used by Jull et al. (1988) to identify a symptomatic cervical joint. It includes assessing for an unusual resistance to passive movement of the joint, an abnormal joint end-feel, and reproduction of pain on testing of passive accessory movements (Jull, Bogduk, & Marsland, 1988). The C1-C2 joint was considered to be the dominant symptomatic level of dysfunction if it displayed each of these characteristics (Ogince et al., 2007). The flexion-rotation test involves having the participant relaxed in supine lying, with the cervical spine fully flexed (the participant's occiput rests against the examiners abdomen) and then the head is rotated (Ogince et al., 2007). The flexion-rotation test is proposed to provide an indication of the mobility at C1-C2 by isolating cervical rotation to the C1-C2 level. However, the connection between C1-C2 mobility and the results of the flexion-rotation test remains theoretical as it has not been conclusively shown that movement is isolated to this joint level (Hall & Robinson, 2004). It has also been disputed whether manual therapists can specifically identify a dysfunctional cervical spinal level using a passive segmental mobility test (King, Lau, Lees, & Bogduk, 2007). The theory that the C1-C2 has reduced mobility in CEH, therefore, cannot be definitively confirmed based on the current evidence but it is likely to be present in at least some CEH patients.

Despite the inability to definitively isolate the C1-C2 joint as the cause of reduced cervical mobility in CEH, an association has been demonstrated between reduced overall cervical rotation and CEH (Jull, Amiri, Bullock-Saxton, Darnell, & Lander, 2007). A restriction in cervical mobility is one of the diagnostic criteria for CEH (Sjaastad, Fredriksen, & Pfaffenrath, 1998). The reason for this reduced overall cervical mobility in patients with CEH has not been determined. Reduced mobility may possibly occur due to factors other than the cervical joints. Despite the inability to directly relate the reduced mobility with joint hypomobility, this finding does provide some evidence for a possible link between CEH and reduced joint mobility.

Cervical joint hypermobility has also been reported to be associated with some types of headache symptoms (Rozen et al., 2006). One study of joint hypermobility assessed 'new daily persistent headaches' using a measure of active cervical mobility, a manual mobility assessment and a screening for systemic hypermobility (Rozen et al., 2006). The authors did not report the reliability of the cervical mobility or the manual mobility assessment performed in this study (Rozen et al., 2006). The hypothesis that cervical hypermobility may contribute to headaches is plausible, but the current evidence for this is not strong, as only one study was identified investigating this issue. No study has specifically investigated any association between cervical hypermobility and CEH.

The dominant cervical level associated with CEH

As well as the lack of evidence regarding the type of joint dysfunction associated with CEH, there is also disagreement over the joint level deemed to be the most common symptomatic joint level in the upper cervical spine in CEH (Cooper et al., 2007; Hall et al., 2010; Hall & Robinson, 2004). The C1-C2, C2-C3 and C3-C4 levels have all been reported to be capable of referring pain to the head (Cooper et al., 2007). The referral of pain into the head from the upper cervical levels in a study by Cooper et al. (2007) was determined by mapping the distribution of pain in patients with neck or head pain. The cervical joint level that was associated with that pain distribution was then determined by noting the controlled diagnostic block that resolved the pain (Cooper et al., 2007). This study provides good evidence that the upper cervical joints are strongly linked with CEH.

The C2-C3 joints have been reported to be the most common source of CEH symptoms (Bogduk & Govind, 2009; Cooper et al., 2007; Jull, 1985). It has been reported that research using diagnostic blocks suggests that C2-C3 is the source of pain in approximately 70% of CEH cases (Bogduk & Govind, 2009). The C2-C3 level was reported to be the most common joint level associated with headaches in one study that examined the agreement between a physiotherapist's manual palpation findings and diagnostic facet joint blocks in patients with CEH (Jull, 1985). The Cooper et al. (2007) study also used diagnostic blocks and determined that the C2-C3 level was the most commonly symptomatic level in the cervical spine. These findings suggest that C2-C3 is likely to be the cervical joint level most commonly causing CEH.

Despite the evidence from these studies using diagnostic blocks, the C1-C2 spinal level has also been proposed as the most common source of symptoms in CEH (Hall et al., 2010; Hall & Robinson, 2004). The proposition that the C1-C2 is the most common level associated with CEH is based on the correlation between a reduction of C1-C2 rotation mobility, as assessed with the flexion-rotation test, and the severity of the CEH (Hall & Robinson, 2004). As described previously, the theory that the C1-C2 spinal level has reduced mobility in CEH cannot be definitively confirmed from the current evidence. C1-C2 has, however, also been reported to be the most common symptomatic level based on the results of a recent investigation using palpation to isolate the symptomatic cervical level in CEH (Hall et al., 2010). The palpation assessment was investigated for levels above C4 and was reported to be reliable (Hall et al., 2010). This palpation assessment identified the C1-C2 level to be the dominant level in 63% of CEH patients (Hall et al., 2010).

In summary, the specific type (hypo- or hypermobility) and level of spinal joint dysfunction that is most commonly associated with CEH is not clear. However, the evidence from studies using diagnostic blocks suggests that C2-C3 is more commonly implicated as the source of symptoms in patients with CEH than other spinal levels. Further, there is more support for reduced joint mobility rather than hypermobility as a contributing factor to CEH symptoms (Jull et al., 2007; Ogince et al., 2007).

2.3.2 Dura mater

Irritation of the dura mater is another possible source of nociception associated with CEH (Fleming et al., 2007). A stretching pressure on the dura mater from the sub-occipital tissues (via the rectus capitus posterior minor muscle and ligamentum nuchae) at the cervical–cranial junction has been reported as a potential source of CEH. However, this theory is based only on anatomical observations of a connection between these structures, rather than on direct evidence of an association (Haldeman & Dagenais, 2001).

2.3.3 Neural system

The possibility of CEH symptoms being associated with nerve irritation due to a traction (over-stretching) injury or due to neural mechanosensitivity has also been proposed (Goldberg et al., 2008; von Piekartz, Schouten, & Aufdemkampe, 2007). A nerve traction injury in the upper sections of the cervical plexus has been reported to be linked to CEH (Goldberg et al., 2008). Goldberg et al. (2008) investigated a technique aimed at treating nerve traction injuries. The treatment involved fluoroscopically-guided deep cervical nerve plexus blocks designed to reduce tension in these structures. These blocks were found to reduce CEH symptoms (Goldberg et al., 2008). However, these results do not provide evidence that the CEH in these patients was caused by a cervical traction injury. The results do support the role of the upper cervical nerves in transmitting nociceptive input in CEH. That is, these nerve blocks may have reduced the headache by blocking nociceptive activity in the cervical nerves that had originated from sources other than that

caused by a nerve traction injury. Nerve traction injury, therefore, remains a possible source of CEH symptoms but further investigation is required to confirm this mechanism.

An association between CEH and mechanosensitivity of neural structures has also been proposed (von Piekartz et al., 2007). One study used an assessment technique described to identify mechanosensitivity that involved measuring the range of cervical flexion in long sitting with the knees either flexed or extended (von Piekartz et al., 2007). This assessment was performed on children with migraine, CEH and a control group. The results demonstrated a significant reduction in cervical flexion in the CEH group when compared to the controls when each group was assessed with their knees extended. These results were reported to suggest CEH patients had increased neural mechanosensitivity (von Piekartz et al., 2007). However, another study that included an assessment of neural mechanosensitivity in CEH did not find this to be a common clinical finding in CEH patients (Zito et al., 2006). Zito et al. (2006) reported that neural mechanosensitivity was 'rare' in CEH as it was identified in only two of twenty-seven (7.4%) patients with CEH in their study. They determined mechanosensitivity by holding an upper cervical flexion position and then tensioning neural tissues by placing the upper and lower limbs in the brachial plexus provocation test and the straight leg raise test positions respectively (Zito et al., 2006). A positive test was a perceived change in tissue resistance combined with a reproduction of neck pain or headache (Zito et al., 2006). The different results from these two studies may be due to the different methods used to determine the presence of neural mechanosensitivity. This suggests that neural mechanosensitivity may contribute to the symptoms of CEH in some individuals, but the association is not clear.

2.3.4 The muscular system

The muscular system has also been reported to contribute to CEH symptoms (Becker, 2010). The upper cervical muscles have been proposed to be the most likely anatomical structure involved in the production of headaches as nociceptive signals from muscles have been demonstrated to produce proportionally bigger increases in trigeminocervical nucleus excitability than nociceptive signals originating from other structures (Bartsch & Goadsby, 2002). A previous study has shown a reduction in CEH with specific muscular exercises, suggesting a link between CEH and muscular system dysfunction (Jull et al., 2002). This does not, however, demonstrate muscular dysfunction is a cause of CEH, as the altered function may also be a result of CEH.

2.3.5 Summary of CEH aetiology

The multiple different theories as to the possible causes of CEH demonstrate that many structures and pathological processes within the cervical spine may be implicated (Haldeman & Dagenais, 2001). The lack of agreement regarding the primary sources of CEH symptoms suggests that there may not be a single individual structure in the cervical region that is primarily responsible for CEH symptoms. The nature and localisation of the source of the cervical nociception in CEH may potentially vary from case to case (Jansen & Sjaastad, 2007). Further, the lack of agreement about the structural sources of CEH symptoms is consistent with the description of CEH as a syndrome (Antonaci, 2008; Coskun et al., 2003; Goldberg et al., 2008; Sjaastad & Bakketeig, 2008). CEH is unlikely

to originate from a single structure in the cervical spine and it is likely to be a syndrome involving a combination of joint, muscle and movement dysfunction (Jull, O'Leary, & Falla, 2008; Moore, 2004).

Despite the different possible causes and clinical presentations in patients with CEH, there is often a history of trauma precipitating CEH onset (Dumas et al., 2001; Jull, Sterling, Falla, Treleaven, & O'Leary, 2008; Martelletti & van Suijlekom, 2004). It has been reported that individuals who have a history of trauma associated with the onset of their CEH have some differences in the pattern of physical impairments compared to individuals with no history of trauma (Dumas et al., 2001). These differences included a significant reduction in the range of cervical flexion, extension and rotation (Dumas et al., 2001). The different physical impairments observed in individuals with CEH with a history of trauma as a precipitating factor, compared to CEH where there is no history of trauma, is further evidence that CEH is a syndrome as it suggests that there is not a singular CEH pattern or presentation.

2.4 Cervicogenic headache (CEH) diagnosis

With headaches that have been occurring daily for three months, CEH has been reported to be one of 22 possible common differential diagnoses (including five primary and seventeen secondary headache types) (Evans, 2009). These multiple possible causes of recurrent headache make it difficult to determine if the cervical region is the definite source of the symptoms, even when an obvious dysfunction exists in the cervical spine. The presence of cervical dysfunction in individuals with headache does not mean that it is the source of headache symptoms.

The process of determining a diagnosis of CEH is not only complicated by the difficulty of establishing the cervical spine as the source of the symptoms, but also by the multiple possible structures within the cervical spine that could be the specific source (Fleming et al., 2007). Determining the source of the symptoms is not only important to establish a specific diagnosis, but is also crucial for the prescription of accurate and appropriate treatment (Lucas et al., 2009). It has been reported that multiple approaches to treatment are likely to be required due to the varied possible causes of CEH (Fredriksen, 2008).

The difficulty in establishing the cervical region as the source of the headache symptoms in patients with CEH has resulted in disagreement as to the best method of determining the diagnosis. Two separate proposed ‘diagnostic criteria’ for CEH have been recommended. The ‘diagnostic criteria’ for CEH are focused on discriminating them from other headache types by establishing that the cervical spine is the source of the

headache. The two current criteria are the Cervicogenic Headache International Study Group (CHISG) (1998) diagnostic criteria and the International Headache Society (IHS) (2004) diagnostic criteria (International Headache Society, 2004; Sjaastad et al., 1998).

2.4.1 International Headache Society diagnostic criteria

The current diagnostic criteria for International Headache Society (IHS) 2004 are:

- A. Pain, referred from a source in the neck and perceived in one or more regions of the head and/or face, fulfilling criteria C and D
- B. Clinical, laboratory and/or imaging evidence of a disorder or lesion within the cervical spine or soft tissues of the neck known to be, or generally accepted as, a valid cause of headache
- C. Evidence that the pain can be attributed to the neck disorder or lesion based on at least one of the following:
 - 1. Demonstration of clinical signs that implicate a source of pain in the neck
 - 2. Abolition of headache following diagnostic blockade of a cervical structure or its nerve supply using placebo- or other adequate controls
- D. Pain resolves within 3 months after successful treatment of the causative disorder or lesion

(International Headache Society, 2004).

The criterion does not specify whether a CEH diagnosis requires all or some of these criteria to establish a diagnosis.

2.4.2 Cervicogenic Headache International Study Group (CHISG)

diagnostic criteria

The current major criteria suggested for CEH diagnosis by the CHISG (Sjaastad et al., 1998) are:

A. Symptoms and signs of neck involvement:

1. Precipitation of head pain, similar to the usually occurring one:
 - a) By neck movement and/or sustained awkward head positioning
 - b) By external pressure over the cervical or occipital region on the symptomatic side
2. Restriction of the range of motion in the neck
3. Ipsilateral neck, shoulder or arm pain of a rather vague nonradicular nature

B. Confirmatory evidence by diagnostic anaesthetic blockades

C. Unilaterality of head pain without side shift

(Sjaastad et al., 1998)

These criteria state that at least one of the symptoms and signs of neck involvement in (A) are present, that (B) is an obligatory point for scientific works and that (C) should preferably be present in scientific work.

The only assessment procedure that is reported to establish a definitive diagnosis of CEH is a diagnostic block (Bogduk, 2005; Hanten et al., 2002; Naja, El-Rajab, Al-Tannir, Ziade, & Tawfik, 2006). As diagnostic blocks are the only procedure reported to provide a definite CEH diagnosis, both the IHS (2004) and the CHISG (1998) criteria include the use of these blocks. The CHISG criteria, however, differs from the IHS (2004) criteria in that it includes a list of the specific clinical signs that could be used to implicate a cervical source of symptoms (Sjaastad et al., 1998). The use of diagnostic blocks has limitations in research due to the participant burden of having injections, so CEH research is commonly performed using the clinical signs suggested in the CHISG (1998) criteria to confirm a diagnosis of CEH in potential participants (Hall & Robinson, 2004; Ogince et al., 2007; Zito et al., 2006). The limitations and evidence for using diagnostic blocks or clinical signs to establish a CEH diagnosis are described below.

2.5 CEH diagnosis: Using diagnostic blocks or clinical signs?

2.5.1 Using diagnostic blocks for CEH diagnosis

A diagnosis of CEH can be established using diagnostic anaesthetic blocks (Bogduk & Govind, 2009). However, this diagnosis is not unequivocal unless placebo-controlled blocks under fluoroscopic guidance are used (Bogduk & Govind, 2009). Fluoroscopic guidance involves the exposure of the patient to radiation, and diagnostic anaesthetic blocks often require multiple injections to be performed, so there is the risk of exposing the patient to considerable radiation (Eichenberger et al., 2006). This procedure is also invasive, costly and not widely available (Bogduk & Govind, 2009; Jull, Sterling et al., 2008; Zito et al., 2006). Further, diagnostic anaesthetic injections in the cervical region cannot access all structures that are capable of generating pain (Becker, 2010).

Confirming a diagnosis based on these injections, therefore, cannot be justified in the majority of individuals suspected of having CEH (Jull, Sterling et al., 2008).

Furthermore, diagnostic blocks are difficult logistically to include in research as they require the patient to be in pain at the time of the assessment (Dumas et al., 2001).

Another issue in using diagnostic blocks for CEH diagnosis is that a decision needs to be made as to the structure to target with these injections. The diagnostic blocks are directed to the structure ‘suspected’ of causing or aggravating the CEH (Martelletti & van Suijlekom, 2004). This means that there is a possibility of targeting an anaesthetic block injection incorrectly, as the selection of the structure to be targeted requires a decision

based on the clinical presentation of the patient. The multiple possible structures that might be implicated and the differing opinions about these mean that selecting a target for the diagnostic block introduces a likely source of error.

The reliability of selecting the correct structure to target with diagnostic blocks based on the clinical presentation has not been established. The use of clinical signs to select an appropriate level for upper cervical facet injections is only accurate in 60% of cases (Aprill, Axinn, & Bogduk, 2002). There has been a reduction in pain demonstrated in 80% of CEH patients when injections are targeted to the greater occipital nerve (Bovim & Sand, 1992). However, approximately 80% of CEH patients have also been found to have reduced pain if injections are targeted to the lateral atlantoaxial joint (Narouze et al., 2007). The decision regarding the cervical structure to target with these injections is not clear.

In a recent synthesis of best evidence, Nordin et al. (2008) found four studies on injections into the cervical spine for diagnostic purposes. They concluded that facet joint injections have not been validated to identify the source of the pain and that these injections do not have acceptable reliability (Nordin et al., 2008). These results were based on studies of individuals with chronic neck pain. However, this does suggest that attempts to isolate the specific spinal level responsible for CEH symptoms by using anaesthetic facet blocks may also lack validity and reliability. Confirmation of reduced symptoms as a result of an anaesthetic block is required to fulfil both sets of CEH diagnostic criteria. This is despite criticism that there is no consensus regarding the use of

the various possible injection techniques and that no clinical trials support this position (Haldeman & Dagenais, 2001).

These difficulties in confirming a CEH diagnosis with diagnostic anaesthetic blocks suggests that further investigations into the validity and reliability of using clinical signs to diagnose CEH is required (Bogduk & Govind, 2009). It has been reported that the use of controlled blocks will not advance our understanding of CEH unless they are used in combination with a detailed clinical examination (Goadsby, 2009).

2.5.2 Using clinical signs for CEH diagnosis

Most physiotherapists use signs and symptoms from a clinical examination of the cervical region to diagnose CEH (Jull, Sterling et al., 2008; Ogince et al., 2007; Zito et al., 2006). The clinical examination determines the presence of specific clinical signs that could indicate abnormal function (dysfunction). However, the use of clinical signs to provide a CEH diagnosis has been criticised, as establishing the presence of a cervical dysfunction does not mean that this is the source of the CEH symptoms (Bogduk, 2005). The CEH diagnostic criteria proposed by the IHS (2004) and the CHISG (1998) provide some guidance as to the use of clinical signs and symptoms in the diagnosis of CEH, but each emphasises different clinical signs.

The decision about the exact clinical signs to be used in CEH diagnosis in the IHS (2004) criteria is left to the judgement of the researcher or clinician. The criteria state that the

clinical signs used must have demonstrated reliability and validity, but the specific clinical signs that would meet this criterion are not described. This decision as to the specific clinical signs to use to provide a CEH diagnosis is problematic as it has been demonstrated that individual clinical signs are not helpful in differentiating CEH (Amiri, Jull, Bullock-Saxton, Darnell, & Lander, 2007). Researchers and clinicians diagnosing CEH using clinical signs are reported to be achieving a 'probable' or 'reasonably valid' CEH diagnosis (Antonaci, Ghirmai, Bono, Sandrini, & Nappi, 2001; Frese & Evers, 2008). The need for further investigation into clinical signs in CEH has been suggested, as determining clinical signs and symptoms that are both reliable and valid for establishing a cervical source of pain in CEH is required (Bogduk & Govind, 2009).

2.6 Evidence that a combination of clinical signs may be needed in CEH diagnosis

The inability of any individual clinical sign or injection procedure to discriminate CEH is consistent with the description of CEH as a syndrome (Antonaci, 2008; Coskun et al., 2003; Sjaastad & Bakketeig, 2008). This inability of individual clinical signs to establish a CEH diagnosis has been addressed by attempts to identify a combination or pattern of physical impairments that characterises CEH (Jull et al., 2007). In one study, restricted cervical movement combined with impairment in the craniocervical flexion test and palpable upper cervical joint dysfunction had 100% sensitivity and 94% specificity to identify CEH (Jull et al., 2007). A palpable upper cervical joint dysfunction was judged to be present if the therapist determined that the upper cervical joints displayed abnormal

displacement and there was an abnormal tissue resistance to displacement when a postero-anterior (PA) pressure was applied combined with the patient reporting a provocation of pain (Jull et al., 2007). The craniocervical flexion test in this study used a combination of surface electrodes and electrodes inbuilt into a nasopharyngeal tube to measure the relative activity in the deep and superficial cervical flexor muscles while performing an upper cervical flexion movement (Jull et al., 2007). An impaired craniocervical flexion test result was deemed to be reduced deep cervical flexor activity combined with increased superficial flexor activity when compared to controls (Jull et al., 2007). The demonstration of the combined diagnostic ability of these multiple clinical signs in CEH diagnosis is consistent with descriptions of CEH as being characterised by a combination of movement, joint and muscle dysfunction (Jull, O'Leary et al., 2008; Moore, 2004). The capacity of this pattern of musculoskeletal impairments to diagnose CEH is, however, yet to be validated against the 'gold standard' of diagnostic anaesthetic blocks (Jull et al., 2007).

It has been suggested that identifying other factors that may potentially be involved in the origin of cervical spine symptoms related to headache is important (Jull, Sterling et al., 2008). Identification of any further clinical signs that are associated with CEH would not only help with diagnosis but could also help provide direction for the treatment of these CEH patients (Marcus, 2007; Sjaastad, Fredriksen, Petersen, & Bakketeig, 2003).

Postural strain, resulting from abnormal posture, has been reported to be one of the possible underlying musculoskeletal abnormalities that causes or aggravates CEH (Jull, 1997; Richardson, 2009).

2.7 Posture

Posture is a term that broadly describes the composite positions of all the joints of the body at any given time (Kendall, McCreary, & Provance, 1993). The posture that an individual adopts in any task is reported to be influenced by demands to prevent movement, conserve energy, co-ordinate movement, as well as to safely distribute load to structures adapted for load bearing (Claus, Hides, Moseley, & Hodges, 2009).

Posture is often described as ‘good’ (normal) or ‘bad’ (abnormal). The description of posture as ‘good’ suggests that for any given task an individual can position their body in a way that is ideal, whereas ‘bad’ posture suggests negative consequences. These descriptive terms are used despite an inability to define the specific postures that would qualify as ‘good’ or ‘bad’ (Claus et al., 2009; Jull, Sterling et al., 2008). Moreover, the factors that determine which posture is adopted by each individual are poorly understood (Grimmer-Somers, Milanese, & Louw, 2008).

It is often proposed that when an individual habitually assumes a posture that is ‘bad’, there are abnormal levels of energy expenditure and stress on the musculoskeletal system, resulting in dysfunction and symptoms, including pain (Cheung Lau, Wing Chiu, & Lam, 2009). Ideal static postural alignment is proposed to occur when gravitational forces are distributed along structures that are adapted for weight-bearing (Kuchera, 1997). The ‘ideal’ posture model (with the head balanced over the sub-occipital, cervicothoracic, thoracolumbar, and lumbosacral transitional junctions) proposes that the line of gravity

should achieves the goals of minimal energy expenditure and stress (see Figure 2.2) (Boyle, Milne, & Singer, 2002).

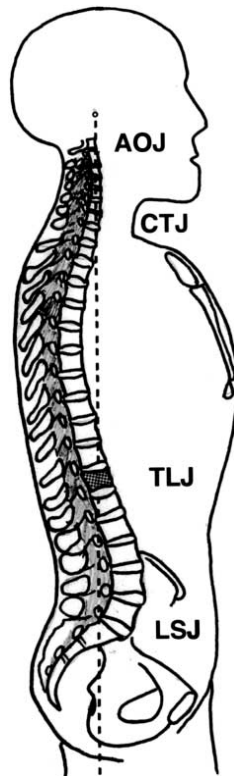


Figure 2. 2 Illustrates the proposed ‘ideal’ static posture in the sagittal plane with the line of gravity aligned with the atlanto-occipital junction (AOJ), cervicothoracic junction (CTJ), thoracolumbar junction (TLJ) and lumbosacral junction (LSJ) (Boyle et al., 2002).

Posture potentially may be more correctly considered a dynamic concept that involves a complex control system constantly adjusting the position of the body in a way that achieves a desired alignment while minimising energy expenditure and stress (Grimmer-Somers et al., 2008). Despite the knowledge of this dynamic nature of posture, the assessment of posture is usually based on analysis of ‘static posture’. ‘Static posture’ is

the position that the body assumes at a specific point in time while performing a specific task. The analysis of static posture in common stationary positions such as standing or sitting has been described as necessary prior to examining dynamic posture (Claus et al., 2009).

Assessment of posture is generally considered an important component of the physical examination and the results can influence decisions about treatment (Cheung Lau et al., 2009). This assessment assumes that identifying postures that are different to the 'ideal' or 'good' posture would provide a meaningful clinical sign that could be related to dysfunction and/or symptoms. If abnormal posture is not related to dysfunction, or to any symptoms that are proposed to be a result of this dysfunction, then it is difficult to justify investigating posture as part of the clinical assessment process. Therefore, research to establish associations between postural variables and symptoms in patients is important. In addition, 'normal' posture must be understood before an analysis of 'abnormal' posture can be made.

The common postural variable assessed in the cervical spine is 'spinal posture'. The definition of spinal posture is different to the more general definitions of posture. Spinal posture is defined as the position of the individual vertebra, or spinal segments, with respect to each other and to gravity (Claus et al., 2009). Cervical spinal posture describes the position cervical structures adopt during specific tasks at specific points in time while supporting the head against gravity (Grimmer-Somers et al., 2008). Wide varieties of cervical spinal postures, identified both radiographically and clinically, have been

demonstrated in the normal population (Grimmer-Somers et al., 2008). This suggests that the strategies used by asymptomatic individuals to achieve their habitual resting posture vary greatly. This means that research aiming to identify a potential difference in spinal posture between asymptomatic individuals and a patient group would require a large number of individuals to be examined to find a distinct difference.

2.8 Why investigate posture?

Improving postural alignment is an important aspect of treatment in many health professions including medicine, dentistry, physiotherapy and chiropractic (Oakley, Harrison, Harrison, Haas, & Oakley, 2005). Improvement of postural alignment is discussed as a method that can restore and rehabilitate normal structure and function (Oakley et al., 2005; Troyanovich, Harrison, & Harrison, 1998). This treatment approach is based on the assumption that sustained abnormal posture relates to poor clinical outcomes and long term biomechanical implications (Guigui, Benoist, & Deburge, 1998; Stemper, Yoganandan, & Pintar, 2005). The expectation of poor outcomes is based on the belief that abnormal posture can result in histopathology, myopathology, neuropathophysiology and kinesio pathology (Troyanovich, Harrison, & Harrison, 1998). It is postulated that the sustained awkward or end of range positions that correspond to poor postural alignment can cause pain (Refshauge & Gass, 2004). Detection of abnormal spinal postures that may correspond with dysfunction or symptoms has been reported as essential for optimising patient care (Wu et al., 2007).

It is difficult to establish a link between abnormal posture, or altered spinal curvatures, and symptoms as there is a wide variety of postural presentations in asymptomatic individuals (Magee, 1997; Szeto, Straker, & Raine, 2002). There are very few postural abnormalities that have been directly related to symptoms (Refshauge & Gass, 2004). The significant variability in cervical spinal posture in the absence of symptoms has been reported to contribute to difficulties in distinguishing postural types between asymptomatic and symptomatic individuals (Johnson, 1998; Szeto et al., 2002). It is important, however, to investigate the interaction between posture and symptoms as treatments focusing on improving posture and joint alignment are commonly being used clinically (Keating et al., 2005). There are very few investigations into the association between posture and symptoms and little evidence that treatment to alter posture can reduce symptoms or change the postural variable that is being targeted (Refshauge & Gass, 2004). Furthermore, recent evidence from one epidemiological study does not support any association between sagittal spinal curves and any health outcome including pain (Christensen & Hartvigsen, 2008). However, this study did report that the methodological quality of the included studies was generally low and that further research of better methodological quality may affect this conclusion (Christensen & Hartvigsen, 2008). Additionally, research looking at changes in the mechanical loading and cervical muscular activity that occurs with different postures has suggested that 'neutral' postures may reduce the risk of pain and symptoms (Edmonston, Sharp, Symes, Alhabib, & Allison, 2011). Further research has therefore been recommended to determine the postures that may be linked with symptoms (Grimmer-Somers et al., 2008).

2.9 Abnormal posture and different headache types

Headaches are often reported to be associated with abnormal posture (Boquet, Biosmare et al., 1989; Fernandez-de-las-Penas & Schoenen, 2009; Richardson, 2009; Watson & Trott, 1993). Abnormal posture may be a response to the symptoms of headache, but it has also been suggested to cause headache symptoms (Martelletti & van Suijlekom, 2004; Vaughan, 2002). Abnormal postures are proposed to contribute to symptoms, including pain, through the development of altered muscle activity, altered loading of ligaments, changes in joint loading or changes in the overall pattern of movement (Edmonston, Henne, Loh, & Ostvold, 2005).

2.9.1 Postural assessment in headache

Despite being considered primary headaches, tension type and migraine headaches are often reported to be associated with abnormal posture of the cervical spine (Evans, 2009; Marcus, 2007). This association between headache and abnormal posture is supported by one study indentifying greater postural abnormalities in patients with tension type headache and migraine headache than in individuals with no headaches (Marcus, Scharff, Mercer, & Turk, 1999). In this study, postural abnormalities were recorded in 90% of patients with headache and in 46% of controls (Marcus et al., 1999). The individual participants in this study were separated into three categories: those with no postural abnormalities, those with mild abnormalities and those with moderate to severe abnormalities (Marcus et al., 1999). The categories did not distinguish the type of

abnormality identified, and the participants were screened for a variety of abnormalities including forward head posture, scoliosis and leg length differences (Marcus et al., 1999). The posture assessment was described as a general assessment of posture in the sagittal and coronal planes so the specific nature of the postural abnormalities present in their sample of individuals with headaches is not known. Nevertheless, the study does provide some support for the link between posture and headache symptoms for tension type and migraine.

Analysis of postural presentation should include specific assessment in the sagittal, coronal and horizontal planes to provide more detailed information about the postures associated with headaches. No studies have been identified specifically investigating the association between coronal plane postural abnormalities and headache symptoms, but there are reported investigations of sagittal and horizontal plane posture. These investigations will be discussed below.

2.9.2 Postural assessment in headache: sagittal plane

Previous studies analysing the association between sagittal plane cervical spinal posture and headache symptoms involved investigations of patients with tension type headaches, migraine and CEH (Fernandez-de-Las-Penas, Cuadrado, & Pareja, 2006; Fernandez-de-Las-Penas, Cuadrado, & Pareja, 2007; Marcus et al., 1999; Nagasawa, Sakakibara, & Takahashi, 1993). The studies investigating sagittal posture in tension headache and

migraine will be discussed later in this section. The studies investigating sagittal plane posture in CEH will also be discussed later in this section.

The most commonly used measure of cervical spine sagittal plane posture is the craniovertebral angle (Grimmer-Somers et al., 2008). The craniovertebral angle (Figure 2.3) is proposed to provide an indication of forward head posture (Zito et al., 2006). Forward head posture is a description of posture in which the head is positioned anteriorly in relation to the theoretical ideal vertical postural line (Figure 2.2). Forward head posture is reported as a common clinical observation in patients with headache, neck and shoulder pain. This posture is reported to occur through a combination of lower cervical flexion, upper cervical hyperextension and a 'rounding' of the shoulders (scapular protraction) (Szeto et al., 2002).

The craniovertebral angle method of analysing cervical spinal posture generally uses photographs. On the photographs the specific landmarks are marked and the angle between these points is measured (see Figure 2.3). The craniovertebral angle is the angle between the horizontal line passing through C7 and a line extending from the tragus of the ear to the tip of the C7 spinous process (Fernandez-de-Las-Penas, Cuadrado, & Pareja, 2007).

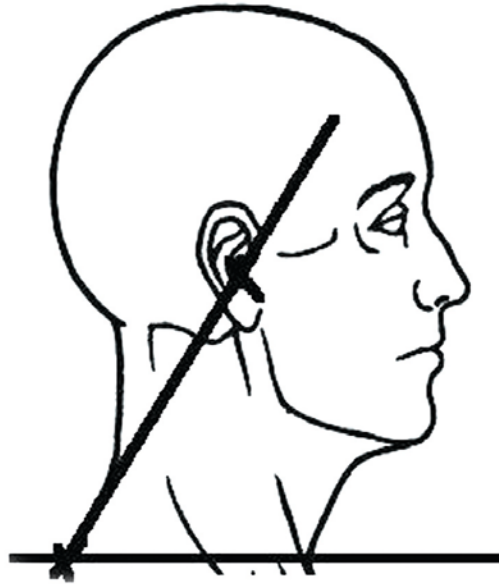


Figure 2. 3 Illustration of the craniocervical angle measurement method. The craniocervical angle is the angle between the horizontal line passing through C7 and a line extending from the tragus of the ear to the tip of the C7 spinous process (Fernandez-de-Las-Penas, Cuadrado, & Pareja, 2007).

Measuring sagittal plane posture in tension type headache and migraine

One study was identified that investigated sagittal plane cervical spinal posture in patients with migraine using the craniocervical angle measurement (Fernandez-de-Las-Penas, Cuadrado et al., 2006). This study included 20 subjects with unilateral migraine and 20 matched controls and found an association between increased forward head posture and migraine (Fernandez-de-Las-Penas, Cuadrado et al., 2006). The mean craniocervical angle in a standing position for the migraine group in this study was 44.7 degrees (Standard deviation (SD) 9.6 degrees) and was 53.7 degrees (SD 7.2 degrees) for the control group (Fernandez-de-Las-Penas, Cuadrado et al., 2006). Two studies were

identified that investigated sagittal plane cervical spinal posture in patients with tension type headache using the craniovertebral angle measurement (Fernandez-de-Las-Penas, Cuadrado, & Pareja, 2007; Fernandez-de-las-Penas, Perez-de-Heredia, Molero-Sanchez, & Miangolarra-Page, 2007). The first study included 15 subjects with episodic tension type headache and 15 matched controls (Fernandez-de-Las-Penas, Cuadrado, & Pareja, 2007). The second study included 10 subjects with chronic tension type headache and 10 matched controls (Fernandez-de-las-Penas, Perez-de-Heredia et al., 2007). These studies also found an association between increased forward head posture and tension type headache (Fernandez-de-Las-Penas, Cuadrado, & Pareja, 2007; Fernandez-de-las-Penas, Perez-de-Heredia et al., 2007). The mean craniovertebral angle in a standing position for the chronic tension type headache group in the first study was 42.0 degrees (SD 6.6 degrees) and was 48.8 degrees (SD 2.5 degrees) for the control group (Fernandez-de-las-Penas, Perez-de-Heredia et al., 2007). The mean craniovertebral angle in a standing position for the episodic tension type headache group in the second study was 50.0 degrees (SD 7 degrees) and was 55.9 degrees (SD 5.5 degrees) for the control group (Fernandez-de-Las-Penas, Cuadrado, & Pareja, 2007).

Radiographic measurement of posture is an alternative to the craniovertebral angle method. One study was identified investigating sagittal plane cervical spinal posture in patients with tension type headache using measurements from radiographs (Nagasawa et al., 1993). This study found a difference in posture in patients with tension type headache compared to controls with a reported flattening of the cervical lordotic curve in the headache group. However, these results do not provide strong evidence as the reliability

of the radiographic measurement technique used in this study was not reported (Nagasawa et al., 1993). No previous studies were identified investigating cervical spinal posture in patients with migraine using radiographic examinations.

The results of these studies demonstrate an association between an altered posture in the sagittal plane in both tension type headaches and migraines. Altered posture occurred in patients with tension type headache and migraine despite both being classified as primary headaches (Evans, 2009). In a primary headache the symptoms are, by definition, not associated with a secondary disease process such as cervical spine dysfunction. Thus, the posture found in these two types of primary headache should probably be considered a symptom of the headache rather than a cause.

Measuring sagittal plane posture in CEH

The relationships between altered posture and migraine and tension type headaches suggest that it may also be a factor in CEH. CEH is by definition a secondary headache whereby the cervical region is the origin of symptoms. Thus, a stronger association between this type of headache and cervical musculoskeletal abnormalities such as abnormal posture might be expected. Indeed, strain resulting from abnormal posture has been reported to be one of the possible underlying musculoskeletal abnormalities that causes or aggravates CEH (Jull, 1997; Richardson, 2009). An association between posture and CEH is also supported by reports that CEH symptoms can be relieved by changes in posture (Liselott, Persson, & Carlsson, 1999; Sahrmann, McDonnell, & Van Dillen, 2005). The changes in posture that have been reported to result in a reduction of

CEH symptoms include postural changes in the scapulothoracic and lumbar regions (Sahrmann et al., 2005). This suggests that CEH may be associated with general postural factors rather than specific cervical postural variables.

Three previous studies were identified investigating the possible association between CEH and sagittal plane cervical posture (Dumas et al., 2001; Watson & Trott, 1993; Zito et al., 2006). These studies used the craniovertebral angle (see Figure 2.3) to measure cervical posture in the sagittal plane (Dumas et al., 2001; Watson & Trott, 1993; Zito et al., 2006). Two of these studies suggest no association between craniovertebral angle and CEH (Dumas et al., 2001; Zito et al., 2006). The third study demonstrated an association between decreased craniovertebral angle and ‘cervical headache’ (Watson & Trott, 1993). The mean craniovertebral angles for the CEH groups in Zito et al. (2006) were reported to be larger than for the control groups (CEH group mean 51.1 degrees, SD 5.8 degrees; control group mean 50.3 degrees, SD 4.6 degrees). The mean craniovertebral angles for the CEH groups in Dumas et al. (2001) were also reported to be larger than for the control groups (CEH group mean 48.5 degrees, SD 5.8 degrees; control group mean 47.4 degrees, SD 6.3 degrees). Watson and Trott (1993) reported a smaller mean craniovertebral angle in the ‘cervical headache’ group (44.5 degrees, SD 5.5 degrees) than in the control group (49.1 degrees, SD 2.9 degrees).

A possible reason for the difference in the results of these studies is that Watson & Trott (1993) was performed prior to the formation of the current CEH diagnostic criteria so their inclusion criteria for their participants with CEH differed from the other two studies.

The reported description of their inclusion criteria indicates that their data includes participants that do not meet the current diagnostic criteria for CEH. Nonetheless, a meta-analysis combining the results of these three studies suggested there was a weak association between having decreased craniovertebral angle and having CEH symptoms compared to asymptomatic controls (Gadotti et al., 2008). As the association was weak, and the data included patients that would not meet current diagnostic criteria, the results should be considered with caution (Gadotti et al., 2008). The weak association between posture and CEH either suggests that no strong postural association exists in this headache type or that the craniovertebral angle measure is not able to isolate changes in the specific postural factors that are associated with CEH symptoms.

Examination of the methods used in the previous studies of posture in CEH using the craniovertebral angle also provides an additional rationale for continuing to investigate the possible relationship between CEH and altered cervical spinal posture. In the study by Zito et al. (2006) which did not demonstrate an association between posture and CEH, participants were recruited from neurologists, general medical practitioners and musculoskeletal physiotherapists. Recent treatment with manual therapy to the cervical region was not reported as a specific exclusion criterion in this study and this may have been a confounding factor. The study by Dumas et al. (2001), which similarly found no link between CEH and posture, also did not specifically exclude participants receiving manual therapy treatment. It is not known if manual therapy techniques might change the postural presentation of these participants, resulting in a variation in postural presentation that may have altered the results of these studies. Watson and Trott (1993) are the only

authors to report a link between ‘cervical headache’ and altered sagittal plane posture using the craniovertebral angle measurement technique, but as described previously this study preceded the formation of the Cervicogenic Headache International Study Group (CHISG) diagnostic criteria (Sjaastad et al., 1998) and potentially some of their participants would not meet currently accepted CEH diagnostic criteria. Therefore, potential relationships between posture and CEH symptoms require further investigation.

General postural measures, such as the craniovertebral angle, may not be appropriate in investigating CEH because this is a general measure that focuses on the whole cervical spine rather than specific vertebrae. The use of the craniovertebral angle measurement in the assessment of cervical spine posture has been criticised due to its inability to accurately determine the alignment of the cervical vertebrae (Johnson, 1998; Zito et al., 2006). The results of Johnson (1998) suggest that variations to cervical spinal posture cannot be inferred from variations in the position of the surface measurement points used in the craniovertebral angle. Radiographic and craniovertebral measurements of cervical spine posture were compared and there was no correlation between the two (Johnson, 1998). The inability of general cervical measurement methods to accurately analyse cervical posture is also supported by the results of a previous study using radiographic measurements with surgical patients undergoing fixation of the upper cervical spine (Yoshimoto et al., 2004). The radiographs demonstrated that lower cervical spine posture often changes to compensate for abnormal upper cervical spine posture (Yoshimoto, et al 2004). These results suggest that using cervical postural measures that differentiate

between the spinal posture of the upper and lower cervical regions may be more effective in analysing posture in CEH than the craniovertebral angle.

The investigation of posture in patients with CEH should be based on a methodology that takes into account the aetiological factors that are most likely associated with the genesis of the symptoms (discussed in section 2.3). In CEH, the structures innervated by the upper cervical levels are suggested as the most likely source (Bogduk, 2001). However, no study has been identified that reports upper cervical posture in CEH. Measurement methods more specific to the upper cervical region may be appropriate for assessing the postural variables in CEH. The methodology used by previous studies to measure upper cervical posture is discussed in the following section. These methods are considered in order to determine the most appropriate method for analysing posture in CEH.

Sagittal plane radiographic measurement techniques for the cervical region

In ‘ideal’ cervical sagittal plane posture, the head is reported to be in a position that involves the line of gravity passing through both the external auditory meatus and the atlanto-occipital junction (Boyle et al., 2002; Yip, Chiu, & Poon, 2008). The cervical spine then normally has a lordotic curve that ends at the cervicothoracic junction. The line of gravity should then pass through the cervicothoracic junction so that the atlanto-occipital junction is balanced directly above the cervicothoracic junction (Boyle et al., 2002). Assessment of sagittal plane posture aims to determine how the posture of an individual compares to this ideal.

Radiographic evaluation has been reported to be the ‘gold standard’ for assessing cervical spinal posture (Wu et al., 2007). Studies that use radiographic analysis to determine the associations that may exist between cervical spinal posture and headache have previously been recommended, but no studies were identified assessing cervical spinal posture in CEH using radiographs (Johnson, 1998).

The aetiology of CEH suggests that investigations of posture in this patient group should include specific analysis of upper cervical spine posture as well as general postural analysis. Previous studies using radiographic assessment of cervical sagittal plane spinal posture included measurement of the upper cervical lordosis as well as general cervical lordosis (Cote et al., 1997; D. E. Harrison et al., 2000; Johnson, 1998). There have been many proposed methods for analysing cervical sagittal spinal posture using radiographic measurement but this discussion will be limited to identified studies that used methods demonstrated to be reliable (Cote et al., 1997; D. E. Harrison et al., 2000; Johnson, 1998).

The only method identified that has been demonstrated to reliably measure upper cervical lordosis is illustrated in Figure 2.4 (Johnson, 1998). An ICC of 0.96 was reported using 10 randomly selected subjects from the 34 in the study (Johnson, 1998). This upper cervical lordosis measure involves measuring the angle between two lines: one line drawn between the most superior dorsal point on the odontoid process of C2 and the most inferior-posterior point on the body of C2, and the second line drawn between the most inferior-posterior point on the body of C3 and the most inferior-posterior point on the body of C4 (Figure 2.4).

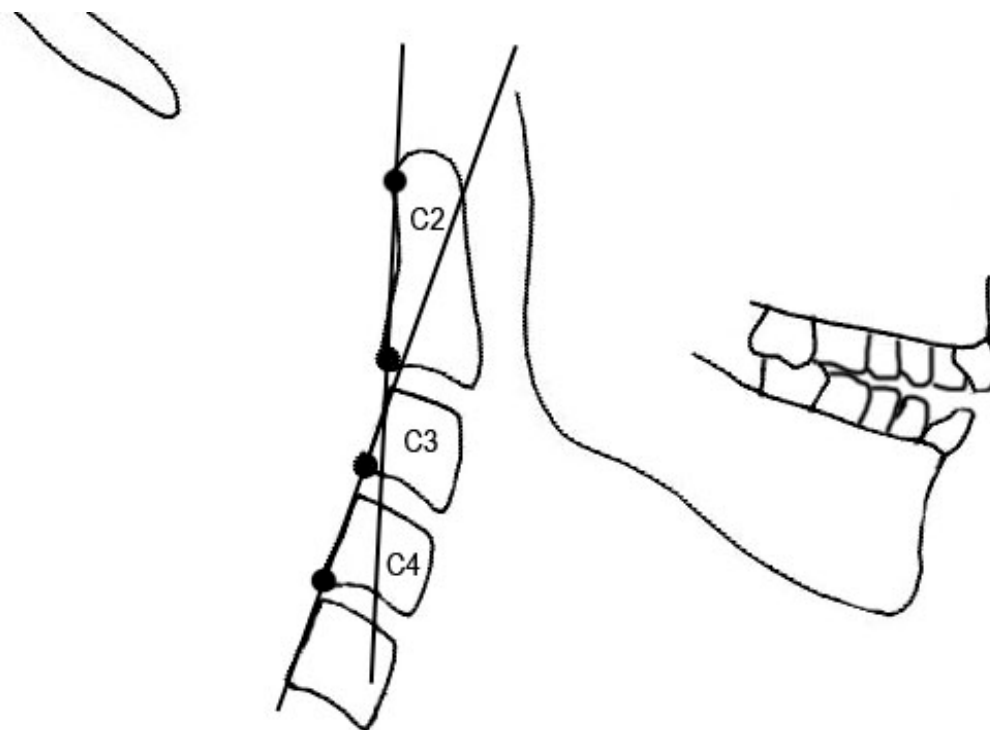


Figure 2. 4 Illustration of the upper cervical lordosis radiographic measurement method.

The acute angle between the two lines is measured in degrees to indicate the upper cervical lordosis (Johnson, 1998).

General cervical lordosis measures have been performed on lateral X-rays with two identified techniques that have been demonstrated to be reliable (Cote et al., 1997; D. E. Harrison et al., 2000). These techniques are the Cobb angle method (Figure 2.5) and the posterior tangent method (Figure 2.6). The reliability of these two methods is comparable with both methods within the excellent range (D. E. Harrison et al., 2000).

The C1-7 and C2-7 Cobb angle measurements on lateral radiographs have both been demonstrated to be reliable (ICC 0.94 for C1-7 measurement, ICC 0.96 for C2-7 measurement) (Cote et al., 1997). The C1-7 method has been reported to overestimate the

magnitude of the cervical lordosis (Cote et al., 1997; D. E. Harrison et al., 2000). The C2-7 method has, however, been reported to underestimate the magnitude of the cervical lordosis (D. E. Harrison et al., 2000). The shape of the C1 vertebra has been reported to make the C1-7 measurements a less accurate representation of the magnitude of cervical lordosis present because of the plane of angulation of C1 (Cote et al., 1997). The use of the C2-7 method has also been recommended in preference to the C1-7 method as the C2-7 method is reported to have ‘better statistical precision’ (Cote et al., 1997). The C2-7 Cobb angle measurement (Figure 2.5) is obtained by joining the perpendiculars to lines drawn parallel to the inferior end plates of C2 and C7 (Cote et al., 1997).

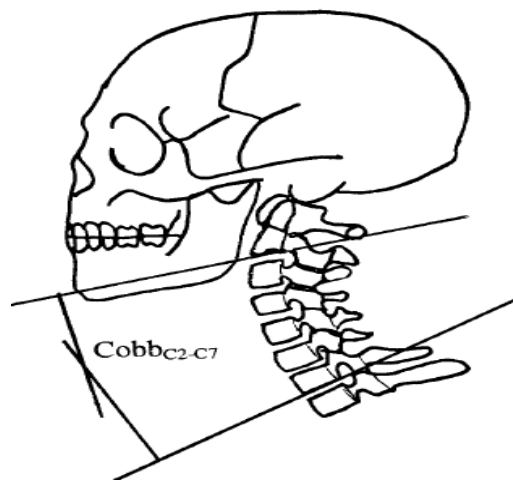


Figure 2. 5 Illustration of the C2-7 Cobb angle radiographic measurement of general cervical lordosis. The acute angle between the two perpendiculars is measured in degrees to indicate the general cervical lordosis (D.E. Harrison et al., 2000).

The C2-C7 posterior tangent method (Figure 2.6) for radiographically measuring the general cervical lordosis involves establishing the angle between two lines: one line

connecting the posterior- superior point on C2 and the posterior inferior point on C2, and the second line connecting the posterior-superior point on C7 and the posterior inferior point on C7 (D. E. Harrison et al., 2000). This method was also found to be reliable (ICC 0.94) (D. E. Harrison et al., 2000).

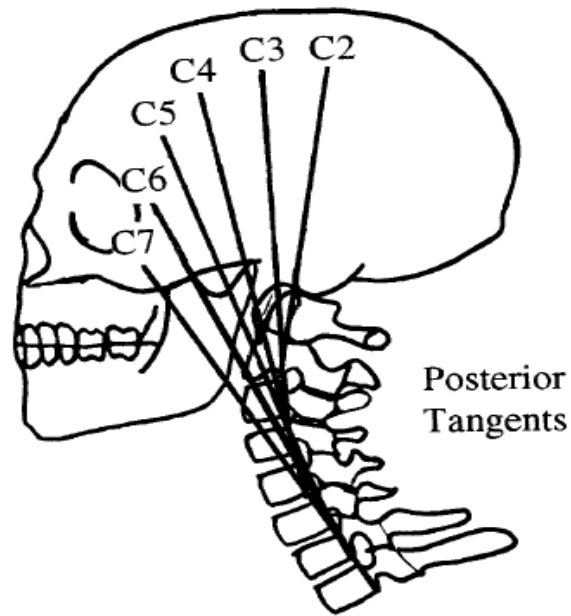


Figure 2. 6 Illustration of the posterior tangent method for radiographically measuring the cervical lordosis. The C2-C7 posterior tangent is the acute angle between two lines: one line connecting the posterior-superior point on C2 and the posterior-inferior point on C2, and the second line connecting the posterior-superior point on C7 and the posterior-inferior point on C7 (D. E. Harrison et al., 2000).

2.10 Postural assessment in headache: horizontal plane

Cervical spinal posture in the horizontal plane has also been investigated in patients with headaches (Boquet, Biosmare et al., 1989; Boquet, Moore et al., 1989; Macpherson & Campbell, 1991). These studies have investigated ‘unilateral headache’ and migraine and have focussed on the posture of C2 using both X-rays and computed tomography (CT) scans (Boquet, Biosmare et al., 1989; Boquet, Moore et al., 1989; Macpherson & Campbell, 1991). No previous studies investigating horizontal plane posture in tension type headache or CEH have been identified.

As described previously, the investigation of cervical spinal posture in CEH should include assessment of the upper cervical levels, as these are the most commonly implicated in CEH (Frese & Evers, 2008; Hall & Robinson, 2004; Ogince et al., 2007). The upper cervical area includes the occiput, C1 and C2 vertebrae (Panjabi, Oda, Crisco, Dvorak, & Grob, 1993). This review of research into the horizontal plane posture of the cervical spine therefore focuses on previous studies analysing the posture and position of C1 and C2.

2.10.1 Measuring C1 horizontal plane posture

Measurement of C1 posture or alignment is not standard clinical practice. The radiographic views that have been proposed to be able to measure the posture or alignment of C1 are the vertex and nasium views (Eriksen & Rochester, 2007). Neither the validity of using these radiographic views nor the association between any ‘abnormal’ findings and symptoms have been established (Haas, Taylor, & Gillette, 1999). Further, these views are not taken as part of a standard cervical spine X-ray series (Bontrager, 2005). Analysis of C1 posture is, therefore, not currently possible without initially demonstrating the validity and reliability of these techniques.

2.10.2 Measuring C2 horizontal plane posture

The C2 vertebra is named the ‘axis’ as it provides the axis for head rotation in the horizontal plane in the upper cervical spine (Crawford & Hurlbert, 2002; Standring, 2005). The structure of C2 is unique as it supports the large mass of the head in a region of high flexibility and highly vulnerable central nervous structures (Panjabi, Duranceau, Goel, Oxland, & Takata, 1991). One feature that differentiates C2 from the other cervical vertebrae is the size and shape of the spinous process. A typical C2 vertebra is represented in Figure 2.7. The C2 spinous processes are larger than those at lower cervical levels and this is reported to be due to the number of muscles that attach to it that produce strong forces on the spinous process (Panjabi et al., 1991). The position of the C2 spinous process relative to mid-line is a method that has been used previously to

indicate the horizontal plane posture of the cervical spine (Boquet, Biosmare et al., 1989; Gradl et al., 2005).

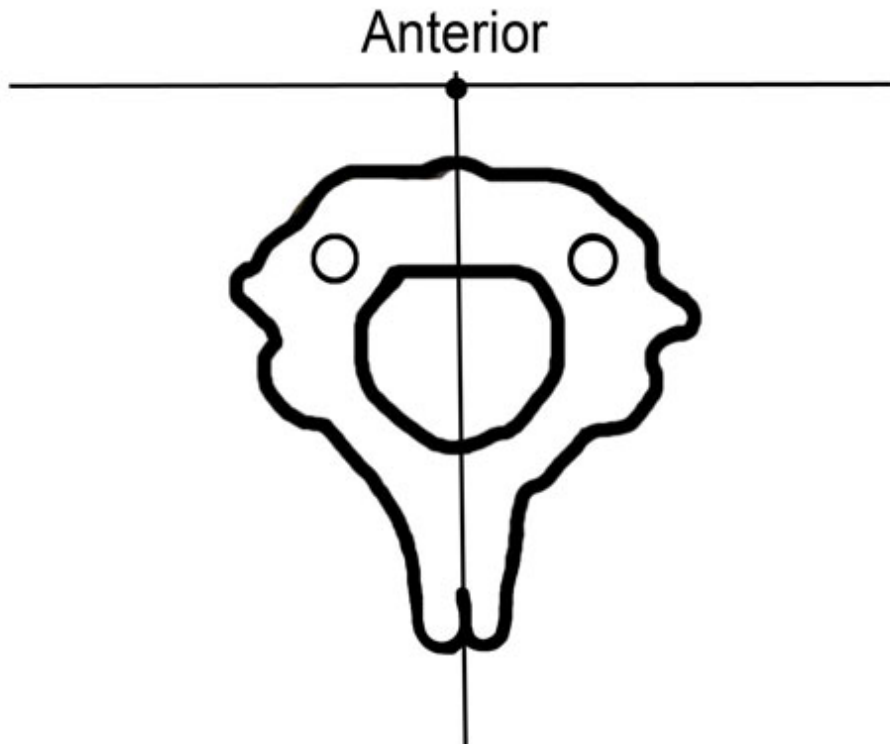


Figure 2. 7 Represents a typical C2 vertebra viewed in the horizontal plane.

2.10.3 Factors complicating C2 horizontal plane assessment

The assessment of cervical horizontal plane spinal posture by using the position of the spinous process relative to midline is complicated by the multiple factors that can cause the C2 spinous process to appear deviated from the midline. Van Schaik et al (1989) reported that a spinous process can appear to be deviated from mid-line for a number of reasons including a rotation of the entire vertebra or an isolated deviation of the spinous process. Also, the C2 spinous processes are usually considered bifid with two tubercles but the tubercles have been reported to often be unequal in size (Standring, 2005). This may be another reason for the C2 spinous process to appear deviated from the midline.

Descriptions of the possible types of asymmetry of the C2 spinous process in the horizontal plane are described in this section. The following section (2.10.4) describes the previous studies identified that investigated the association between the alignment of the C2 spinous process and headache.

Deviated spinous process

A deviation of the C2 spinous process from the mid-line has been reported to indicate an anatomical variation that could result in dysfunction (Maitland et al., 2005). A deviated spinous process (Figure 2.8) may, for example, result in the muscles that attach from either side of this spinous process being different lengths which could potentially result in asymmetrical muscular tension that impacts the movement pattern of the surrounding joints.

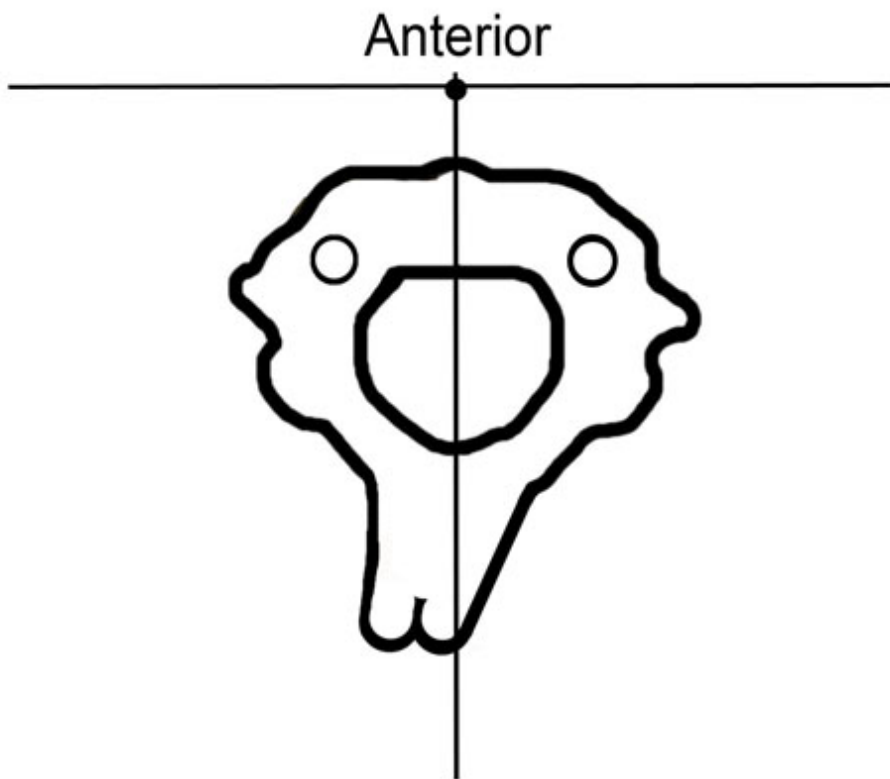


Figure 2. 8 Represents a deviation of the C2 spinous process to the left with C2 viewed in the horizontal plane.

Rotation of the entire vertebra

The C2 spinous process, if it is not deviated with respect to the C2 body, should remain in the midline when the head is in the neutral position. The C2 vertebra should not rotate until the head has rotated at least 23 degrees (Pang & Li, 2004). A measured shift of the C2 spinous process away from the midline, on an anterior-posterior (AP) radiographic view, can indicate that the C2 vertebra is rotated (Figure 2.9). If C2 is rotated when the head is positioned in neutral this may suggest a pathological movement pattern between C1 and C2 that may indicate the presence of dysfunction (Pang & Li, 2004).

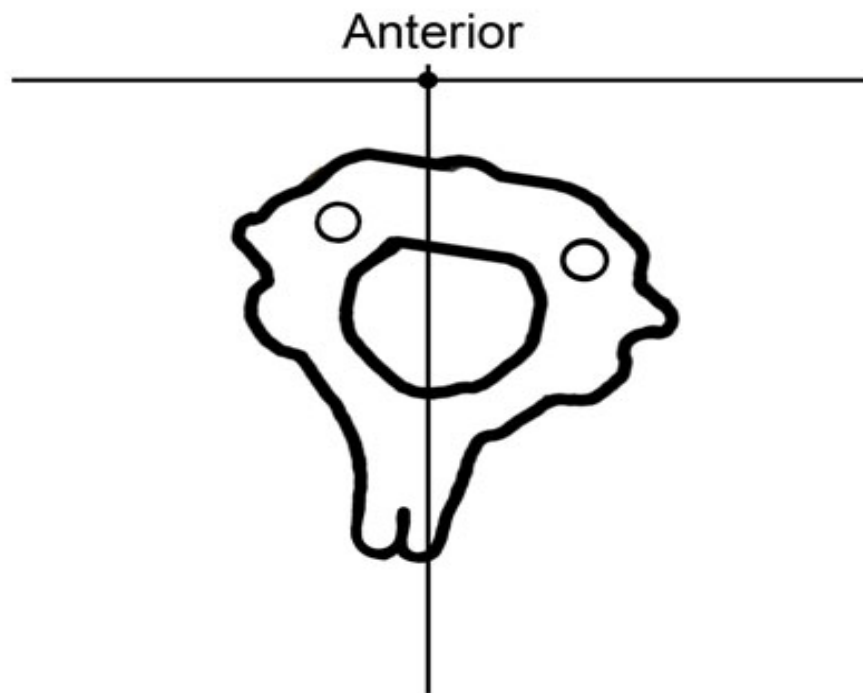


Figure 2. 9 Represents a rotation of the C2 vertebra to the right with C2 viewed in the horizontal plane.

Asymmetry of the two spinous process prominences

The C2 bifid spinous process can present with an asymmetrical prominence of the two prominences of the spinous process (Figure 2.10). Macpherson and Campbell (1991) in a study of migraine type headache reported that when there is an asymmetry of the bony prominences at the tip of the spinous process that the prominent side correlated in six out of seven cases to the side of the headache (Macpherson & Campbell, 1991). This finding may suggest that asymmetry of the spinous process may be associated with headache symptoms.

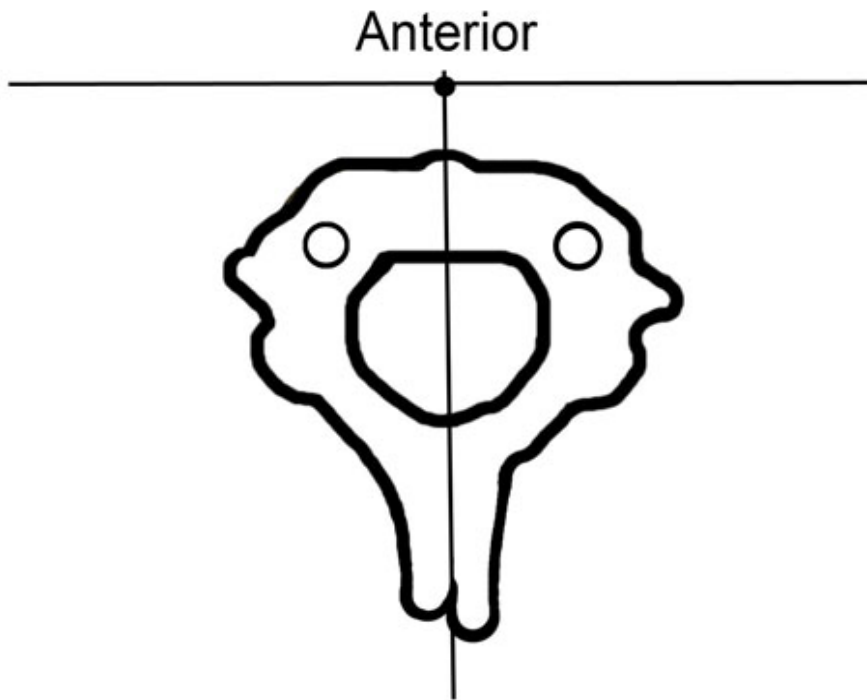


Figure 2. 10 Represents an asymmetrical bifid C2 spinous process with the right tip being more prominent, viewed in the horizontal plane.

2.10.4 Research investigating horizontal plane posture at C2 in headache patients

Two investigations of ‘unilateral’ and migraine headaches that assessed the position and symmetry of the C2 spinous process have reported that altered C2 horizontal plane posture is associated with headaches (Boquet, Biosmare et al., 1989; Boquet, Moore et al., 1989). These authors suggested that altered C2 posture may result in headache or migraine symptoms due to the C2 posture being associated with an irritative focus and local muscle hyperactivity / trigger points that could then result in increased activity in the trigeminocervical nucleus (Boquet, Biosmare et al., 1989). An investigation by Boquet, Biosmare et al., (1989) used radiographic analysis and identified a C2 spinous process deviation in 20 of 24 patients with migraine headache and the spinous process was reported to be deviated in the direction of the headache in 19 of these patients. The results of this study, however, do not provide strong evidence for C2 spinous process deviation in migraine as the participants were identified as being abnormal based on a visual assessment of a radiograph rather than a specific reproducible measurement method, the reliability of this method was not reported and there was no control group (so the prevalence of this presentation in the normal population was not determined) (Boquet, Biosmare et al., 1989). Also, inclusion in the headache group for participants in this study was based on a ‘descriptive’ approach with a main criterion being the presence of a ‘unilateral’ headache. The descriptive approach consisted of the presence of a pattern of symptoms that was suggestive of migraine. The pattern of symptoms for inclusion involved a unilateral headache combined with nausea, vomiting, throbbing pain,

phonophobia and/or photophobia (Boquet, Biosmare et al., 1989). The use of this ‘descriptive’ diagnosis meant that it was possible that participants with different types of headaches, including CEH, may have been included. The authors of this study acknowledged that in some participants the symptom pattern may have also been consistent with a diagnosis of CEH (Boquet, Biosmare et al., 1989).

In a subsequent study using CT scans, cervical abnormalities were found to be associated with a deviation of the C2 spinous process in 18 of 20 participants with headaches (Boquet, Moore et al. 1989). The headache group in this study was reported to include patients with both migraine and CEH (Boquet, Moore et al., 1989). The C2 spinous process postural abnormalities identified in the CEH participants in this study were proposed to indicate a ‘trigger’ for CEH (Boquet, Moore et al., 1989). This provides some support for an association between C2 spinous process deviation and CEH, but it is limited due to the participant sample including a mix of headache types.

Any association between C2 spinous process posture and headache has been challenged by Macpherson and Campbell (1991) who reported that asymmetry and rotation of C2 was so common in asymptomatic individuals that any association with headache symptoms was co-incidental. This study investigated cervical spinal posture in participants with migraine headaches using CT scans (Macpherson & Campbell, 1991). The participants were diagnosed with migraine according to the International Headache Society classification, and are likely to have differed from those in previous studies due to this use of a specific diagnosis of migraine. Their control group did, however, include

individuals referred to a neurology clinic for medical conditions that may be associated with upper cervical dysfunction including post-traumatic headache (n=4), dizziness (n=2) and facial pain (n=1). Control subjects were not excluded on the basis of previous history of other headache types (e.g., tension type headache or CEH) or neck pain, and this may have contributed to the numbers of controls found to have C2 spinous process deviation. The lack of difference in C2 spinous process posture between 30 controls and 30 migraine headache subjects reported by Macpherson and Campbell (1991) is also not surprising considering that cervical dysfunction is not a diagnostic criteria for migraine. Further, the lack of difference between the groups may also have been related to the inclusion of some control group participants that potentially had medical conditions that could be associated with cervical dysfunction. Therefore, the results of this study do not provide strong evidence that could be used to either accept or reject the possibility of an association between C2 posture and migraine.

Despite the conclusion of Macpherson and Campbell (1991) that asymmetry or rotation of C2 was not likely to be associated with migraine headaches, they did report that in patients with a bifid C2 spinous process, where there were asymmetrical prominences of the two components, there was a common association (in six out of seven cases) between the side of the prominence and the side of the headache. The significance of this finding was reported as uncertain due to the small numbers of participants that displayed these characteristics but it does indicate a potential association may exist between the side of the C2 spinous process asymmetry and the side of the headache.

The results of these previous investigations into any potential associations between the direction of C2 spinous process asymmetry and the side of the headache do not provide strong evidence to either accept or reject the hypothesis that headaches may be associated with C2 spinous process deviation. Boquet, Biosmare et al., (1989) may have included individuals with CEH when they identified a link between spinous process deviation and headaches. Macpherson and Campbell (1991) may have included CEH participants in their control group when they identified a high proportion of abnormalities in this group. The investigation of the C2 level in CEH is appropriate as C2 is proposed as the most common cervical level for CEH genesis (Bogduk, 2001; Frese & Evers, 2008). Additionally, the investigation of C2 spinous process deviation in CEH is further justified by the proposition that the postural abnormalities seen at C2 may result from cervical trauma (Gradl et al., 2005). CEH has been reported to commonly have trauma as a precipitating factor (Dumas et al., 2001; Jull, Sterling et al., 2008). Thus, these findings suggest that an analysis of horizontal plane posture of C2 in CEH is warranted.

2.10.5 Horizontal plane measurement techniques for C2

The C2 spinous process can be visualised radiographically using the AP open mouth view. AP open mouth X-ray views are taken as part of the standard cervical X-ray series for patients with cervical disorders (Bontrager, 2005). It would be expected that a measurable shift of the C2 spinous process from midline on AP open mouth radiograph would occur in patients with a deviated C2 spinous process (Figure 2.7), a rotated C2 (Figure 2.8) or an asymmetrical C2 spinous process (Figure 2.9).

A technique has been proposed for analysing the position of C2 on radiographs using the measurement of the spinous process deviation from the midline (Figure 2.11) (Gradl et al., 2005). The comparable results in this study of the measurement of C2 rotation using CT scan, magnetic resonance imaging (MRI) scan and X-ray were described as indicating that X-ray can contribute substantially to the diagnosis of C2 rotation without the need for CT or MRI scans (Gradl et al., 2005). The method described in Gradl et al. (2005) involves a vertical line passing through the mid-point of the tip of the odontoid process and a second vertical line passing through the mid-point of the spinous process of C2 (see Figure 2.10). The distance between these two lines is measured in millimetres and then this distance is converted to an estimation of the degrees of rotation by using a coefficient of rotation (1.62 degrees per millimetre of rotation).

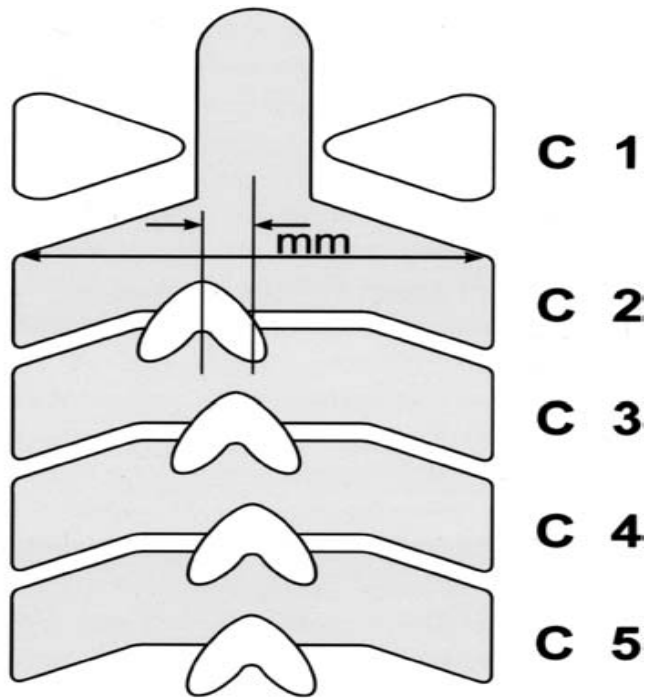


Figure 2. 11 Demonstrates the technique for measuring C2 spinous process deviation from the midline using an AP X-ray (the distance in millimetres between the lines indicates the deviation of the C2 spinous process from the midline) (Gradl et al., 2005).

An alternate technique that has been proposed to measure C2 horizontal plane rotation on radiographs is the odontoid lateral mass interspace (OLMI) technique (Iannacone, DeLong, Born, Bednar, & Ross, 1990). This method involves measuring the distances between the odontoid process and each lateral mass of C1 (Figure 2.12) (Iannacone et al., 1990). This method had previously been proposed to demonstrate rotation when the odontoid lateral mass interspace was asymmetrical, but research using CT scans as the ‘gold standard’ has demonstrated that interspace asymmetry on radiographs does not indicate C2 rotation (Iannacone et al., 1990). Further, as the odontoid lateral mass

measurement technique does not directly measure the C2 spinous process it cannot identify C2 spinous process deviation or asymmetry. These results suggest that this method is not appropriate for measuring C2 horizontal plane posture.

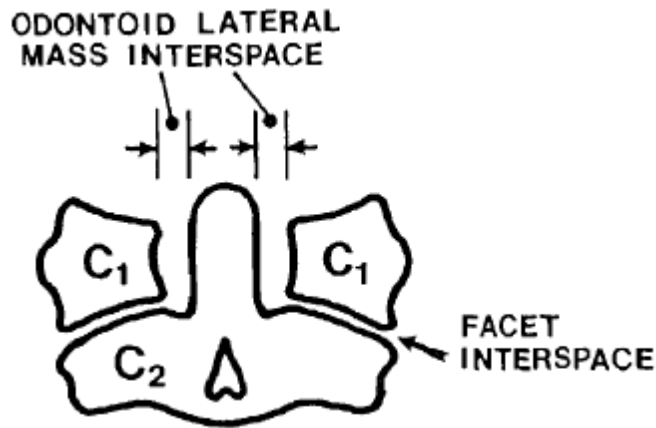


Figure 2. 12 Demonstrates the distances measured in the odontoid lateral mass interspace technique (Iannacone et al., 1990).

Another technique for determining cervical horizontal plane posture using radiographs has been described by Janik et al. (2001). This technique has been demonstrated to be reliable and involves two AP radiographs, one in neutral and one in lateral bending with rotation, and then a calculation of the horizontal posture based on average cervical dimensions from the literature (Janik et al., 2001). The use of these ‘average cervical dimensions’ introduces a source of error that may make this technique invalid despite being reliable. Further, this method doubles the radiation exposure to the patient compared to methods that use a single AP radiograph. Due to this increased radiation exposure the use of a technique, such as that described in Gradl et al. (2005), is preferable.

2.11 Why is assessing posture in CEH important?

The investigation of specific cervical postural abnormalities potentially associated with CEH is important as this knowledge could improve the assessment and treatment of this condition. It is likely that the investigation of the posture of the upper cervical spine is more relevant in CEH than for other headache types due to the primary role that structures in this region play in the genesis of CEH. In addition, the upper cervical nerves have been described as having a primary role in controlling head posture (Nicolakis et al., 2000). Recent research investigating the craniovertebral angle has, however, demonstrated a stronger association between thoracic posture and neck pain than between cervical posture and neck pain using the craniovertebral angle measurement method (Lau et al., 2010). This result suggests that general postural factors should also be considered when investigating any association between posture and cervicogenic symptoms.

Abnormal posture may possibly be a cause of CEH if nociceptive signals are generated along the upper cervical nerves as a result of this posture. It has been proposed that nociceptive signals might be generated from abnormal posture if the cervical structures are placed at a mechanical disadvantage causing abnormal tissue positioning and stretch (Grimmer-Somers et al., 2008). Movement dysfunction in the upper cervical spine has been proposed to be a potential source of upper cervical nociceptive signal generation (Martelletti & van Suijlekom, 2004). Movement dysfunction may result from abnormal cervical posture (Edmonston et al., 2005). Specific analyses of upper cervical biomechanics have shown that a reduction in overall cervical range of movement occurs

when cervical movements are initiated from end of range positions (i.e., extremes of posture) (Edmonston et al., 2005). Changes in posture also alter the coupling pattern in the upper cervical region (Panjabi et al., 1993). Therefore, altered posture can change both the range and pattern of the movement in the upper cervical spine. This suggests that upper cervical postural abnormalities may result in movement dysfunction and, therefore, may contribute to nociceptive signals in the upper cervical nerves.

Nociceptive signal generation in CEH may also be linked to the presence of inflammatory mediators in the upper cervical joints. A link between CEH and local joint inflammation has been implicated with a reduction of CEH symptoms shown following the use of local joint steroid injections (Narouze et al., 2007; Reale et al., 2000). The inflammatory process can cause a profound change in the response of the nociceptive system during movement, with the system becoming sensitised to the point where movements even in normal ranges can cause nociceptive activity to occur (Kidd, Morris, & Urban, 1996). This suggests that nociceptive signals may be generated or magnified in CEH by mechanical stress, even if the increased stress is minimal, due to the sensitisation of the nociceptive system by a local inflammatory process. Posture is one factor that could result in these increased mechanical stresses due to movement dysfunction.

The role of postural factors in CEH is also supported by one study demonstrating a reduction in symptoms following exercises focused on cervical postural correction and control (Jull et al., 2002). This study demonstrated that CEH symptoms reduced following exercise despite a lack of measureable changes in posture (Jull et al., 2002). As

highlighted previously when discussing studies investigating associations between CEH and posture, these results may mean that either no postural change occurred or that measurements of posture did not isolate the specific postural factors associated with CEH. It has been proposed that measures that more accurately reflect the complex postural variables associated with CEH may be required (Dumas et al., 2001).

There were no studies identified that investigated cervical spinal posture in CEH using radiographic measurement of posture. This is despite radiographic measurement being considered the most valid method for postural evaluation when measuring either general or segmental spinal posture (Wu et al., 2007). The IHS (2004) diagnostic criteria for CEH include “imaging evidence of a disorder or lesion within the cervical spine” (International Headache Society, 2004, p.115). Demonstrating an association between cervical spinal posture and CEH symptoms using radiographic analysis could potentially fulfil this IHS diagnostic criterion and, thereby, implicate the cervical spine as a source of symptoms.

Previous research using radiographs to investigate CEH has only assessed specific pathology used to diagnose CEH (Fredriksen, Fougner, Tangerud, & Sjaastad, 1989; Pfaffenrath, Dandekar, & Pollmann, 1987). Two studies have reported that no specific X-ray pathology is characteristic of the CEH (Fredriksen et al., 1989; Pfaffenrath et al., 1987). However, the evidence from these two studies is not strong as the sample sizes were relatively small (11 and 15 subjects respectively) and the analysis was descriptive rather than statistical. Investigation of MRI scanning in a study including 22 CEH patients and 20 controls has also failed to identify a specific pathological finding

underlying the aetiology of cervicogenic headache (Coskun et al., 2003). These studies attempted to identify specific pathology but did not specifically investigate cervical posture.

Establishing an association between abnormal posture and CEH will provide evidence to support clinicians making informed decisions regarding the assessment or treatment of postural factors in CEH patients. The use of postural assessment in CEH is only worthwhile as a diagnostic tool if postural factors that differentiate CEH from other headache types, or from asymptomatic individuals, can be isolated. If postural factors are found to be associated with CEH then the specific role of postural assessment in CEH can be determined.

2.12 Proposed methods for analysing posture in the upper cervical spine

The assessment of postural abnormalities in the upper cervical spine has previously been proposed, in both physiotherapy and chiropractic literature, to ideally involve a combination of palpation and radiographic assessments (Jende & Peterson, 1997; Maitland et al., 2005). The previous investigations of the agreement between palpation by chiropractors and radiographic findings in the upper cervical spine have, however, reported conflicting results (Eriksen, 1996; Hart, 2006; Jende & Peterson, 1997; Spano, 1995). Two studies found poor agreement between palpatory findings and radiographic findings of bony asymmetry (Eriksen, 1996; Jende & Peterson, 1997). These studies used

different methods for palpation assessment with Jende and Peterson (1997) reporting palpation of the position of C1 using bony landmarks and Eriksen (1996) reporting palpation of the sub-occipital muscles. Both studies used the kappa statistic to analyse the level of agreement (Eriksen, 1996; Jende & Peterson, 1997). Another study reported an ‘apparent corroboration’ between a palpation of the sub-occipital muscles and radiographic measurements (Spano, 1995), reporting agreement in ten of the twelve subjects without a control group or a statistical analysis of the results (Spano, 1995). A more recent study investigated a combination of palpation techniques (both a muscle palpation technique and an assessment of the position of bony prominences) and radiographic measurement techniques (Hart, 2006). This study used kappa statistics to determine the reliability of the palpation and radiographic measurement techniques, but did not determine the level of agreement between the two methods. The results demonstrated that none of the palpation techniques studied had acceptable reliability (Hart, 2006). This suggests that a comparison between the results of palpation and radiographic assessments of posture may not be useful due to the lack of reliability of the palpation assessment.

The methods used in the palpation assessments in two of these previous studies are not clear as the patient position during the palpation assessment was not described (Eriksen, 1996; Hart, 2006). The other two studies differed in their methods, with the palpation assessment performed in either supine lying or sitting (Jende & Peterson, 1997; Spano, 1995). The methodological differences in these studies may explain the differences in the reported results, but further investigation is warranted to clarify the ability of clinicians to

reliably determine the presenting postural characteristics of the cervical spine using palpation. Further, no study has been identified that reports on the reliability of physiotherapists to palpate the presenting postural characteristics of the cervical spine or on the reliability of any clinician performing this palpation assessment in prone lying.

2.13 Palpation assessment of posture in CEH

It is recommended that palpation assessment includes a combination of multiple palpatory findings rather than a single palpatory test (Gibbons & Tehan, 2002).

Individual palpation assessment techniques may not be reliable without consideration of the findings of the other components of the palpation assessment. Vaughan (2002), in a paper reviewing palpation assessment techniques, recommends a palpation assessment should include a combination of pain, posture, range of motion and tissue texture findings. Pain and range of motion are usually included in the palpation assessment process. The incorporation of an assessment of bony asymmetry, or spinal posture, may contribute to improving the validity and reliability of palpation assessments (Vaughan, 2002).

Studies that have investigated the reliability of palpation to identify a symptomatic level in cervical dysfunction included mobility assessments believed to be associated with symptoms (Jull et al., 1988; King et al., 2007; Tuchin, Pollard, & Bonello, 2000).

Mobility assessments included assessments of abnormal 'end feel' (an abnormal quality of palpated resistance at the extreme end of range of motion), abnormal quality to the

resistance of motion through range, and the reproduction of pain as indicators of abnormality. These studies did not include an identification of posture or bony asymmetry, even though the pattern and range of cervical spine movement has been shown to alter with changes in posture (Edmonston et al., 2005). Having the ability to identify changes in spinal posture may therefore increase the likelihood that a correct interpretation of the mobility assessment is made, considering that the actual range and pattern of mobility changes in different postures. If the examination of joint motion is performed without an understanding of the underlying postural presentation and its effects on joint motion, then the interpretation of the cervical joint motion examination may be flawed.

The assessment of posture with palpation requires an ability to identify bony landmarks and then determine the relative position of these landmarks. A recent study, involving 49 subjects, investigating the ability of physiotherapists with post-graduate training in manual therapy to identify specific bony landmarks demonstrated a poor inter-rater reliability (Kappa of 0.18 for C7 spinous process) (Robinson, Robinson, Bjørke, & Kvale, 2009). Pain reproduction during palpation is suggested to be more reliable than spinal landmark identification (Harlick, Milosavljevic, & Milburn, 2007). Poor reliability in identifying bony landmarks suggests the ability of physiotherapists to determine posture by assessing the relative alignment of bony landmarks may also be unreliable. However, if the assessment of posture by palpation could be shown to be reliable, it offers advantages over radiography including simplicity, cost-effectiveness and a lack of radiation exposure (D. E. Harrison et al., 2005). These benefits suggest that further

investigation of the reliability of various aspects of the palpation examination is appropriate (Robinson et al., 2009).

The use of palpation to differentiate the potential source of a patient's headache pain is standard procedure in the assessment of individuals with CEH (Sjaastad et al., 1998). It has been reported that CEH can be reliably distinguished from other headache types using a palpation examination for cervical musculoskeletal abnormalities (Marcus, 2007). Hall et al. (2010) found physiotherapists to be reliable in agreeing on a symptomatic spinal level in patients with CEH. This study did not, however, compare palpation with double blinded anaesthetic blocks so it is unknown whether the agreed spinal level corresponded to the level causing the symptoms, casting some doubt on the validity of palpation. Jull et al. (1988) has reported one physiotherapist to be reliable in identifying a symptomatic cervical level as compared to anaesthetic injections as the 'gold standard'. However, the authors suggested these results should be reproduced before they should be considered generalisable. The injections performed in Jull et al. (1988) were also not fluoroscopically guided, and these are required to establish an unequivocal diagnosis (Bogduk & Govind, 2009). A subsequent study that attempted to replicate the methods of Jull et al. (1988) with a larger sample of patients, did not find palpation to be accurate in determining the level of dysfunction in the cervical spine (King et al., 2007). Importantly the method used in King et al. (2007) differed from that of Jull et al. (1988) in that the palpation assessment was performed by a medical doctor rather than a physiotherapist. King et al. (2007), therefore, does not specifically determine that physiotherapists are

inaccurate, but neither do the results of Jull et al. (1988) demonstrate that physiotherapists are generally accurate, so further investigation is required.

Establishing that palpation is a valid method for determining the symptomatic level in the cervical spine is consequential as diagnosis of the symptomatic level and choice of cervical manual therapy treatment techniques are commonly based on the results of a cervical palpation examination (Jull et al., 1988; Tuchin et al., 2000). Including an assessment of the underlying posture of the cervical spine may provide additional information that allows the accuracy of the palpation assessment to be improved.

The accuracy of a general palpation examination is reported to be affected by the training, experience and skill level of the examiner (Gerwin, Shannon, Hong, Hubbard, & Gevirtz, 1997). The ability to perform a palpation examination to identify changes in posture is reported to require significant skill due to the subtle nature of many postural abnormalities (Palmer & Epler, 1998). This suggests that the skill level and specific training of the examiners in palpation for postural alignment factors may be especially important to achieve accuracy. Determining the accuracy of palpation in identifying the postural presentation is required. This knowledge may then be used to make recommendations regarding the inclusion of a postural assessment as part of a palpation examination.

The ability to reliably identify the postural presentation of the cervical spine may be an important skill due to the possible difference that posture may make to the resistance

characteristics of the cervical spine as identified by Edmonston et al. (2005). As previous research has suggested an asymmetrical presentation of the C2 spinous process in headache patients (Boquet, Biosmare et al., 1989; Boquet, Moore et al., 1989), investigating the ability of palpation to identify the postural presentation of the C2 spinous process may also be worthwhile. The ability to palpate a spinous process is considered a basic skill in physiotherapy graduates and a prerequisite for other manual therapy techniques (Robinson et al., 2009). Despite it being considered a 'basic skill,' only one study has been identified that has investigated the reliability of palpating the C2 spinous process (Hart, 2006). This study found that the discrimination of C2 rotation/asymmetry by palpation was unreliable ($K = 0.38$) (Hart, 2006). [A Kappa of 0.4 is considered the minimum acceptable level of agreement for a clinical test to be reliable (Fjellner, Bexander, Faleij, & Strender, 1999)]. This investigation included chiropractors of different levels of experience, including chiropractic interns (Hart, 2006). This factor may have affected the reliability as inter-rater reliability in palpation improves if examiners are more experienced and trained before a study commences (Gerwin et al., 1997). Palpation reliability may improve for this specific clinical test by standardising the technique used, conducting examiner training and using only experienced manual therapists (van Suijlekom, De Vet, Van Den Berg, & Weber, 2000). Training may be essential for reliability as variability between therapists has been reported to have a greater effect on reliability than any patient defined factors (Harlick et al., 2007).

2.14 Radiographic assessment of posture in CEH

The study by Boquet, Moore et al. (1989), described previously, reported a correlation between a painful prominence of the C2 spinous process (identified using palpation) with abnormalities at C2 on the side of the headache identified using radiographic assessment. This study included only three participants with a diagnosis of CEH, and the criteria used to achieve this CEH diagnosis were not described. It was however reported that all three of these participants demonstrated abnormalities of the upper cervical spinous processes on both radiographic analysis and palpation (Boquet, Moore et al., 1989). These results suggest that further investigation of CEH using radiographic analysis of cervical spinal posture may be appropriate.

Analysis of spinal posture using radiographic measurement methods is supported by demonstrations of the reliability of these techniques (Cote et al., 1997; D. E. Harrison, Harrison, & Troyanovich, 1998; Johnson, 1998). In the chiropractic profession, radiographic analysis is considered a primary diagnostic tool (McAviney, Schulz, Bock, Harrison, & Holland, 2005). The use of radiographic analysis to assess the upper cervical spine has been reported to typically involve the use of the lateral and AP open mouth X-ray views (Jende & Peterson, 1997).

This use of radiographic analysis of cervical spinal posture is reported to be common despite the lack of an accepted benchmark for the determination of abnormal findings (McAviney et al., 2005). The measurement of spinal posture on radiographs may be

reliable but the validity of these methods, the link between alterations in alignment on radiographs and symptoms, has not been established (Christensen & Hartvigsen, 2008; Haas et al., 1999). A recently published review of related literature has recommended that the routine use of X-ray to analyse spinal posture is currently not justified in non-acute management of cervical injuries (Nordin et al., 2008). Demonstrating specific postural factors that are associated with CEH symptoms would, however, not only help establish validity of this assessment method but may also help with the process of diagnosis. Identifying specific changes in spinal posture that are associated with CEH symptoms may also help provide treatment strategies.

The association between specific cervical spinal postures measured radiographically and symptoms is not clear. One study has linked a reduced cervical lordosis, measured using the posterior tangent method on radiographs, to cervicogenic symptoms (McAvinney et al., 2005). A second study has, however, found no association between clinical signs and symptoms and a reduced cervical lordosis curvature (Matsumoto, Fujimura, Suzuki, Yoshiaki, & Shiga, 1998). This earlier study did not, however, use a method of measuring cervical lordosis that has been reported to be reliable (Matsumoto et al., 1998). This lack of agreement between different studies may reflect differences in the measurement methods, but it also suggests that further investigation is warranted.

At present no imaging tests have been demonstrated to help discriminate CEH (Martelletti & van Suijlekom, 2004). The IHS (2004) CEH diagnostic criteria includes ‘imaging evidence of a disorder’ in the cervical spine. Demonstrating an association

between cervical spinal posture and CEH symptoms using radiographic analysis could fulfil the IHS (2004) diagnostic criteria and this may be used in the future to improve the accuracy of diagnosing CEH. Research is needed in CEH, using radiographic analysis, to investigate both general cervical spinal postures, as well as specifically focussing on the upper cervical spine to determine if there is an association between this type of headache and altered posture.

2.15 Summary

CEH is a syndrome that is potentially related to dysfunction in multiple different structures in the cervical spine. Diagnosing CEH is difficult in the physiotherapy clinical setting as the only method reported to provide a definite diagnosis is fluoroscopically guided anaesthetic diagnostic blocks. As these fluoroscopically guided anaesthetic diagnostic blocks cannot be performed by physiotherapists, a clinical examination is commonly used to assess CEH despite it providing only a 'reasonably valid' diagnosis (Frese & Evers, 2008). No individual clinical test or sign has been demonstrated to discriminate CEH from other headache types (Jull et al., 2007). As well the challenges involved in diagnosing CEH, there is also a difficulty in isolating the specific cervical structure or dysfunction that is causative of CEH. Identifying the involved structure(s) or dysfunction could potentially provide a direction for treatment.

The inability to isolate an individual clinical test or sign that can diagnose CEH has led to research that has isolated a pattern of musculoskeletal impairments that are associated

with CEH (Jull et al., 2007). This pattern of impairments involves a combination of joint, muscle and movement dysfunction (Jull, O'Leary et al., 2008; Moore, 2004). Abnormal posture of the cervical spine has also been proposed to be a cause or aggravating factor in CEH (Jull et al., 1997; Richardson, 2009). Demonstrating an abnormal posture that is associated with CEH may strengthen the diagnosis, as well as provide a specific direction for treatment.

As the upper cervical region is most strongly implicated in the genesis of CEH symptoms, analysis of posture should include a method for assessing the upper cervical posture as well as including a general cervical spinal postural analysis. Radiographic analysis of posture can identify the specific spinal posture of the upper cervical region with techniques that have also been demonstrated to be reliable (Johnson, 1998; Rochester, 1994).

Assessment of upper cervical posture using a combination of the results of radiographic and palpation assessments is common practice in physiotherapy. The reliability of the radiographic postural measurement methods has been demonstrated but palpation has not been shown to be reliable. If postural variables associated with CEH can be identified then it is important to determine if palpation can be used to reliably identify specific postural abnormalities. If palpation assessment method does prove reliable then there would be a reduced justification for clinicians to perform an X-ray assessment in the analysis of posture.

Chapter 3

Method

3.1 Overview

The present study had two distinct aims. Firstly, it investigated the association between static cervical spinal posture and CEH by using radiographic assessment to identify postural factors that may be more prevalent in individuals with CEH. Secondly, it investigated the reliability of physiotherapist examiners in determining the presenting postural characteristics of the cervical spine using palpation. To achieve this, the study involved 60 volunteer human participants, three physiotherapist examiners and two radiographer examiners.

This chapter describes the recruitment of participants and examiners, the palpation techniques used in the assessment of posture, the radiographic protocols, the techniques used to analyse the radiographs, and the methods used to analyse the data.

3.2 Study design

The present study used a single blind, age and gender matched, comparative measurement design to evaluate the differences in cervical spinal posture, as measured on cervical radiographs, between asymptomatic participants (control group) and participants who had CEH (CEH group). The CEH diagnosis was determined using a questionnaire based on the pattern of symptoms consistent with the diagnostic criteria of the ‘Cervicogenic Headache International Study Group’ (CHISG) for CEH (CEH group), including a palpation assessment of the cervical region to reproduce a ‘familiar’ headache (Sjaastad, Fredriksen, & Pfaffenrath, 1998). The present study also included a related but separate investigation into the inter-rater reliability of physiotherapist examiners in determining the presenting postural characteristics of the cervical spine by using postural palpation examination.

The research design involved each participant undergoing a palpation assessment of their cervical spine, followed immediately by two radiographs of the cervical spine. The palpation assessment was performed separately by two physiotherapists with post-graduate training in manual therapy and clinical experience of 28 years and 30 years respectively. The palpation assessment was performed to assess the presenting postural characteristics of the cervical spine. This assessment was performed after the palpation assessment for reproduction of a familiar headache and prior to the radiographic assessment.

The radiographic data collection involved taking two standard radiographic views of the cervical spine (one anterior-posterior open mouth view and one lateral view). The radiographs were performed on all participants using well recognised and standardised techniques (Bontrager, 2005).

All participants gave their informed consent to take part in the study. The protocol described below was approved by the University of Newcastle Human Research Ethics Committee (HREC) Approval Number: H-2008-0196 (approved on 11/6/2008) (Appendix A).

3.2.1 Rationale for study design

The investigation of the reliability of the physiotherapist palpation was included in this study because a reliable method for assessing cervical posture in routine clinical screening is required if altered posture is found to be associated with CEH. Chiropractic literature and well accepted physiotherapy texts have proposed that the assessment of postural abnormalities in the upper cervical spine should involve a combination of palpation and radiographic assessments (Jende & Peterson, 1997; Maitland et al., 2005). Moreover, a recently published review of related literature has recommended that the routine use of radiographs is not justified in the non-acute management of the cervical spine due to a lack of evidence supporting their utility (Nordin et al., 2008). Radiographs are arguably, therefore, not justified in a clinical setting for the routine screening of

patients with CEH. This suggests that postural screening would require a method other than radiographs to be used in the clinical setting.

It has been reported that a significant proportion of the assessment and treatment techniques used in the management of musculoskeletal disorders by healthcare professionals rely on a competency in palpation (Holsgaard-Larsen et al., 2010).

Palpation is a quick and easy technique to perform in a clinical setting that is safe and is already routinely performed as part of the clinical examination. It has been previously reported that CEH can be distinguished from other headache types using a palpation examination for cervical musculoskeletal abnormalities (Marcus, 2007). Determining the reliability of specific palpation skills is required. The reliability of the palpation examination for assessing posture has not been established. If palpation of cervical posture is found to be reliable this could allow cervical posture to be assessed as part of the standard clinical examination. Demonstrating the reliability of this palpation assessment may provide an alternative to the use of radiographs in the assessment of cervical posture which could in turn prevent the exposure of these patients to the associated ionising radiation.

Gender and age have both been shown to alter the alignment of the upper cervical spine (Johnson, 1998). A design that matched age and gender between the control and CEH groups was used to ensure any difference in the results was not due to these factors.

3.3 Sample Size

Data from previous investigations using radiographs to analyse cervical posture were used to inform the sample size calculations (Johnson, 1998; Cote et al., 1997). These studies were chosen as they had used the same radiographic views and measurement methods as in the current study. The variability of upper cervical lordosis posture in normals as reported by Johnson (1998), suggested that a 5 degree difference between groups in the current study could be detected with 80% power with 24 participants per group. The variability in overall cervical lordosis, as reported by Cote et al. (1997), suggested a 10 degree difference in overall lordosis could be detected with 80% power with 22 participants in each group. No study was identified investigating C2 rotational posture which provided enough information or data to enable sample size calculations to be performed. As the sample size calculation was informed by only the variability of cervical lordosis measures, there was a possibility that there might be a larger variability in C2 posture. Therefore, a sample size of 60 participants (30 each for the CEH group and the control group) was targeted for recruitment to allow for this possibly larger variability in neck postures.

3.4 Recruitment

Recruitment information was distributed through flyers (Appendix B) that were placed on noticeboards on the Callaghan and Ourimbah campuses of the University of Newcastle and emailed to all University of Newcastle staff, post-graduate students and undergraduate students. Both the recruitment flyers and email announcements provided the student researcher's contact phone number and email address. Potential participants responded by contacting the student researcher to express their interest in participation. These potential participants were provided a copy of the Research Information Statement (Appendix C). Potential participants who expressed interest in participation after reading the Research Information Statement were then contacted by the student researcher and were screened for inclusion into either the CEH or control group by answering questions in the Phone Call Screening Questionnaire (Appendix D). Participants that responded to the recruitment information by email were asked to provide a contact phone number so that the student researcher could conduct the Phone Call Screening Questionnaire. The Phone Call Screening questionnaire was formulated to include questions to determine that the potential participant fulfilled the inclusion criteria for the study while not reporting any medical history consistent with the exclusion criteria. Participants with and without headaches were recruited through this process. A flow chart demonstrating the recruitment process for potential participants and then the sequencing of the assessments performed on participants is displayed in Figure 3.1.

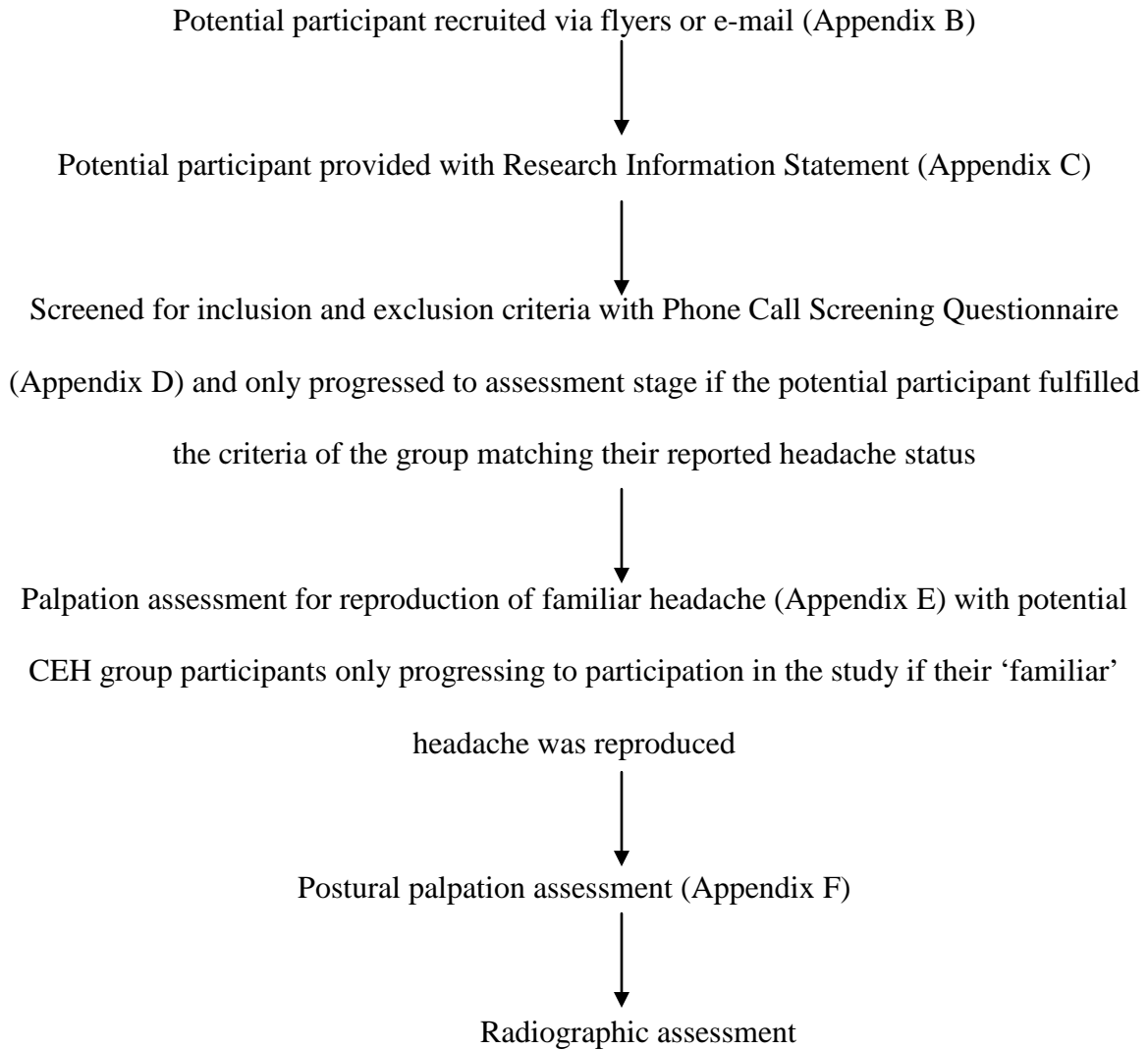


Figure 3. 1 Flow chart demonstrating the sequencing of the recruitment process for potential participants and the assessments performed on participants.

3.5 Inclusion and exclusion criteria

All potential participants were only included in the study if they answered the Phone Call Screening Questionnaire (Appendix D) in a manner that fulfilled the criteria of the group that matched their headache status (CEH group or control group) and did not report any contraindications for manual therapy to the cervical spine. To participate in the study volunteers had to be healthy adults aged between 18 and 50 years with no history of significant medical conditions that might be potential contraindications to manual therapy of the cervical spine (Murtagh & Kenna, 2001). They also needed to be able to make an informed decision about whether to take part.

The answers to the Phone Call Screening Questionnaire that were required to fulfil the inclusion criteria for the CEH group were based on the CHISG diagnostic criteria for CEH. These potential participants needed to report the following characteristics to be included:

- Headache distribution on only one side of the head or, if on both sides, always worse on one side
- Headaches associated, either before, during or following, with neck pain
- Headaches associated with movements of the neck or the position of the head or neck, change or aggravate the headache
- Headaches have been occurring at least once per week over the past two months
- No treatment by a physiotherapist, chiropractor, osteopath or any other manual therapist in the last two months
- The participant is not currently involved in any workers' compensation, third party or litigation claim related to their symptoms
- Participant does not experience an aura (visual phenomenon that may include seeing flashing lights or geometric patterns)
- Aged 18-50.

A potential participant was excluded if they reported a medical history that included:

- Inflammatory, infectious or rheumatological diseases (e.g., rheumatoid arthritis) affecting the neck
- Neurological conditions (e.g., stroke)
- History of cancer
- History of osteoporosis
- Congenital abnormalities
- Instability in the neck
- Paraesthesia, weakness or pain extending down the arm
- Dizziness related to neck movement.

This list included the conditions that were considered to constitute a potential contraindication for manual examination of the neck such as a known history of cancer, osteoporosis, nerve root compromise, instability of the neck, congenital abnormalities in the neck, or potential symptoms of vertebrobasilar insufficiency such as dizziness and double vision (Murtagh & Kenna, 2001). The exclusion of known neurological conditions (such as stroke) or inflammatory conditions (such as rheumatoid arthritis) was also required, as the effect of these conditions on cervical posture is not known and might possibly have been a confounding factor.

Potential participants younger than 18 or older than 50 were excluded. The exclusion of people under 18 was required as the posture of the upper cervical spine in children is known to be different from adults (Johnson 1998). The exclusion of individuals over 50 was required so that the normal degenerative process that occurs in the spine with ageing was not a confounding factor in the results (van Saase, van Romunde, Cats, Vandenbrouke, & Valkenburg, 1989). Any potential female participant that reported a possibility of being pregnant was also excluded due to the use of radiographic examinations in this study. The exclusion of those currently involved in litigation or a worker's compensation claim was due to evidence that individuals with compensation claims have higher reported pain than those with non-compensable injuries (Workcover NSW, 2003). This could have been a confounding factor in the assessment of headache reproduction. Potential participants who had treatment for neck or headache symptoms by a manual therapist within the last two months were also excluded as the effect of this manual treatment on cervical posture is not known and could be a confounding factor in the assessment of cervical posture.

To participate in the study potential participants reporting headaches were required to have CEH as other headache types may present with different postural characteristics. Potential CEH group participants were, therefore, excluded if they had a history of an 'aura' associated with their headaches as this is a feature of migraine headaches. They were also excluded if their headache was bilateral as this is a common feature of tension type headache and other non-CEH headache types.

The screening process to determine if potential participants met the inclusion and exclusion criteria for this study was conducted through the Phone Call Screening Questionnaire (Appendix D). The screening questions to determine the eligibility to participate in the CEH group differed from those for the control group so each potential participant was only asked the questions in the Phone Call Screening Questionnaire that related specifically to their reported headache status. The Phone Call Screening Questionnaire was also used to ensure that no participant entered the study that reported any symptoms or medical history that would normally be considered a contraindication for manual therapy to the cervical spine. The potential participant's age and gender were also recorded as this allowed the CEH group and the control group to be age and gender matched.

The questions in the Phone Call Screening Questionnaire that were used to determine if the potential CEH group participants met the inclusion criteria were based on the diagnostic criteria for CEH identified by the CHISG (Sjaastad et al., 1998). The potential CEH participants were only considered for progress to the physical assessment component of the screening process if they answered all of the phone call screening questions in a manner consistent with the CHISG diagnostic criteria. The CHISG diagnostic criteria have been used widely as the basis for inclusion criteria in CEH research (Stanton & Jull, 2003; Zito, Jull, & Story, 2006). These criteria have been reported as reliable in the diagnosis of CEH (Martelletti & van Suijlekom, 2004).

3.5.1 CEH group inclusion and exclusion criteria

The CHISG diagnostic criteria for the CEH included reproduction of ‘familiar headache symptoms’ combined with a unique pattern of headache presentation. Inclusion into the CEH group required a cervical palpation assessment to be performed that reproduced the potential participant’s ‘familiar headache’ as this is considered an important diagnostic criterion for CEH (Sjaastad et al. 1998). The assessment for headache reproduction of a familiar headache with palpation was performed on all participants by one physiotherapist with post-graduate qualifications in manual therapy and 16 years clinical experience as a manipulative physiotherapist (i.e., titled member of the Australian Physiotherapy Association).

The assessment of a ‘familiar headache’ on palpation could not be performed until the potential participant met the inclusion criteria assessed through the Phone Call Screening Questionnaire, consented to be part of the study and then presented for assessment (data collection session). The palpation assessment for reproduction of a familiar headache, therefore, was performed as the first component of the assessment process as a potential CEH group participant could not be included in the study until this inclusion criterion had been fulfilled. The effect of this palpation examination on posture was unknown and there was a possibility that this assessment may have possibly changed a person’s normal posture. Therefore, an identical assessment for the reproduction of a ‘familiar headache’ was performed on all potential CEH and control group participants even though this assessment was not required for inclusion in the control group. As the examiner may

have altered the assessment process depending on the headache status of the participant this examiner was blinded as to the headache status of each participant. The performance of exactly the same palpation assessment process on each of the participants also helped ensure that the other physiotherapist examiners (i.e., those doing the palpation assessment for posture) remained blinded as to the headache status of all of the participants.

The student researcher informed all participants prior to their assessment that they should not discuss their headache status (i.e., if they were in the CEH or control groups) with any of the assessing physiotherapists or the radiographer. Each participant was informed that they should, however, report to the physiotherapist performing the palpation assessment for reproduction of their familiar headache when this headache was reproduced. Only the student researcher was aware of the headache status of the participants. The student researcher determined if a potential CEH participant could continue into the study once the result of the palpation for reproduction of familiar headache was determined.

Potential CEH group participants were excluded from further participation if they failed to report “precipitation of head pain, similar to the usually occurring one, with external pressure over the upper cervical or occipital region on the symptomatic side” (Sjaastad et al., 1998, p. 442). The palpation assessment for reproduction of a familiar headache was performed in a pre-determined sequence and once any headache reproduction was reported the assessment was discontinued as the participant had then fulfilled the criteria for inclusion. The techniques used for the palpation assessment were based on the

cervical spine passive accessory intervertebral movement assessment techniques as described in Maitland et al. (2005). The participants were positioned for the palpation assessment in a comfortable prone lying position with their head resting in the face cut-out of a standard treatment table. The palpation was performed initially on the soft tissues and then progressed to palpation of the cervical vertebrae. The techniques involved palpating from the occiput to C7 level commencing at the occiput and progressing to each vertebral level sequentially. Each technique in the assessment was completed for each cervical vertebra before the examining physiotherapist proceeded to the next vertebral level.

The palpation assessment was initially performed in a neutral spine position with both central (over the spinous process) and unilateral pressure (over the articular process) to the point of resistance at each joint level. If a potential participant reported no symptoms during this, the same sequence was then repeated with pressure to the end of range. If no symptoms were reproduced in the neutral position, the cervical spine was also palpated with end of range unilateral pressure in 30 degrees rotation. However, the rotated position was only used if there was no symptom reproduction in neutral. No combined movement positions were used. The physiotherapist examiner was provided with an examiner recording sheet for the 'Palpation assessment for reproduction of familiar headache' (see Appendix E).

Diagnostic blocks

In using the CHISG criteria in the current study to guide the participant inclusion criteria there was one omission. This study did not use diagnostic anaesthetic blockades to provide a CEH diagnosis. The CHISG recommends the use of diagnostic anaesthetic blockades to provide a definitive CEH diagnosis (Sjaastad et al., 1998). However, previous studies have not used anaesthetic blockades as this procedure is considered too invasive and costly in the research setting with volunteer participants (Jull, Sterling et al., 2008; Zito et al., 2006). Moreover, despite the recommendation for diagnostic anaesthetic blocks to be used to establish a CEH diagnosis, this procedure has been demonstrated to abolish other types of headaches, including migraine headache (Goadsby et al., 2002). Diagnostic anaesthetic blocks, therefore, do not establish an unequivocal CEH diagnosis.

Diagnostic anaesthetic blocks also rely on the participant presenting for assessment at the time that they are experiencing symptoms, as the diagnosis is made based on a resolution of symptoms from the blockade. As CEH is typically an intermittent headache that does not occur in a regular cycle it was not logistically possible to only assess CEH participants when symptomatic. Also, CEH patients often present in the clinical setting to a physiotherapist during symptom-free periods, so it was considered important to determine if there was a difference in posture between the groups irrespective of the participant's symptoms at the time of the assessment.

3.5.2 Control group inclusion and exclusion criteria

The inclusion or exclusion of a potential participant in the control group was based on the responses to the Phone Call Screening Questionnaire. As all participants were required to have the same palpation assessments once included in the study the exclusion criteria for the control group included all the same possible contraindications to manual therapy as for the CEH group. A potential participant was also excluded from the control group if they had sought treatment for neck pain or headache in the previous 12 months. To be included in the control group, a potential participant was required to have a medical history that included being aged 18-50, free of neck pain and headaches and with no history of major trauma to the head or neck.

3.6 Data collection

3.6.1 Postural palpation assessment

Two physiotherapists with post-graduate training in manual therapy (with 28 and 30 years clinical experience respectively) performed the postural palpation assessment. The examinations were performed with one therapist randomly selected to be the first examiner of a participant. The second therapist performed their assessment on that same participant within two minutes of the first examiner completing their assessment, while the participant remained positioned in prone lying on the same treatment table. The postural palpation assessment involved an examination of the posture of the neck performed by gently feeling the bony landmarks in the neck to determine position and symmetry. This is a standard physiotherapy clinical procedure in the assessment of the neck (Maitland et al., 2005). The physiotherapist examiners in this study did not receive any type of verbal feedback from the participants. They were each blinded to the results of the other physiotherapist examiner, and had no knowledge of the radiographic results as their palpation assessments were performed prior to X-ray examination. The physiotherapist examiners were also blinded to the results of the assessment for the reproduction of a familiar headache so they had no knowledge of the headache status of each participant.

The postural palpation assessment was performed immediately following the assessment for the reproduction of a familiar headache. There has been no evidence identified in the literature to suggest that palpation assessment may have an effect on the presenting postural characteristics of the participants. To further reduce any possible confounding effect from the palpation assessment on the results of the study, all participants underwent the same palpation assessment process prior to the radiographic assessment, regardless of group. This study design therefore minimised the chances that the palpation assessment would have been a confounding factor in the investigation of postural differences between groups as any influence of the palpation assessment on posture is likely to have similarly affected both the control and CEH groups.

The postural palpation assessment was only performed in the prone lying position. The palpation position and methods described by Maitland et al. (2005) were used as the basis for the instructions to the physiotherapists performing the postural palpation assessment. Maitland et al. (2005) is a standard physiotherapy text that is widely used to train physiotherapists in cervical spine assessment and treatment techniques. The prone lying position is also a position recommended for use in the treatment of the cervical spine (Maitland et al., 2005). Thus, many physiotherapists use the prone lying position in treatment so many may also assess the cervical spine with the patient in this position. The methods of the current study were also based on the methods of Hanten et al. (2002) who also investigated palpation in CEH by assessing the participants in the prone lying position and also used two physiotherapist examiners without the participant changing position between assessors.

The patient was asked to position themselves in prone lying with their forehead resting in the face cut-out of the plinth. The therapists then consecutively palpated for the alignment of the C2 vertebra in the horizontal plane and determined the postural presentation of the sagittal curve in the cervical region by palpation. Once the initial examiner had completed their assessment they left the room and the second examiner entered the room. The participant position was not altered between assessors with the participant remaining in the prone lying position.

The physiotherapist examiners were provided with an examiner recording sheet for the 'Postural Palpation Assessment' (see Appendix F) to use to record the results of their assessment for each participant. The two physiotherapist examiners were given specific categories that they could choose for each of the different postural characteristics that they were asked to assess, as well as being given the opportunity to record any alternative results. The postural characteristics that the physiotherapist assessors were asked to identify were the relative alignment of C2 in the horizontal plane and the characteristics of the sagittal curve of the cervical spine. The C2 postural palpation assessment included the physiotherapist examiner's judgement as to whether the C2 vertebra was in a neutral position, rotated or had a deviated spinous process. The C2 vertebra was chosen as previous investigations on patients with headaches have reported that altered C2 horizontal plane posture is commonly associated with headaches (Boquet, Biosmare et al., 1989; Boquet, Moore et al., 1989). C2 was also chosen as protocols for palpation of C2 are well documented and it is considered an obvious landmark being relatively easy to

palpate in the upper cervical spine (Magee, 1997). The C2 spinous process is a prominent landmark in the upper cervical spine and the ability to palpate a spinous process is considered to be a basic skill and a prerequisite for other manual therapy techniques (Robinson et al., 2009). The characteristics of the general (occiput to C7) and the upper cervical (occiput to C3) sagittal curve were assessed and recorded separately. The examiner's recording sheet for the 'Postural Palpation Assessment' allowed the physiotherapist examiners to record the sagittal curve that they felt best matched the presentation of the participant. It included categories for normal lordosis, hyper-lordosis and hypo-lordosis, and also allowed documentation of any alternative finding the physiotherapist perceived.

The method of the postural palpation incorporated strategies that have been recommended by previous investigators to improve the reliability of palpation. These studies demonstrated that palpation assessment has higher reliability when using symptomatic participants (Hubka & Phelan, 1994). The use of a standard palpation method and the use of experienced examiners have also been demonstrated to improve reliability (Gerwin et al., 1997; van Suijlekom et al., 2000). The lack of repositioning of the participants cervical spine between the assessments is another factor that is likely to improve the reliability of the palpation assessment.

3.6.2 Radiograph method and measurement

Each participant underwent a radiographic examination of their cervical spine using two radiographic views (AP open mouth and lateral views). The radiographs were performed with a Philips Diagnostic Vertical Bucky Stand attached to a Philips Optimus 50 Medium Frequency Generator and Philips R0 1648 Hi-Speed Rotating Anode X-Ray tube in a Philips ROT 360 X-ray Tube Housing (Philips Healthcare, Best, Holland). A bucky is the image plate holder contained within the vertical X-ray stand which also contains a scattered radiation device called a grid. Two Fuji Computed Radiography (model DS) imaging cassettes were used comprising of one 18 by 24cm cassette (for AP open mouth view) and a 24 by 30cm cassette (for lateral view) (Fujifilm Holdings Corporation, Tokyo, Japan). The cassettes contained a standard definition Fuji Digital Image Receptor Plate Model: CR ST-VI. All images were obtained using a grid technique (105 line/inch 12:1 grid) (Fujifilm Holdings Corporation, Tokyo, Japan).

The radiographic examinations were all performed by the same registered radiographer with 35 years experience who was blinded to the headache status of the participants. Standard radiographic views and standard positioning techniques were used (Bontrager, 2010). All participants were given the same instructions by the radiographer regarding their positioning, described below for each radiographic view. The radiographic views and instructions are standard procedure in a cervical radiographic series and are therefore comparable to what would be performed on a patient in everyday radiography practice. These standard views are also the same as the views that would likely have been

performed on a patient presenting to a physiotherapy practice with a cervical radiographic series. Similarly, they are the same views that would normally be performed when a physiotherapist refers a patient for cervical radiographs.

Lateral view

A right lateral radiographic projection was taken for all participants with a focal film distance of 178cm. The patient was instructed to stand erect with the right shoulder touching the projection equipment (rotated 90 degrees from the AP position). The participant's feet were slightly apart for patient stability and the hands clasped behind their back, with the right shoulder just touching the erect bucky. No participant required additional positioning aides, such as holding hand weights, to provide further depression of the shoulders to ensure C7/T1 could be visualised. The exposure was taken during normal suspended respiration. The participant was asked to 'look straight ahead and relax their shoulders' with the cervical spine in the neutral position (Bontrager, 2010). These instructions are considered not to have a significant impact on the posture of the cervical spine (Bontrager, 2010). The measurements taken from lateral view radiographs were, therefore, not expected to be altered by using this radiographic protocol. The measurements performed on the lateral radiographic view were for both general cervical lordosis and the upper cervical lordosis.

AP view

For the AP open mouth radiographic view, the participant was instructed to stand erect with their back against the vertical bucky stand and to look straight ahead. A focal film distance of 110cm was used. The participant had their mouth open, with the upper incisors aligned to the occipital protuberance (the central ray of the X-ray tube was directed horizontally through the inferior aspect of the upper incisors and exiting at the occipital protuberance), and the exposure was taken during suspended respiration. The positioning protocol used in the AP open mouth radiograph is considered not to have a significant impact on the posture of the cervical spine in the horizontal plane (Bontrager, 2010). The measurement performed on the AP open mouth radiograph was the position of the C2 spinous process relative to the midline.

Techniques used to minimise participant radiation exposure

A high kVp, low mAs (77kVp at 8mAs) exposure technique was used to minimise the radiation exposure. The risks involved in the radiological assessment were analysed prior to the commencement of the study by a medical radiation physicist. The dose range for each participant in this study was estimated to be considerably less than 0.2 mSv. This equates to the dose delivered by natural background radiation in a few weeks. It is considerably less than the variations in annual dose from natural background radiation to persons living in different locations, and the risk level is considered minimal. The risk involved was determined to be a Category 1 risk. The level of benefit needed to justify

conducting research using Category 1 doses is minor and includes investigations expected only to increase knowledge. The risks of the radiographic assessment were further minimized by using tight collimation. Collimation refers to limiting the x-ray beam to a specific area on the image plate. A device is attached to the front of the x-ray tube and a projection light identifies the beam area. The radiographer can adjust this light to cover the area of interest and once the x-ray beam is initiated it is only applied to the area previously outlined. The risks were also minimised by taking a minimal number of images to obtain the information needed, by using equipment meeting Department of Environment and Climate Change standards and by applying the ALARA (As Low As Reasonably Achievable) principle (Bushong, 2009). The exposure factors in the current study produced at least a 50% reduction in radiation exposure compared to the same radiographic views in clinical applications. The images obtained using these exposures were affected by these methods but they did not compromise the ability to identify the required landmarks and make accurate measurements.

Radiographic measurements

The radiographic images were obtained digitally and then transferred to Centricity Webpacs V2.1 (GE Medical Systems, Wisconsin, USA) which is the software system that was used to perform the measurements. Radiographic measurement tools within Centricity Webpacs V2.1 were used to measure angles and distances on the electronic image. A qualified radiographer experienced in the use of this measurement tool performed all measurements using the same computer and monitor for each participant. A

second experienced radiographer repeated the measurements on a subset of 20 randomly selected participants to determine inter-rater reliability of the on-screen measurement techniques, though good reliability has been previously demonstrated when the techniques were performed by drawing on hard copies of radiographs (Cote et al., 1997; D. E. Harrison et al., 2000; Johnson, 1998; Rochester, 1994). Both radiographers were blinded to the headache status of each participant and the measurements of the other radiographer. The present study included this analysis of the reliability of the radiographic measurement methods as the previously published studies that demonstrated good reliability of these measurements had used physical marking of the required landmarks on X-ray films with manual measurement of the required distances or angles (Cote et al., 1997; Johnson, 1998; Rochester, 1994). The current study used the same measurement techniques but used digitised images with software (Centricity Webpacs V2.1) capable of automatically determining the nominated angles or distances once the required landmarks had been located and marked. The method used in the present study was assumed to provide increased reliability but no study was identified that had determined this reliability for the specific measurement methods used.

The analysis of posture using radiographic measurements in the study involved measurement of the upper cervical lordosis, general cervical lordosis and an assessment of the deviation of the C2 spinous process from midline. Radiographic measurements assessing these specific cervical spinal postural variables have previously been shown to be reliable (Cote et al., 1997; Johnson, 1998; Rochester, 1994). The previous study demonstrating good reliability of the upper cervical lordosis was, however, performed

with cephalometric radiographs rather than standard radiographs (Johnson, 1998). Cephalometric radiographs involve the use of a framework structure to support and maintain the head position of the participant (Johnson, 1998). In the current study, the head was unsupported so that a participant's natural spinal curvature was not altered, and so that positioning corresponded to standard AP and lateral radiographic views in a clinical setting.

Upper cervical lordosis measurement

The upper cervical lordosis radiographic measurement was based on the technique described by Johnson (1998) (see Figure 3.2). The technique involved drawing a line between the most superior-posterior point on the odontoid process of C2 and the most inferior-posterior point on the body of the second cervical vertebra. A second line was then drawn connecting the most inferior-posterior point on the body of C3 with the most inferior-posterior point on the body of C4. The angle for upper cervical lordosis was determined by measuring the acute angle formed between these two lines.

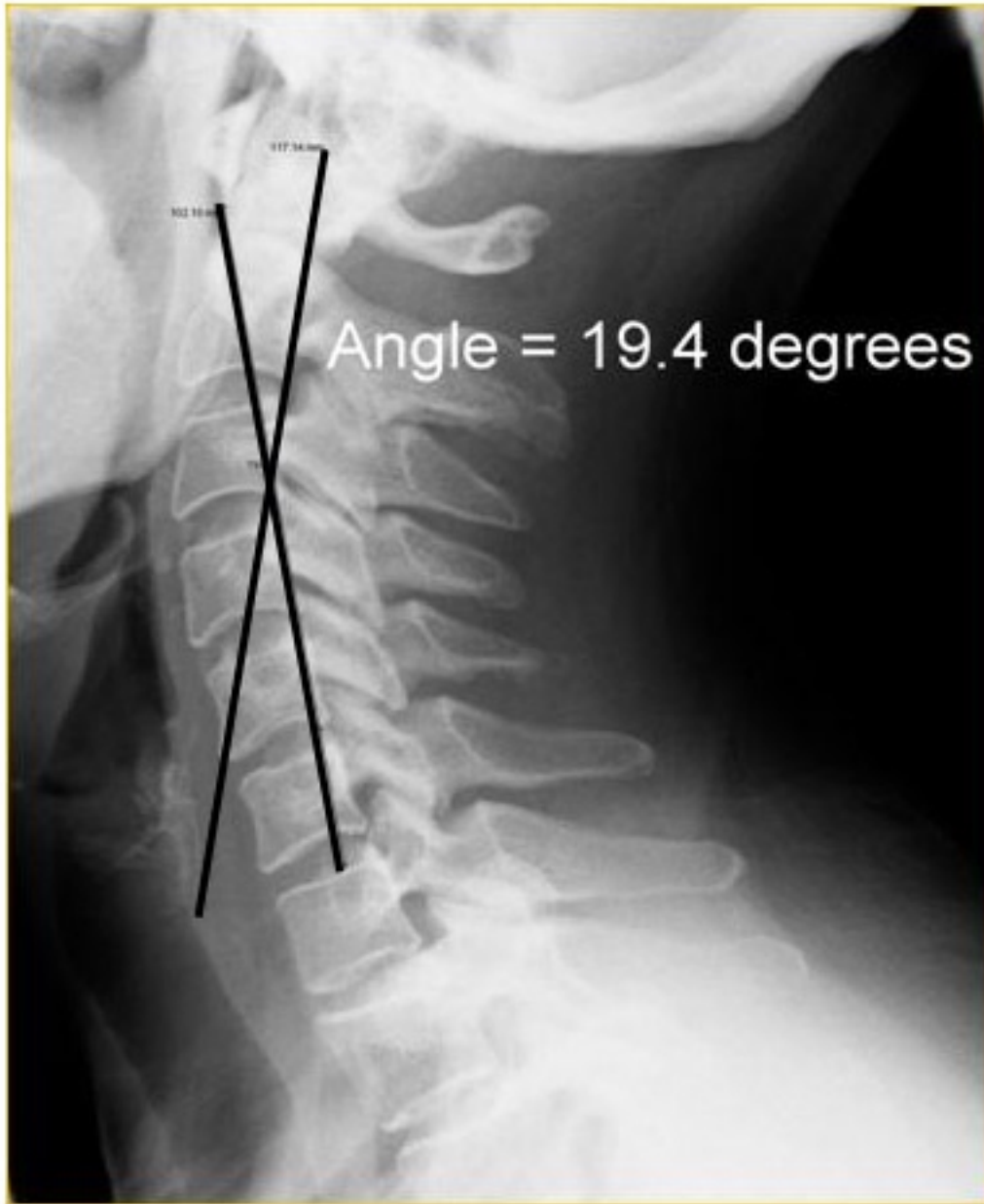


Figure 3. 2 Example of upper cervical lordosis measurement on a radiograph.

General cervical lordosis measurement

The general cervical lordosis method was based on the ‘Cobb method’ as described in Cote et al. (1997). The Cobb method was chosen in this study as it is a widely known and recognised method, and the angle was able to be calculated directly by the computer software used for this study once the landmarks had been identified. The Cobb method measurement (see Figure 3.3) was obtained by drawing lines parallel to the inferior end-plates of C2 and C7 and then the software package automatically generated perpendiculars to these lines. The acute angle formed between the two perpendiculars was generated by the software package and this angle was recorded. In Figure 3.3 the lines and perpendiculars were added to the radiograph manually to demonstrate the angle that was measured.



Figure 3. 3 Example of a general cervical lordosis measurement (Cobb C2-C7 measurement) on a radiograph.

The angle in Figure 3.3 would be recorded as -4.5 degrees demonstrating that this cervical spine is in kyphosis

C2 spinous process alignment measurement

The assessment of C2 spinous process alignment was based on the method described in Gradl et al. (2005). This method involves a measurement of the distance that the C2 spinous process deviates from the mid-line at the level of the atlas on the AP open mouth X-ray (see Figure 3.4). The mid-line is determined by placing a vertical line passing through the mid-point of the tip of the odontoid process. A vertical line is also drawn passing through the mid-point of the spinous process of C2. The distance between these two lines is measured and the distance recorded in millimetres. The direction the spinous process is displaced from midline is also noted.



Figure 3. 4 Example of a C2 spinous process deviation measurement on a radiograph.

The distance between the two lines in Figure 3.4 represents the distance in millimetres of C2 spinous process deviation from the mid-line. The spinous process is deviated 1.60 mm to the left.

3.7 Data analysis

3.7.1 Participant physical characteristics

Descriptive statistics were calculated for age and gender of participants in the CEH and control groups and for participants in two CEH subgroups: occipital and frontal. In addition, descriptive statistics were also calculated for duration and frequency of headache symptoms for participants in the CEH group.

3.7.2 Postural palpation assessment

Inter-rater reliability analysis determined if the two physiotherapist examiners were able to agree on the presenting cervical posture of the participants. An inter-rater reliability analysis was performed using Cohen's kappa for each of the three spinal posture variables assessed: C2 spinous process deviation, upper cervical lordosis and general cervical lordosis. A kappa statistic of 0.4 or above was considered to demonstrate an acceptable level of inter-rater reliability as this has been reported to represent moderate agreement between examiners (Lucas et al., 2009).

3.7.3 Radiographic examination

3.7.3.1 Reliability of the radiographic measurement

A reliability analysis was performed to determine if the two radiographers were reliable in executing the radiographic measurement methods used in the present study. The analyses of the consistency of the radiographers using these measurement methods were performed using an intraclass correlation coefficient (ICC, 2,1) for each of the three spinal posture variables.

3.7.3.2 Investigating the association between CEH and spinal posture

Differences between postural variables between the CEH and control groups were determined using paired t-tests (matching participants by age and gender) or the non-parametric equivalent where appropriate. The three spinal postural variables measured were the General Cervical Lordosis (GCL), Upper Cervical Lordosis (UCL) and the deviation of the C2 spinous process from the mid-line (C2).

Regression analysis was also used to determine if the three postural variables were associated with CEH. To determine whether the data met the assumptions for regression analysis, correlations between these spinal postural variables were assessed for both the whole sample and also for the CEH group. A correlation between postural variables for

data from the CEH group alone was performed because there was a possibility that there was a different interaction between postural variables in individuals with headaches that did not occur in control group participants. Both Pearson's r and Spearman's Rho tests were used to analyse the correlation because the data from at least one of the radiographical measures were not normally distributed. If these tests agreed, then only results for Pearson's r are reported for simplicity.

A matched pairs binary logistic regression analysis determined whether measurements taken of cervical spinal posture on radiographs (GCL, UCL and C2) demonstrated an association with the likelihood of experiencing CEH. The dependent variable was the headache status of the participant and the independent variables were the measurements of spinal posture (GCL, UCL and C2).

3.7.3.3 Sub-group analysis based on headache distribution

To determine if the distribution of CEH contributed to the postural presentation of the participants, the CEH group was separated into sub-groups based on headache distribution. This was done to determine if headache distribution could be used as an additional predictor of postural presentation. The distribution of the headache was defined as the dominant region in the head that the participant described the headache to manifest when the physiotherapist examiner reproduced their familiar headache with the palpation assessment. The two sub-groups were the 'occipital headache sub-group' and 'frontal headache sub-group'. An ANOVA of the age and gender characteristics of the

headache distribution sub-groups was also performed to determine if there were differences in these characteristics between the sub-groups.

A nominal logistic regression using the Wald test was performed to determine if either the occipital or frontal headache subgroups demonstrated an altered postural presentation in the measured postural variables on radiographs when compared to the control group. Nominal logistic regression was used to analyse posture in sub-groups because this analysis was exploratory, and the sub-groups were not age and gender matched. In this analysis, the dependent variable was the headache distribution and the independent variables were the radiographic measurements of spinal posture. Postural variables were only included as independent variables if they had a demonstrated association with CEH in the binary (matched pairs) regression model. An analysis of variance (ANOVA) was performed on these subgroups to determine if there were differences in the age or gender proportions of the participants between the control group, occipital headache subgroup and frontal headache subgroups. This was performed to determine if the subgroup analyses may have been influenced by a lack of age or gender matching.

3.7.4 Statistical analysis

Statistical analysis was undertaken using JMP Version 8 (SAS Institute Inc., NC, USA), except for the matched pairs logistic regression analysis where PROC LOGISTIC was used (SAS 2002 V9.1.3 (SP4), SAS Institute Inc., NC, USA).

Chapter 4 Results

4.1 Overview

This study used a single blind, age and gender matched, comparative measurement design to evaluate, using radiographs, the differences in cervical spinal posture between asymptomatic participants (control group) and participants with CEH. The reliability of radiographical measurement is reported. The study also included a separate investigation of the inter-rater reliability of physiotherapist examiners in determining the presenting postural characteristics of the cervical spine by using a postural palpation examination. This chapter includes a description of the physical characteristics of the participants and the findings of their radiographic examinations. The reliability of the postural palpation examination and the radiographic measurement techniques used are also reported.

4.2 Physical characteristics of participants

The screening process and data collection for the study took place over a 14 month period of time with approximately 350 potential participants volunteering for the study as either control group or CEH group participants. In the CEH group, the most common reasons for exclusion following the phone call screening questionnaire were the presence of bilateral headaches or an aura. The subjects that were excluded were otherwise similar to those included in terms of age and gender distribution. In the control group, the most common reason for exclusion was that the potential control group participant was not

required in the study as there was not an age and gender matched CEH group participant.

Potential control group participants were not included in the study unless a CEH participant of the same gender and similar age had already been included.

Sixty participants entered the study. There was a heavy bias in the gender distribution in the study with 52 of the 60 participants being female. The age and gender characteristics of the participants are described in Table 4.1.

Table 4. 1 The age and gender characteristics of the participants in the cervicogenic headache (CEH) and control groups.

Participant group	N	Age : mean (SD)	Females : N (% of group)	Males : N (% of group)
CEH	30	31.4 (10.0)	26 (87)	4 (13)
Control	30	29.8 (9.4)	26 (87)	4 (13)

4.3 CEH group characteristics

The participants in the CEH group reported a mean of 1.2 headaches per week (SD 1.8, range 1-7). These participants had experienced their headaches for a mean of 152.4 weeks (SD 311.7), ranging in duration from 2 months to 30 years (one headache per week for two months was considered the minimum duration for inclusion in the CEH group).

To be included in the CEH group the potential participants were required to have both appropriate responses to the 'CEH group' section of the phone call screening questionnaire and reproduction of familiar headache symptoms with the palpation assessment. Of the approximately 300 potential CEH group participants that volunteered to be part of the present study, only 30 were deemed to have a symptom pattern consistent with CEH based on their responses to the phone call screening questionnaire. Only these 30 potential CEH participants were assessed for a reproduction of their familiar headache. The reproduction of familiar headache by palpation occurred in all 30 of these potential CEH group participants. In this palpation assessment to reproduce 'familiar headache', one potential control group participant did report the reproduction of a familiar headache despite previously reporting no history of headaches. This individual was, therefore, excluded from participation in the study, as they were not asymptomatic and they did not fulfil all the other criteria for inclusion into the CEH group. All the other potential control group participants were included in the study.

The physiotherapist that assessed for the reproduction of the familiar headache in the potential participants recorded both the reported distribution of that headache and the structure they were palpating when this headache was reported. The structure that the physiotherapist reported they were palpating when headache was reproduced is shown in Table 4.2.

Table 4. 2 Number of CEH participants reporting reproduction of their familiar headache with palpation at each cervical level.

Palpation level*	N (%)
Occiput	11 (37)
C1	12 (40)
C2	4 (13)
C3	2 (7)
C4	0 (0)
C5	1 (3)
Total	30 (100)

* The palpation assessment for reproduction of a familiar headache was performed in a pre-determined sequence and once any headache reproduction was reported the assessment was discontinued as the participant had then fulfilled the criteria for inclusion. There was a possibility that a participant may have reported headache reproduction from more than one cervical level. The palpation assessment was not, however, continued as this may have increased the risk of aggravating the participants' headache and this risk was not considered to be justified as the level of headache was not used as part of any subgroup analysis.

The participants in the present study were asked to describe the dominant region in their head that they experienced their headache when it was reproduced with the palpation assessment. The participants reported their headache to be either in an occipital distribution (18 participants) or a frontal distribution (12 participants). The participants' reported distribution of the headaches reproduced with the cervical palpation assessment is shown in Table 4.3, along with the age and gender distribution of these sub-groups.

Table 4. 3 The age and gender of the participants with CEH separated into sub-groups based on the distribution of their reported headache reproduced by palpation.

Headache distribution	N	Gender	N (%)	Mean age (SD)
Occipital	18	Female	14 (78%)	32.1 (11.0)
		Male	4 (22%)	31.3 (10.3)
Frontal	12	Female	12 (100%)	30.5 (9.6)
		Male	0 (0%)	-
Control	30	Female	26 (87%)	29.2 (8.8)
		Male	4 (13%)	33.8 (13.6)

4.4 Using palpation to assess cervical spinal posture

The analyses of the reliability of the physiotherapist examiners indicate that inter-rater reliability is not acceptable in determining the presenting postural characteristics of the cervical spine for any of the physiotherapist assessed variables. The level of agreement between the two physiotherapists assessing the postural presentation is shown in Table 4.4. The actual postural presentation selected by the physiotherapist examiners for each of the postural variables are recorded in Appendix G.

Table 4. 4 Kappa scores and standard error for the agreement between physiotherapy examiners for each of the spinal postural variables assessed with postural palpation.

Postural variable	Kappa	Std error	95% CI	% agreement
General cervical lordosis	0.15	0.11	-0.07, 0.37	47
Upper cervical lordosis	0.19	0.11	-0.02, 0.42	57
C2 spinous process alignment	0.04	0.07	-0.10, 0.18	37

Due to the lack of reliability between therapists, an analysis of the differences in the palpation findings between the headache group and the non-headache group was not performed. The lack of inter-rater reliability also suggested that further analysis of a possible correlation between the results identified in the palpation assessment and the postural measurements from the radiographs was not worthwhile.

4.5 Radiographic measurement of cervical spinal posture

Digital radiographs were compromised for two participants and their radiographic data considered unusable; therefore analyses of radiographic data include 58 participants. One excluded radiograph was from the CEH group and one from the control group. The reporting and analysis of data in Sections 4.4 and 4.5 therefore only includes 58 participants.

4.5.1 Reliability of the radiographic measurements

The reliability of the radiographic measurements used in the present study was calculated using the intraclass correlation coefficient (ICC) (2,1). The inter-rater reliability was calculated for two radiographers on the radiographs of 20 randomly selected participants. The ICC values and the 95% confidence intervals for the radiographic measurements are shown in Table 4.5 An ICC above 0.70 is considered very good agreement and above 0.90 is considered excellent (Domholdt, 2000). The ICC values for each of the radiographic measures, therefore, indicate very good to excellent reliability. The 95% CI values were also included as the result for the upper cervical lordosis radiographic measurement extends from 0.47 to 0.89. This result suggests that the reliability of measurements of upper cervical lordosis on radiographs is potentially good but as an ICC between 0.26 and 0.49 is considered low agreement (Domholdt, 2000) there is also the potential that the reliability is low.

Table 4. 5 Intraclass correlation coefficients (ICC) (2,1) and 95% confidence intervals (CI) of the cervical spinal postural variables measured on radiographs.

Postural variable	ICC	95% CI
General cervical lordosis	.90	.77 , .96
Upper cervical lordosis	.75	.47 , .89
C2 spinous process deviation	.88	.73 , .95

4.5.2 Analysis of associations between posture and CEH using the radiographic measurements

The data from C2 and UCL measurements were normally distributed, but the GCL data were not. Therefore, the analysis of the radiographic measurements required a combination of parametric and non-parametric statistical tests. A summary of the radiographic measurement results, as well as the normality tests for these data are displayed in Table 4.6.

There were no significant differences between the control and CEH groups for the UCL or C2 measurements using t-tests ($p > 0.05$). As the data for GCL were skewed (Shapiro-Wilk test, $p = 0.0002$) the Wilcoxon rank sum test was used to assess the difference between the CEH and control groups for this postural measurement. The Wilcoxon rank sum test found no statistically significant difference between the GCL of the control and CEH groups ($p = 0.06$).

Table 4. 6 Descriptive statistics, normality tests and comparisons of radiographic postural variables between participants in the cervicogenic headache (CEH) and control groups.

Radiographic measurement	Participant group	N	Mean	Range	SD	Shapiro-Wilk test	P value	Wilcoxon rank-sum test
C2 spinous process deviation (mm)	CEH	29	3.00	0-6.53	1.66	0.11	0.77	-
	Control	29	2.86	0-8.34	2.04			
Upper cervical lordosis (degrees)	CEH	29	11.86	1.5-25.8	6.46	0.20	0.10	-
	Control	29	9.44	0.7-19.6	4.28			
General cervical lordosis (degrees)	CEH	29	10.97	0.5-26.1	7.50	0.0002#	-	0.06#
	Control	29	7.13	0-26.8	5.69			

Wilcoxon rank sum used for general cervical lordosis, as data for this variable were not normally distributed

4.5.3 Correlations between the measured spinal postural variables on radiographs

Prior to logistic regression analyses, correlations between radiographic measurements of the three spinal postural variables were assessed. Analyses of possible correlations between postural variables within the whole sample and within the CEH group alone are shown in Table 4.7. These results demonstrate that there were no statistically significant correlations between any of the spinal postural variables (Pearson's r for any comparison < 0.3).

Table 4. 7 Pearson's correlation between the radiographic measures of cervical spinal posture for the whole sample and for the CEH group.

Variable 1	Variable 2		Correlation	P value
General cervical lordosis	Upper cervical lordosis	All	0.18	0.18
		CEH group	0.21	0.27
Upper cervical lordosis	C2 spinous process deviation	All	-0.07	0.59
		CEH group	-0.24	0.20
C2 spinous process deviation	General cervical lordosis	All	-0.18	0.18
		CEH group	-0.12	0.54

4.5.4 Logistic regression analysis of radiographic measurements

A binary matched pairs logistic regression analysis of the radiographic data was performed to determine if there was an association between the measured cervical spinal postural variables and CEH. The results of the binary matched pairs logistic regression analysis of radiographic data are listed in Table 4.8. The UCL and C2 alignment measurements of cervical spinal posture were not associated with an increased likelihood of experiencing CEH. An association was, however, identified between GCL and an increased likelihood of experiencing CEH. As GCL increased there was a statistically significant increased chance of experiencing CEH ($p=0.042$).

Table 4. 8 Associations between the radiological measurements of the cervical spinal postural variables and the likelihood of experiencing CEH.

Postural variable assessed	Likelihood ratio test				
	Chi-square	DF	P value	Odds ratio#	95% CI
General cervical lordosis	4.12	1	0.042*	1.08	1.00 , 1.19
Upper cervical lordosis	2.86	1	0.091	1.09	0.99 , 1.23
C2 spinous process alignment	0.11	1	0.74	1.06	0.77 , 1.46

* denotes statistical significance, $p \leq 0.05$

Exact methods (SAS proc logistic) were used to obtain the 95% confidence interval (CI) for odds ratio as the Wald statistic provided an interval (0.994, 1.18) for GCL that was inconsistent with the significance indicated by the likelihood ratio test.

The odds ratio for the association between increased GCL and the likelihood of experiencing CEH was 1.08 (Table 4.8). This odds ratio equates to an 8% increased likelihood of experiencing CEH with each degree increase of GCL. The difference

between the mean GCL of the CEH group and the control group was 3.84 degrees (Table 4.6). This 3.84 degree difference equates to a 35% increase in the likelihood of experiencing CEH.

4.6 Sub-group analysis based on headache distribution

The sub-group analysis based on headache distribution was performed to determine if the radiographic measurements of posture may have been associated with the distribution of the headache. The GCL measurement was the only postural variable analysed by sub-group, as it was the only spinal postural variable statistically associated with an increased likelihood of experiencing CEH. As the sub-groups were not age and gender matched to the control group, possible differences in age and gender between the sub-groups were determined using an analysis of variance (ANOVA).

4.6.1 The effect of age or gender differences on the sub-group analysis

The characteristics of the headache distribution sub-groups are described in Table 4.9. Analysis of variance (ANOVA) demonstrated that there was no statistically significant difference ($p=0.82$) in the ages of the participants between the control group, occipital headache subgroup and frontal headache subgroup, suggesting subgroup analyses were not influenced by a lack of age matching.

Table 4. 9 Characteristics of the CEH, control and headache distribution sub-groups.

	Gender	N (% of total in group)	Mean age (SD)	GCL (mean degrees, SD)
CEH group	Male	4 (14)	31.3 (10.3)	9.8 (4.8)
	Female	25 (86)	31.8 (10.2)	11.2 (7.9)
Occiput headache sub-group	Male	4 (22)	31.3 (10.3)	9.8 (4.8)
	Female	14 (78)	32.1 (11.0)	12.9 (8.7)
Frontal headache sub-group	Male	0	-	-
	Female	11 (100)	31.4 (9.6)	8.9 (6.4)
Control group	Male	4 (14)	33.8 (13.6)	10.1 (8.1)
	Female	25 (86)	29.6 (8.8)	6.7 (5.3)

The proportions of males and females in the sub-groups were different from those in the CEH group. Therefore, comparisons of general cervical lordosis measurements for males and females were performed to determine if the proportions of males and females affected the results of the sub-group analysis. There were no differences in general cervical lordosis between males and females for the whole sample (Wilcoxon $p = 0.57$), the CEH group (Wilcoxon $p = 1.00$) or the control group (Wilcoxon $p = 0.57$). These results suggest there were no differences in general cervical lordosis between genders.

4.6.2 Findings of sub-group analysis

The general cervical lordosis measurement was the only postural variable analysed by sub-group, as it was the only spinal postural variable statistically associated with an increased likelihood of experiencing CEH. Binary logistic regression analysis indicated there was not a statistically increased likelihood of experiencing occipital compared to frontal headache with increasing general cervical lordosis ($p= 0.18$).

Chapter 5 Discussion

5.1 Principal Findings

The present study is the first, to our knowledge, that has investigated the association between posture and CEH using a radiographic analysis of the cervical spine. This study included both a general measure of the cervical lordosis, as well as specific measurements of upper cervical spinal posture (a measurement of upper cervical lordosis and of the distance of the C2 spinous process from the midline). Moreover, this is the first study to our knowledge to specifically investigate upper cervical spine posture in CEH. An increase in GCL was found to be associated with an increased likelihood of experiencing CEH. UCL and C2 spinous process alignment, as measured radiographically, were not found to be associated with CEH.

The present study is also the first study, to our knowledge, to investigate the reliability of physiotherapists performing palpation assessment of cervical posture. Palpation assessment was included to determine if this procedure could be used in place of radiographs to determine the postural presentation of the cervical spine. The palpation assessments of the cervical spine evaluated in the present study were not found to be reliable in discriminating cervical postural presentation. The poor reliability of postural palpation suggests that it cannot be recommended in cervical postural assessment.

This chapter discusses the principal findings of the present study. Possible reasons for the differences between the results of the present study and previous studies examining cervical posture are discussed along with the limitations and clinical implications of the results. The possible directions for future research are outlined and the conclusions that can be made from this study are discussed.

5.2 Population

5.2.1 Participants

The sample for this study was a sample of convenience. The participants were recruited through flyers placed on noticeboards at The University of Newcastle, as well as by email to all staff, post-graduate students and undergraduate students at The University of Newcastle.

There was an unequal mix of males and females in the present study. The increased proportion of females is consistent with reports that women experience CEH more frequently than men (Martelletti & van Suijlekom, 2004; Sjaastad et al., 1998). The increased proportion of females in the present study is also consistent with the previous studies that investigated cervical posture in CEH, as they also reported an increased proportion of females (Dumas et al., 2001; Zito et al., 2006). Zito et al. (2006) only included female participants and 77% of the participants reported in Dumas et al. (2001) were female.

5.2.2 Examiners

The two examiners in the postural palpation assessment in the present study were registered physiotherapists. The examiners were both experienced, with 28 and 30 years of physiotherapy clinical experience respectively, and both had completed post-graduate training in manual therapy. The training and experience level of these physiotherapy examiners allowed a meaningful comparison between the examiners to be made as there would not be expected to be a wide discrepancy between their skills.

5.3 General cervical lordosis

The logistic regression analysis of GCL identified a significant association between GCL and CEH ($p = 0.042$). The likelihood of experiencing CEH increases as GCL increases. As discussed previously in the results section the odds ratio for this association between increased GCL and the likelihood of experiencing CEH was 1.08 (Table 4.8). This odds ratio equates to an 8% increased likelihood of experiencing a CEH with each degree increase of GCL. The difference between the mean GCL of the CEH group and the control group in the present study was 3.84 degrees (Table 4.6). A 3.84 degree increase in GCL equates to a 35% increase in the likelihood of experiencing CEH in the CEH group. If these results can be extrapolated, a clinician finding a patient with a 10 degree increase in GCL should consider that this posture could increase the likelihood of CEH by 122%. This increased likelihood of CEH may lead the clinician to focus treatment strategies on

reducing the patients GCL however this treatment would need to be proven to result in a reduction in symptoms before it could be recommended. This is discussed further in the future research section.

Although there was a demonstrated association between CEH and GCL, the results of this comparative study cannot indicate the reasons for this association. The increased general cervical lordosis may be causing CEH, aggravating CEH, a response to the CEH symptoms or it may be that individuals who experience CEH use this posture in an attempt to prevent or reduce future episodes. This will be discussed more fully in the clinical implications section.

The interpretation of the results of the present study should be made in the light of the results of previous studies investigating cervical lordosis. There have been no studies identified that have assessed general cervical lordosis using the radiographic C2-7 Cobb angle measurement in CEH. However, previous studies have reported these measurements for individuals with neck pain and for individuals considered to have 'normal' cervical posture (Boyle et al., 2002; D. D. Harrison et al., 2004). The study by Boyle et al. (2002) was performed post-mortem so these measurements were not considered to be comparable. Harrison et al. (2004) used similar methods to the present study and included three groups (acute neck pain, chronic neck pain, and controls), so the measurements used in this study were considered to be comparable with those of the present study. The results of the present study and those reported in Harrison et al. (2004) are listed in Table 5.1.

Table 5. 1 Comparison of general cervical lordosis (C2-C7 Cobb angle) measurements (degrees) between the present study and Harrison et al. (2004).

		Mean	Standard deviation	N
Present study	CEH group	10.97	7.50	29
	Control group	7.13	5.69	29
Harrison et al. (2004)	Acute pain group	16.5	8.74	52
	Chronic pain group	12.7	12.54	70
	Control group	26.8	9.72	72

The chronic neck pain group in the Harrison et al. (2004) study was considered most comparable to the CEH group in the present study. It included participants that had been experiencing symptoms for greater than 12 weeks and included patients with varying symptoms, including headache. The CEH group participants in the present study had experienced their symptoms for a mean duration of 152.4 weeks (SD 311.7). A t-test analysis comparing the C2-7 Cobb angle from the chronic pain group from Harrison et al. (2004) and the same measurement in the CEH group in the present study suggests that there is no significant difference in the general cervical lordosis of these two groups ($p=0.49$). The C2-7 Cobb angle results for the CEH group in the present study are, therefore, consistent with the results previously reported for patients with chronic cervical symptoms.

A comparison between the control group in the present study and the control group of Harrison et al. (2004) was also performed. The results of this t-test analysis showed that there was a statistically significant difference between the control groups of these two studies ($p < 0.0001$). The general cervical lordosis for the control group in the present

study was significantly smaller. The possible reasons for this result needs to be explored as the interpretation of the results of the present study are based on a comparison between the CEH and control groups. A discussion of the differences between the present study and Harrison et al. (2004) that may account for the significantly lower lordosis identified in the control group of the present study follows. Factors that may potentially account for the differences in the control group measurements include differences in the inclusion criteria, proportion of females and age of the participants.

An important difference between the studies is the exclusion by Harrison et al. (2004) of potential participants from the control group if they had cervical radiographs that demonstrated non-lordotic curvatures or a large ($> 10\text{mm}$) anterior head translation. Non-lordotic curves were not defined but potential participants were reported as excluded if they did not have a 'normal' lordotic curve, as the authors' reported aim was to "compare subjects with a cervical lordosis" (D. D. Harrison et al., 2004). This exclusion of 'normal' individuals based on the presence of non-lordotic curves suggests that the sample chosen may not be representative of the normal population.

The exclusion of individuals with non-lordotic curves would be expected to result in an increase in mean cervical lordosis. This increase in mean cervical lordosis would be due the fact that a non-lordotic curve is a reduced or reversed curve and the lordosis measurements for these non-lordotic curves would be smaller than those for a lordotic curve. The size of this effect would be expected to be determined by the numbers of these excluded individuals. Harrison et al. (2004) reported that despite 266 lateral radiographs

of asymptomatic subjects being available for their study only 72 asymptomatic subjects were included. This suggests that a large number of asymptomatic subjects were excluded due to the presence of a non-lordotic curve and, therefore, the mean lordosis value for this study would be expected to be larger than if these individuals had not been excluded.

In previous studies of cervical lordosis in asymptomatic participants using radiographic assessment, a non-lordotic curve was identified as a common postural presentation (Gore, Sepic, & Gardner, 1986; Matsumoto et al., 1998). Gore et al. (1986) in an analysis of the cervical lordosis of 200 asymptomatic participants found non-lordotic curves to be a normal postural variation with nine percent of participants in their study presenting with non-lordotic curves. Matsumoto et al. (1998) also found non-lordotic curves to be a normal postural presentation. They compared the radiographs of 488 patients with acute whiplash to 495 asymptomatic healthy volunteers and concluded that non-lordotic curvatures were present commonly in both groups and that this posture should not be considered to be a pathological finding (Matsumoto et al., 1998). These findings suggest that individuals with non-lordotic cervical curves should not be excluded from a control group in studies investigating cervical posture.

The decision regarding inclusion/exclusion in the control group of the present study was not based on the radiographic presentation of the participant. In the present study, there was no prior knowledge of the radiographic presentation of the control group and the radiographic results of all participants were included in the final results. The mean

general cervical lordosis value in the current study would, therefore, be expected to be lower than in studies that had chosen to exclude individuals that had non-lordotic curves.

The comparably small general cervical lordosis angles measured in the control participants in the present study may also be due to the relatively high proportion of females that were included. The control group in Harrison et al. (2004) had 72 participants and 50% of these participants were females. The control group in the present study comprised 86% females. Helliwell et al. (1994) examined cervical spinal posture using radiographs and reported that women are more likely to have a reduced cervical lordosis than males with an odds ratio of 2.81 (CI 1.23 to 6.44) for this postural presentation. This agrees with the results of Nagasawa et al. (1993) who analysed the posture of 225 control group participants (135 females and 90 males) using cervical radiographs and showed that female control participants had reduced cervical lordosis compared to males.

Increased cervical lordosis, as measured radiographically, has also been demonstrated to be associated with being older (Gore et al., 1986; Nagasawa et al., 1993). The mean age of the control group in Harrison et al. (2004) was 40.6 years (SD 10.4, $n = 72$), while the mean age of the control group in the present study was 30.2 years (SD 9.3, $n = 29$). It would therefore be expected that the mean lordosis of the control group of the present study would be smaller than that of the control group reported by Harrison et al. (2004), as the participants were significantly younger ($p < 0.0001$).

The above factors may also have a combined effect on the cervical lordosis as Matsumoto et al. (1998) found individuals who are both younger than 40 years and female to be more likely to have non-lordotic curves. These factors, combined with the exclusion of non-lordotic curves by Harrison et al., provide possible explanations for the difference between the cervical lordosis values found for the control group of the present study compared to the control group of Harrison et al. (2004).

5.4 Upper cervical spinal posture

Upper cervical spinal posture, as measured with the UCL and C2 spinous process measurements, was not associated with CEH. The lack of statistically significant associations between upper cervical spinal posture variables and CEH suggests that despite the upper cervical region being considered the predominant region for the generation of CEH, symptoms may not correspond with upper cervical postural variations. The interpretation of these results needs to consider the UCL measurement method used in the present study. The UCL measurement was chosen as a reliable measurement of upper cervical lordosis however this method does not include a measure from the cranium. Different results may have been found if a different measurement method for UCL was used. If a valid and reliable method that measured from the cranium to C3 was available this may have been preferable however the author is not aware of any method that has been developed that would meet these requirements. In using the chosen methods for UCL measurement the present study found no association between UCL and CEH, and there were no previous studies identified that investigated associations between

UCL and CEH. As increased UCL is one of the components of forward head posture, these results support the findings of previous investigations that concluded there is no association between forward head posture and CEH (Dumas et al., 2001; Zito et al., 2006).

The hypothesis that a radiographic assessment could identify differences in the horizontal plane posture of C2 in the CEH group when compared to control group was also not supported. Thus, the results of the present study also agree with those of Macpherson and Campbell (1991) who found any deviation of the C2 spinous process in headache patients may be coincidental.

5.5 Clinical implications

The following section discusses the clinical significance of the findings of this research.

5.5.1 Reliability of cervical postural palpation assessment

Physiotherapists commonly use palpation to determine the relative alignment of vertebrae in the cervical spine. This common practice is reflected by a widely used physiotherapy manual therapy text that recommends that a palpation assessment of upper cervical spine alignment be performed as part of the clinical assessment process (Maitland et al., 2005).

The results of the present study suggest that palpation cannot be used in place of radiographs to determine the postural presentation of the cervical spine. The reliability of

palpation has been reported to worsen when a decision is based on an arbitrary ‘normal’ (Strender, Lundin, & Nell, 1997). The palpation in the present study did use comparisons with an arbitrary ‘normal’ in the GCL, UCL and C2 spinous process assessments and this may have contributed to the poor reliability of these assessments. The physiotherapists’ poor reliability in determining the presenting postural characteristics of the cervical spine supports the results of previous studies that have reported poor reliability for cervical palpation as a clinical assessment tool (King et al., 2007; Robinson et al., 2009). This is consequential as cervical manual therapy treatment techniques are commonly based on a cervical palpation examination (Jull et al., 1988; Tuchin et al., 2000). Studies that have investigated the reliability of palpation to identify a symptomatic level in cervical dysfunction also included the ‘perceived stiffness’ of the joint as an indicator of abnormality believed to be associated with symptoms (Jull et al., 1988; King et al., 2007). Jull et al. (1988) reported one physiotherapist to be reliable in determining the level of cervical dysfunction using palpation that included pain reproduction and perceived stiffness; however the authors recommended their results should be reproduced before they could be considered generalisable. A subsequent study that attempted to replicate the methods of Jull et al. (1988) with a larger sample found palpation unreliable in determining the level of cervical spine dysfunction (King et al., 2007). Importantly, the method used in King et al. (2007) was different from that of Jull et al. (1988) as the palpation assessment was performed by a medical doctor rather than a physiotherapist. This study, therefore, does not specifically determine whether physiotherapists are reliable or not, but neither do the results of Jull et al. (1988) as they cannot be generalised.

The reliability of palpation as an assessment method also needs to be questioned as investigations have found physiotherapists unreliable in identifying specific spinal levels (Harlick et al., 2007; Robinson et al., 2009). As the ability to determine the relative alignment of vertebrae requires that therapists reliably identify each vertebra they palpate, these results further suggest that physiotherapists are likely to be unreliable in determining the relative alignment of vertebral levels.

Analysis of reliability in prone lying is important as this position is commonly used in physiotherapy assessment and treatment techniques of the cervical spine (Maitland et al., 2005). The poor reliability of determining the static cervical postural presentation in prone lying found in the present study has added to the body of evidence regarding the poor reliability of palpation as a postural assessment method. Previous studies that have assessed the reliability of postural palpation have either positioned the patient in sitting or in supine lying, or have failed to report the patient position, but no study was identified that had investigated reliability with the patient positioned in prone lying (Eriksen, 1996; Hart, 2006; Jende & Peterson, 1997; Spano, 1995). The results of the present study showing poor inter-rater reliability for the palpation assessment of the position of the C2 spinous process agree with the results of previous studies (Eriksen, 1996; Hart, 2006). Poor reliability of determining rotation of C2 may be related to poor reliability in identifying the specific spinous process (Harlick et al., 2007; Robinson et al., 2009). The lack of association between the position of the C2 spinous process, measured on

radiographs, and CEH does, however, suggest that the position of the C2 spinous process may not be a meaningful clinical indicator.

Cervical spine stiffness has also been demonstrated to vary when the assessment is performed in different postures (Snodgrass & Rhodes, 2008). The movement pattern of the cervical spine has also been reported to alter when the movements were initiated in different positions (Edmonston et al., 2005). Therefore, the assessment of cervical joint stiffness may require an ability to determine the posture in which the joint is being assessed. The reliability of the assessment of cervical symptomatic level may be partly due to the therapist not being able to determine the contribution that the patient's posture is making to any perceived cervical joint range of movement or stiffness which are key components of the manual palpation assessment (Jull et al., 1988). The conflicting reports of the reliability of assessment of cervical symptomatic level by King et al. (2007) and Jull et al. (1988) may be related to poor reliability in determining the presenting postural characteristics of the cervical spine. Further research may determine if establishing methods to ensure that patients are assessed in the same posture are worthwhile. Consistent joint positioning may also help to improve the reliability of other palpation assessment techniques.

5.5.2 The association between static cervical spinal posture and cervicogenic symptoms

The present study is the first to our knowledge to analyse static posture in CEH using radiographs. The only previous identified study that used radiographs to assess static cervical lordosis posture in patients with headache investigated patients with tension type headache (Nagasawa et al., 1993). Nagasawa et al. (1993) found an association between tension type headache and decreased cervical lordosis. Other studies have also reported an association between neck pain and decreased cervical lordosis (D. D. Harrison et al., 2004; McAviney et al., 2005). In contrast, the present study demonstrated an association between CEH and increased cervical lordosis. This is the only identified study reporting an association between any head and neck symptoms and an increased cervical lordosis and this may be unique to CEH.

Improving the understanding of the association between cervical posture and CEH may both help to strengthen the ability of clinicians to diagnose CEH using clinical signs and to direct future treatment strategies in CEH. Repeated studies are required to substantiate the association between CEH and increased cervical lordosis but if future research agrees with the current findings then further study may be able to determine if this knowledge can assist CEH diagnosis. The ability to use clinical signs to diagnose CEH is important as the anaesthetic injections that are currently recommended in the diagnostic criteria for CEH are invasive, costly and not widely available (Jull, Sterling et al., 2008). Increased cervical lordosis may, in addition to other clinical symptoms and signs already identified

to be associated with CEH by Jull et al. (2007), help to provide a valid and reliable means of CEH diagnosis without the need for diagnostic anaesthetic injections. Future investigations into the ability of treatment strategies to reduce the lordosis may also be worthwhile to determine if this results in reducing CEH.

A recent epidemiological study reported that there was no evidence to support an association between cervical sagittal spinal curves and any clinical signs or symptoms, including pain (Christensen & Hartvigsen, 2008). The findings of the present study challenge this conclusion as the association established between CEH and general cervical lordosis provides some evidence for an association between sagittal plane cervical posture and pain. This finding suggests that further investigations into the possible associations between spinal posture and other clinical signs or symptoms may be worthwhile.

5.5.3 Understanding the association between CEH and general cervical lordosis

The results of the present study demonstrate an association between increased general cervical lordosis and CEH. However, this association does not establish whether the general cervical lordosis is the cause of the CEH or if this postural presentation is a response to the symptoms. Despite the difference between the groups in the present study being only relatively small it does, however, provide additional information that may provide insight into the dynamics of this association and indicate directions for future research.

Upper cervical flexor muscle dysfunction has been established as a feature of CEH (Jull et al., 2007; Jull et al., 2002). Treatments to improve upper cervical flexor function and control have been recommended, and demonstrated to be effective in patients with CEH (Jull, O'Leary et al., 2008; Jull et al., 2002). Potentially, upper cervical flexor dysfunction contributes to the association between CEH and general cervical lordosis found in the present study as the upper cervical flexor muscles have been reported as essential in controlling cervical lordosis (Mayoux-Benhamou et al., 1994). Upper cervical flexor dysfunction in CEH may potentially be associated with the posture of the cervical spine in CEH.

In static positions, cervical extensor muscle contractions and head weight are reported to increase cervical lordosis unless these forces are countered by the action of the upper

cervical flexors (Mayoux-Benhamou et al., 1994). An increase in cervical lordosis, therefore, suggests that there may be either increased forces generated by the cervical extensor muscles, reduced upper cervical flexor forces or a combination of both. Reduced muscle strength in both cervical flexors and extensors is a feature of CEH (Jull et al., 2007). These findings suggest that the reduced forces generated by the cervical flexor muscles may be a factor in the postural presentation of CEH patients identified in the present study. This potential link between cervical flexor dysfunction and posture in CEH is discussed below.

Postural muscles, such as the upper cervical flexors, have been proposed to provide dynamic support in activities when the spine is positioned in neutral (Falla, 2004). It has been speculated that the upper cervical flexor muscles have a role in coordinating neck function, and that maintenance of normal function in these muscles protects an individual against cervicogenic headache (Tagil, Ozcakar, & Bozkurt, 2005). Further investigation of the role of these muscles has been recommended in order to improve the understanding of biomechanics in the cervical spine and, potentially, the pathogenesis of CEH (Tagil et al., 2005). The role of the upper cervical flexor muscles in proprioception has also been proposed to be a possible factor that contributes to chronic headaches when these muscles are dysfunctional (Fernandez-de-Las-Penas, Cuadrado, Arendt-Nielsen, Ge, & Pareja, 2008).

This theoretical association between posture and reduced cervical flexor function does not, however, clarify the type of association as the posture may be a cause or an effect of the altered muscular function. In the lumbar spine, sustained positioning in a flexed

posture is associated with altered neuromuscular control, as suggested by a delayed muscle reflex response (Rogers & Granata, 2006). This delay in muscle reflex responses has been linked to an increase risk of injuries in the lumbar spine (Cholewicki et al., 2005). An increased risk of injury, due to altered muscle reflex responses, is proposed to be due to the possibility that the delayed reflex responses subject the local structures to increased strain and stress (Reeves, Cholewicki, & Narendra, 2009). The postural pattern identified in CEH patients may result in a similar process in the cervical region. Sustained cervical extension may cause deactivation of the cervical flexors resulting in an increased susceptibility to cervical symptoms including CEH. Further research to investigate associations between the magnitude of the general cervical lordosis and the degree of dysfunction in the cervical flexors may help to determine the interaction between postural factors and neuromuscular control in the cervical spine.

The suggestion that altered posture is not the cause of CEH but rather a consequence of CEH is supported by research in chronic neck pain and whiplash (Woodhouse & Vasseljen, 2008). One study, that found altered cervical motor control patterns in patients with whiplash or chronic neck pain, concluded that the altered motor control seemed to be related to ‘long-lasting’ pain and not to a history of trauma or current pain (Woodhouse & Vasseljen, 2008). The authors reported that altered movement patterns in these chronic neck pain patients may reflect a protective postural control strategy (Woodhouse & Vasseljen, 2008). This suggests that in some situations the postural presentation may be a strategy to reduce the likelihood of re-aggravating CEH symptoms.

5.5.4 Does an increased cervical lordosis differentiate CEH from other headache types or 'normals'?

The present study does not provide evidence to differentiate CEH from other headache types or normal individuals based on postural presentation. Not all individuals with a large general cervical lordosis experience CEH.

Previous research on lumbar spines may help to explain why all individuals with specific postural presentations do not experience the same symptoms. The amount of lordosis and intrinsic mechanical properties of the lumbar spine have been reported to be equally important in predicting the magnitude and direction of coupled movements in the lumbar spine (Cholewicki, Crisco, Oxland, Yamamoto, & Panjabi, 1996). This suggests that the amount of lordosis and the intrinsic mechanical properties of the spine can alter the functional properties of the spine. It is possible that cervical lordosis contributes to the functional properties of the cervical spine in a similar way. Lordosis may contribute to the functional properties of the cervical spine, however the impact of this lordosis may depend on the presence or absence of other contributing factors such as reduced disc spaces, stiffened facet joints or tightened muscles. The combined effect of the lordosis with other factors may explain why not all individuals with an increased cervical lordosis have CEH, as posture is not the only factor influencing cervical function. Certain individuals may, for example, have intrinsic cervical mechanical properties that make them more susceptible to CEH symptoms. Alternatively, if increasing cervical lordosis is a strategy used by patients with CEH to manage their symptoms, then other contributing

factors may influence the effectiveness of this strategy for each individual and, therefore, determine the degree of the lordosis.

The finding that posture alone cannot be used to discriminate CEH, and that the generation of CEH may be due to a number of contributing factors, is consistent with previous CEH research that determined that no individual clinical sign can be used to differentiate CEH (Jull et al., 2007). This finding is also consistent with the categorisation of CEH as a syndrome. The underlying symptoms in CEH can originate from multiple possible structures so patients may have a variety of clinical presentations. No individual clinical sign has been demonstrated to independently differentiate CEH. Alternatively, a pattern of clinical signs for CEH diagnosis has been proposed (Jull et al., 2007). The potentially unique association between increased cervical lordosis and CEH symptoms suggests that, when added to other differentiating clinical signs, the presence of increased general cervical lordosis may strengthen CEH diagnosis. A further potential indicator of a unique association between CEH and posture is the demonstration in previous studies that tension type headaches and migraines are both associated with an increased craniovertebral angle (Fernandez-de-las-Penas, Alonso-Blanco, Cuadrado, Gerwin, & Pareja, 2006; Fernandez-de-Las-Penas, Cuadrado et al., 2006), whereas CEH are not (Dumas et al., 2001; Zito et al., 2006). Further investigation into the association between posture and CEH is, therefore, recommended to help determine if postural assessments can be used in CEH diagnosis.

5.5.5 Association between the distribution of the headache and posture

If posture is a response to CEH symptoms, then potentially individuals with headaches in different distributions may exhibit a different postural response. Different postures may potentially be associated with headaches in different distributions being mediated by different nerves. The occiput is a region of the head supplied by the cervical nerves so occipital headaches are reported to be associated with nociceptive activity in the cervical nerves, whereas frontal headaches are reported to be mediated through the trigeminal nerves (Bogduk & Govind, 2009). Serrao et al. (2003) reported that headaches in the frontal distribution result in a stimulation of the trigeminal nerves which can lead to increases in both upper and lower motor neuron activity that induces cervical extension. This cervical extension has been reported to be a protective mechanism that is a reflex withdrawal of the head from pain (Serrao et al., 2003). If pain in the frontal region of the head can result in an increased cervical extensor muscle activity then it could be argued that a similar reflex withdrawal mechanism for pain in the posterior region of the head would result in activation of the cervical flexor muscles. The increased general cervical lordosis associated with CEH was, however, not found to vary between CEH patients with different headache distributions. The similarity of postural presentations in patients with CEH in different distributions suggests that headache distribution is unlikely to be contributing to the postural presentation through a reflex withdrawal response to pain.

If increased cervical lordosis was a general response to head pain then it might be expected that individuals with other types of headaches would display the same posture. However, individuals with tension type headache have a decreased cervical lordosis compared to control participants (Nagasawa et al., 1993). The different postural presentations reported for tension type headache compared to CEH patients suggest that the postural presentation is unlikely to be a general response to pain in the head, but possibly a unique response related to the type of head pain and its symptom generators.

The different postural presentations between different headache types may reflect a difference in the underlying muscular dysfunction associated with each headache type. CEH is associated with dysfunction of upper cervical flexors and, as discussed previously, this may be a factor in the association between increased cervical lordosis and CEH. Tension type headache has been found to be associated with trigger points in the superficial cervical flexor muscles and this presentation has been proposed to indicate a strategy of increased superficial cervical flexor activity to compensate for a dysfunction in deep cervical flexors (Fernandez-de-las-Penas, Perez-de-Heredia et al., 2007). The difference in the cervical lordosis between CEH and tension type headache could either indicate that there are different strategies to compensate for the upper cervical flexor dysfunction or that the type of upper cervical flexor dysfunction may differ between different headache types. A pilot study has suggested that chronic tension type headache patients have greater upper cervical flexor endurance than patients with chronic neck pain, although both groups demonstrate a deficit compared to controls (Fernandez-de-las-Penas, Perez-de-Heredia et al., 2007). This difference has been proposed to suggest that

chronic neck pain may have a greater influence on the endurance of the upper cervical flexors than tension headache (Fernandez-de-las-Penas, Perez-de-Heredia et al., 2007). Symptoms in patients with CEH may therefore have a greater influence on upper cervical function compared to other headaches types, as CEH symptoms originate from the neck. This may contribute to the differences observed in cervical lordosis in these patients compared to other headache or neck pain sufferers.

5.5.6 Relationship between upper cervical posture and general cervical posture

It has been reported that the relationship between the upper and lower cervical spine influences neck posture (Wu et al., 2007). However the present study found no correlation between general cervical lordosis, upper cervical lordosis and C2 horizontal plane posture. These results support those of a previous study that found that upper cervical posture varies independently of general cervical posture (Johnson, 1998). The lack of evidence for a consistent relationship between upper and general cervical posture suggests that there are likely to be many additional factors that determine the postural presentation of each individual.

The present study adds to the previous level 3 evidence from one case report on CEH that reported a link between CEH and general postural factors (Sahrmann et al., 2005). The present study also adds to the level 2 evidence that CEH is not associated with forward head posture from studies of the craniovertebral angle in patients with CEH, as forward

head posture includes an increased upper cervical lordosis and this was not found in the CEH group in the present study (Dumas et al., 2001; Zito et al., 2006).

5.5.7 Reliability of radiographic measurements

The radiological measurements used in the present study varied in reliability. The method found to be most reliable was the measurement of general cervical lordosis. This measurement only required the base of the C2 and C7 vertebral bodies to be identified and then the computer software package generated the required lines and determined the angular measures automatically. The reliability of this measurement may have been good due to the ease of determining the base of the C2 and C7 vertebral bodies or because there was no possible human error in the placement of the perpendicular lines for the measurement of angles. In contrast, the C2 spinous process measurement required a decision to be made as to the midpoint of the C2 spinous process which occasionally is asymmetrical and may be difficult to determine. The upper cervical lordosis measurement also required a decision as to the most superior posterior point on the odontoid process which might also be open to interpretation (Johnson, 1998). Clinicians or researchers relying on radiographic measurements should consider these factors when choosing their methods.

5.6 Limitations

5.6.1 The order of the palpation and radiographic assessments

Performing the palpation assessments prior to radiographic assessment may be considered a potential confounding factor in this study, as the palpation may have affected the postural presentation of the participants. As described in the methodology section, this ordering was required because the reproduction of a familiar headache with palpation was a criterion for inclusion in the study. The effect of this ordering is not known. To minimise the likelihood of confounding by either the palpation for reproduction of a familiar headache or the postural palpation examinations, these examinations were performed on all participants with the same method and in the same sequence regardless of the participant's headache status. The method involved the palpation for reproduction of a familiar headache being performed on the control participants, even though these participants had already reported that they had no 'familiar headache'.

No studies were identified that have assessed the effects of palpation on subsequent radiographic postural presentation. Also, no research was identified that compared the effects of palpation on other cervical characteristics such as stiffness or range of movement. However, previous research has assessed the effect of cervical joint mobilisation, a form of palpation not dissimilar to the methods used in the present study, on these cervical characteristics. Tuttle, Barrett and Laasko (2008) demonstrated that

cervical joint stiffness decreases and active cervical range of movement increases following joint mobilisation for at least 4 minutes. The mobilisation treatment was found to only alter these cervical characteristics when the treatment is performed at a joint that is both symptomatic and hypo-mobile (Tuttle et al., 2008). These results suggest that for mobilisation to affect cervical function it needs to be applied to a symptomatic level. In the present study, the palpation assessment methods might be expected to have less effect on cervical function than the mobilisation treatment techniques used by Tuttle et al. (2008) because the present study did not involve continued repetitive pressures, were not focused on symptomatic levels, and when a symptomatic level was identified palpation was immediately discontinued. This suggests that the palpation assessment methods used in the present study are unlikely to have had significantly changed the presenting cervical posture subsequently measured on radiographs.

5.6.2 CEH subgroups

A limitation of the current study is the modest sample size. A larger sample size would have allowed for additional subgroup analysis of patients with CEH. The additional subgroupings that may have been worthwhile are discussed in the future research section (Section 5.7.4). The current study would have required a larger sample size for this additional sub-grouping to have been useful, as each subgroup would need adequate participant numbers to allow appropriate statistical analysis.

5.6.3 Patient position in the postural palpation assessment

The assessment of posture was performed in prone lying. The palpation assessment for discriminating the presenting postural characteristics of the cervical spine was unreliable but this may be unique to this particular patient position and/or the skills of the two examiners. Further, the cervical posture in prone lying may have been different to that in other positions. These differences could be due to variations in the effect of gravity and the degree of muscle tension/relaxation that may occur in different postures. The prone lying position was selected because physiotherapists commonly use this for the assessment and treatment of the cervical spine (Maitland et al., 2005). The physiotherapist examiners in the present study were both experienced with the commonly used clinical methods utilised in this study, and using experienced examiners usually improves the reliability of palpation (van Suijlekom et al., 2000). Using an alternative position for palpating posture would have required a training process and the examiners

would have had less experience with other positions. The reliability analysis would then have been arguably determining the effectiveness of the training process and not specifically the reliability of the physiotherapist examiners using their usual clinical technique.

5.6.4 Posture may alter when CEH patients are not experiencing symptoms

The participants in the present study were not asked if they had symptoms at the time of the postural palpation or radiographic assessments. It therefore cannot be determined if participants were experiencing CEH at the time of the assessment, even though each CEH participant had experienced their familiar headache immediately prior to the postural palpation and radiographic assessments. Not knowing if the CEH participants had symptoms at the time of the postural assessments is a limitation of the current study. This limitation is difficult to manage as even if the participants were only measured at a time when they were experiencing their CEH; there was no way of ensuring that the symptoms would continue for the duration of data collection. Headache symptoms can vary over time so even if an attempt had been made to only include participants with a current headache, there is the possibility that the symptoms for some participants may have altered between the palpation and radiographic assessments. Therefore, participants were included if they regularly experienced CEH, rather than if they had a current headache. This is often how patients with CEH present to the clinic, so including these patients was appropriate. Including these patients meant that the association demonstrated between

CEH and posture was not based on the presence or absence of symptoms at the time of the assessment.

5.7 Future Research

The following recommendations for future research are made on the proviso that the results of the present study are confirmed with a larger study.

5.7.1 Cervical lordosis in other headache types

The association between CEH and an increasing cervical lordosis may be unique to CEH as no other studies have been identified that have reported an association between increased general cervical lordosis and any disorder, including headaches. Further research into cervical sagittal plane posture in other headache types may help to determine if this association is unique to CEH. The demonstration of a different association between posture and tension type headache suggests that posture may be useful in the differentiation of headache types (Nagasawa et al., 1993).

5.7.2 Investigating the nature of the association between CEH and posture

Further investigation of cervical posture in the sagittal plane in CEH may also assist in determining the nature of the postural association. The present study has not determined if the postural association is a cause of the CEH or a response to symptoms or if changing the general cervical lordosis has a positive influence on the symptoms. Understanding the nature of this association may contribute to future investigations of assessment and treatment strategies in CEH. Longitudinal studies could be particularly useful, as they could potentially determine whether posture is a cause or effect of CEH. It is also recommended that future research includes a sub-group analysis of those participants experiencing symptoms at the time of the assessment to determine if the postural presentation differs between patients with current symptoms and patients in a symptom-free period. This may partially inform whether or not posture is a response to pain. A rating or other quantification of pain severity at the time of data collection would be required.

5.7.3 Investigating the link between upper cervical flexor function and posture

Further investigation of the interactions between upper cervical muscular dysfunction and posture may also contribute to determining if attempts to alter these muscles may alter posture, or if attempts to alter posture may affect the function of these muscles. This knowledge may possibly contribute to evidence for the direction of the interaction between these factors and then direct future treatment strategies in CEH.

5.7.4 Does the postural presentation vary in subgroups of CEH patients?

Future studies may also further subgroup patients with CEH to determine if there are different postural presentations in these subgroups. The subgroup categories that may be worthwhile investigating may relate to the cervical spine level that reproduces a patient's familiar headache, whether or not a patient has a history of trauma or whether the CEH symptoms were provoked by sustained postures or relieved by postural change.

As different cervical joint levels are known to have different functional roles and neurological connections, patients with CEH that have a particular primary spinal level of dysfunction may display different physical characteristics. Differences in the physical characteristics of CEH patients with different primary spinal levels of dysfunction have

previously been reported (Hall & Robinson, 2004). The differences identified in the study by Hall and Robinson (2004) were in the range of motion of patients identified with dysfunction at C1-C2 compared to C2-C3 in the flexion-rotation test. This result suggests that dysfunction at different spinal levels may cause differing physical characteristics. As these differences may include the presenting postural characteristics, further investigation of the relationships between symptomatic spinal levels and posture is worthwhile.

A patient's history of trauma may also potentially inform the postural presentation as the physical characteristics of patients with traumatic and non-traumatic onset of CEH have been shown to be different (Dumas et al., 2001). A recent systematic review also suggested that future research in CEH should separate traumatic and non-traumatic onset CEH patients, however this recommendation seems to be based only on the results of one study (Gadotti et al., 2008). Further clarification of the differences in physical characteristics between patients with CEH of a traumatic or non-traumatic onset may be required prior to routine separation of traumatic and non-traumatic onset CEH patients in future research due to the increase in sample sizes that may be required with this type of sub-grouping. The present study did not subgroup patients according to whether they had a history of trauma, as studying subgroups of patients was not the aim of the research so this was not considered in sample size estimates.

5.7.5 Investigating other components of posture

The present study included two upper cervical postural measures and one general cervical postural measure. This decision was based on reports that the upper cervical region is most commonly connected with CEH symptoms (Bogduk, 2001; Cooper et al., 2007; Hall et al., 2010; Hall & Robinson, 2004; Narouze et al., 2007; Ward & Levin, 2000). The finding that the GCL measurement was associated with CEH suggests that the assessment of other general postural measures in the future may be worthwhile. Further, the investigation of any association between dynamic postural factors and CEH should also be considered.

One case report has suggested a possible link between CEH and altered scapulothoracic and lumbar posture, as the authors reported improvement in CEH symptoms in response to treatment strategies to improve the posture of these regions (Sahrmann et al., 2005). Performing radiographs of the whole spine to analyse general posture based on this single case report may not be justified due to the extra radiation exposure required. However, with the addition of the results of the present study, further investigation of these other general postural factors may be reasonable. This suggestion is also supported by a recent study that found thoracic posture was more closely associated with neck pain than cervical posture (Lau et al., 2010).

5.7.6 Determining the specificity of the palpation for reproduction of familiar headache

The present study did not include individuals with other types of headache and it would have been informative to include these to determine if cervical palpation reproduced a familiar headache in only the CEH patients or if this occurs with other headache types. The reproduction of familiar headache with the palpation assessment in the current study indicates 100% sensitivity of the Phone Call Screening Questionnaire to differentiate individuals with CEH from those with no headaches, but this result does not provide an indication of specificity as individuals that experienced headache types other than CEH were excluded prior to the palpation assessment. The inclusion of patients with other headache types would have enabled the specificity of the palpation assessment for reproduction of familiar headache to be determined. If future research found that the reproduction of familiar headache was unique to CEH then the 100% sensitivity demonstrated for the Phone Call Screening Questionnaire in the present study would suggest that the palpation assessment would not be required in the differential diagnosis of CEH in patient selection in future studies. This information might also result in a clinically useful questionnaire for differentiating CEH that would reduce dependence on palpation assessment.

5.7.7 Assessing the reliability of postural palpation in different patient positions

A future study on the reliability of palpation for discriminating the presenting posture of the cervical region in different patient postures may be worthwhile. The supine position has been recommended for palpating the posterior structures of the cervical spine (Gross, Fetto, & Rosen, 2002). There may also be different postures, such as sitting or standing, in which physiotherapists may more reliably palpate the presenting postural characteristics of the cervical spine.

5.8 Summary and Conclusions

The hypotheses of the present study that trained and experienced physiotherapists can use palpation to consistently determine the presenting postural characteristics of the cervical spine for the variables assessed was not supported. If palpation is to be continued to be used as an assessment tool to inform clinical decisions then further research should be performed to investigate the reliability of current methods and to establish methods that are reliable. Potentially, palpation in multiple or different patient positions may provide increased reliability, or alternatively physiotherapists may require increased training in palpation. Teaching material that advises physiotherapists to assess cervical alignment with palpation should possibly be revised due to its unreliability and clinicians should be made more aware of the unreliability of determining spinal posture using palpation.

The hypotheses of the present study that radiographic assessment can identify statistically significant differences in the C2 spinous process alignment in the horizontal plane in individuals with CEH when compared to controls was not supported. The C2 spinous process alignment assessed radiographically cannot be used to discriminate individuals with CEH from controls.

The hypotheses of the present study that radiographic posture can identify statistically significant differences in the sagittal plane posture in individuals with CEH when compared to controls was also not supported. The present study found that static cervical spinal posture cannot be used to discriminate patients with CEH from asymptomatic individuals. This is consistent with previous investigations of clinical characteristics in patients with CEH which have found that no individual clinical feature can be used to discriminate CEH (Jull et al., 2007). The present study did, however, demonstrate that as general cervical lordosis increases there is an increased likelihood of experiencing CEH. This association between increased general cervical lordosis and CEH may be unique. No other study has been identified that has linked an increased general cervical lordosis with any form of headache or neck pain. The increased general cervical lordosis associated with CEH may be a response to the symptoms or it may contribute to the symptoms, but in either case further investigation of the association between cervical posture and CEH is warranted. The results of this study suggest that general cervical lordosis may be an important clinical characteristic to identify in the assessment or management of CEH.

Improving the understanding of the association between cervical spinal posture and CEH may help direct future assessment or management strategies for this condition.

As a CEH is a syndrome, patients present with a multitude of possible causes for their symptoms and it is likely that individuals display a wide variety of clinical presentations. This variety potentially requires that therapists assess for the specific dysfunctions present in each individual, and address these issues rather than providing a general treatment strategy for all patients with CEH. The results of this present study suggest that analysis of general cervical lordosis and the assessment of factors that may be contributing to this postural presentation in patients with CEH may be worthwhile. Future research may potentially further substantiate the association between CEH and general cervical lordosis, and assist researchers and clinicians to understand the role that this posture plays in patients with CEH.

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Appendix A Ethics approval letters



HUMAN RESEARCH ETHICS COMMITTEE

Notification of Expedited Approval

To Chief Investigator or Project Supervisor:	Associate Professor Darren Rivett
Cc Co-investigators / Research Students:	Mrs Suzanne Snodgrass Mr Peter Farmer
Re Protocol:	An investigation of the association between upper cervical spine posture and cervicogenic headache
Date:	18-Jun-2008
Reference No:	H-2008-0196

Thank you for your **Initial Application** submission to the Human Research Ethics Committee (HREC) seeking approval in relation to the above protocol.

Your submission was considered under **L3 Full** review by the Committee. The Committee would like to commend the researchers on a well-prepared, well written application.

I am pleased to advise that the decision on your submission is **Approved** effective **11-Jun-2008**. During discussion the following points were raised. They are for noting:

1. Study protocol.

Given that this is a case/control study involving the use of ionising radiation, the researchers will need a method to ensure that the participants are matched before conducting the examination.

2. Effective Dose Calculation.

The dose calculation was for only 1 projection so the value of 0.06 mSv, as stated in the Participant Information Statement does not apply. Consider changing the Participant Information Statement to state "The effective dose from this study is about 0.15 mSv". This amendment would not change the category of risk.

3. Recruitment poster.

- As the research is to be conducted under the auspices of The University of Newcastle, the recruitment poster should display the University logo. Logo templates are available via the following link:
<http://www.newcastle.edu.au/mpr/templates/logos.html>
- Consider whether the poster should also state that pregnant women are excluded from participating in this research project.

4. Data management.

Paper copies of data should be kept until after the student researcher's Masters Degree has been awarded to allow for the cross-checking of data for accuracy/consistency, and to respond to potential enquiries from supervisors and/or examiners.

A formal *Certificate of Approval* will soon be issued. In the interim your approval number is **H-2008-0196**.

If the research requires the use of an Information Statement, ensure this number is inserted at the relevant point in the Complaints paragraph prior to distribution to the potential participants.

You may proceed with the research. Best wishes for a successful project.

Professor Val Robertson
Chair, Human Research Ethics Committee

For communications and enquiries:
Ms Genevieve Farrell
Human Research Ethics Officer

Research Services
Research Office
The University of Newcastle
Callaghan NSW 2308
T +61 2 49216333
F +61 2 49217164
Genevieve.Farrell@newcastle.edu.au

HUMAN RESEARCH ETHICS COMMITTEE

Notification of Expedited Approval

To Chief Investigator or Project Supervisor:	Professor Darren Rivett
Cc Co-investigators / Research Students:	Dr Suzanne Snodgrass Mr Peter Farmer
Re Protocol:	An investigation of the association between upper cervical spine posture and cervicogenic headache
Date:	30-Jun-2009
Reference No:	H-2008-0196

Thank you for your **Variation** submission to the Human Research Ethics Committee (HREC) seeking approval in relation to the above protocol.

Variation to:

1. Add a second radiographer (Mr John Tessier) to the research team who will also take measurements of the de-identified and coded cervical spine X-ray images to allow the investigation of the inter-rater reliability of the measurement techniques used.
2. Expand recruitment source/methods by emailing all local University students (not just post-graduates).

Your submission was considered under **Expedited** review by the Chair/Deputy Chair. I am pleased to advise that the decision on your submission is **Approved** effective **30-Jun-2009**. The full Committee will be asked to ratify this decision at its next scheduled meeting. A formal *Certificate of Approval* will be available on request.

****PLEASE NOTE:**

The following sentences should be added to the end of the recruitment email: "This project has been approved by The University of Newcastle Human Research Ethics Committee, Approval H-2009-0196."

Associate Professor Alison Ferguson
Chair, Human Research Ethics Committee

For communications and enquiries:
Human Research Ethics Administration

Research Services
Research Office
The University of Newcastle
Callaghan NSW 2308
T +61 2 49216333
F +61 2 49217164
Human-Ethics@newcastle.edu.au

Appendix B Recruitment flyer



THE UNIVERSITY OF
NEWCASTLE
AUSTRALIA

Volunteers Required Headache Study




We are recruiting individuals to participate in a research study investigating the relationship between neck posture and headaches. You must be between 18-50 years old and not have any conditions that would normally prohibit manual treatment of the neck. We are recruiting people with headaches (experiencing at least one headache per week over the last 2 months) and people without headaches (no headaches or neck symptoms for which you sought treatment in the previous 12 months).

This University of Newcastle based project will require you to attend the School of Health Sciences Laboratories in the Hunter Building at Callaghan on one occasion to have an assessment of your neck that includes a postural evaluation and X-rays. Please note: Pregnant women are unable to participate in this study.

For more information about the study please contact Research Higher Degree candidate Peter Farmer on 0404490406 or Peter.Farmer@studentmail.newcastle.edu.au

This project has been approved by the University of Newcastle Human Research Ethics Committee, Approval No H-2008-0196.

Appendix C Research Information Statement

<p>Associate Professor Darren Rivett Head of School, School of Health Sciences Hunter Building The University of Newcastle Callaghan NSW 2308 Phone: 02 49217220 Fax: 02 49217053 Darren.Rivett@newcastle.edu.au</p>	 <p>THE UNIVERSITY OF NEWCASTLE AUSTRALIA</p>
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Information Statement for the Research Project:

An investigation of the association between upper cervical spine posture and cervicogenic headache.

Document Version 1; dated 30/5/08

You are invited to participate in the research project identified above which is being conducted by Peter Farmer, Associate Professor Darren Rivett and Suzanne Snodgrass from the Discipline of Physiotherapy, School of Health Sciences at the University of Newcastle. The research is part of Peter Farmer's Masters studies at the University of Newcastle, supervised by Associate Professor Darren Rivett and Suzanne Snodgrass from the School of Health Sciences at the University of Newcastle.

Why is the research being done?

The purpose of this study is to investigate the relationship between neck posture and headache symptoms by comparing the neck posture of people experiencing headache symptoms with the neck posture of people without headache symptoms. Improving knowledge of the link between posture and headaches is expected to lead to improvements in assessment and treatment of patients with headaches. The research project will also determine the ability of different assessment methods, commonly used by physiotherapists, to detect differences in upper neck posture. This will inform decisions about the best methods to use in assessing and treating headaches.

Who can participate in the research?

There are two groups of participants in this study, each between 18 and 50 years of age. The first group are people who have had a headache at least once per week over the past two months, and the second group are those with no headache symptoms (who have not sought treatment for neck pain or headache symptoms within the previous 12 months).

You should not participate if your headache is associated with an aura (a visual phenomenon that can include seeing flashing lights or geometric patterns, or distorted vision) or if your headache occurs equally on both sides of the head at the same time. If your symptoms are related to an injury that is part of a compensation claim or litigation action then you are not eligible for this study.

You should also not participate in this study if you have been diagnosed with any condition that would normally prohibit manual treatment of the neck. These conditions include a known history

of neck instability, osteoporosis (thin bones), malignancies (cancer), infectious diseases affecting the neck, inflammatory diseases such as rheumatoid arthritis, or other symptoms such as dizziness, double vision, episodes of unconsciousness, or trouble with speaking or swallowing. Additionally, you are ineligible to participate if you are pregnant.

What choice do you have?

Participation in this research is entirely your choice. Only those people who give their informed consent will be included in the project. Whether or not you decide to participate, your decision will not disadvantage you.

If you do decide to participate, you may withdraw from the project at any time without giving a reason and have the option of withdrawing any data which identifies you.

What would you be asked to do?

If you agree to participate, you will be asked to:

Attend one data collection session lasting approximately 1 hour at the School of Health Sciences Research Laboratory and Radiography Laboratory at the University of Newcastle at Callaghan

During this session you will:

- Have your age and gender recorded by the researchers.
- Have one of the researchers (a registered physiotherapist with post-graduate qualifications) touch the bones and muscles of your neck to determine if there are any areas that are tender to touch. This assessment of tenderness to touch will use an amount of pressure consistent with that used routinely by physiotherapists in the clinical setting when manually assessing the spine.

The results of this tenderness assessment will determine if further assessment of your neck is appropriate for this research. If it is, you will:

- Have an X-ray assessment of your upper neck using two X-ray views.
- Have your upper neck posture assessed by two registered physiotherapists, both with post-graduate qualifications in manual therapy. The physiotherapists will touch your neck, using an amount of pressure consistent with that routinely used by physiotherapists in the clinical setting when manually assessing the spine.

How much time will it take?

You will be required to attend one data collection session. Completion of the full assessment will take approximately one hour. However, if it is determined following the upper neck tenderness assessment that further assessment is not required, then your data collection session will only last 5-10 minutes.

What are the risks and benefits of participating?

The benefit to you from participating in this research is the opportunity to have your neck posture evaluated using both X-ray measurement and physiotherapy assessment methods. If during the process of reviewing your neck posture with the X-rays any significant pathology is detected you

will be advised to seek further review with your local medical practitioner. You would then be provided with a letter detailing the findings of the X-rays and a copy of the X-rays so that you can take them to your medical practitioner if you choose to do so. In addition, at the completion of the study you can receive, if you wish, a summary of the overall results.

The risks to participating are minimal, but include the potential for temporary soreness in the neck area or headache following the clinical tests for posture and tenderness. These risks will be minimised by careful screening of participants for any conditions which would normally prohibit the application of manual treatment to the neck. However, if you do experience any unpleasant sensations, you can stop the assessment procedures at any time and withdraw from the study. The researchers, who are registered physiotherapists, will discuss any uncomfortable sensations with you, and if appropriate, will provide you with a letter for your medical practitioner.

The X-ray procedure involves exposure to a very small amount of radiation. As part of everyday living, everyone is exposed to naturally occurring background radiation and receives a dose of about 2 millisieverts (mSv) each year. The effective dose from this study is about 0.15 mSv. At this dose level, no adverse effects of radiation have been demonstrated, as any effect is too small to measure. The risk is, therefore, believed to be very low.

How will your privacy be protected?

Your privacy will be protected. Data collected from you will be labelled with a code on the day it is collected. Coded data will be kept on a computer that is password protected and is only accessible to the researchers listed above. The contact details that you provide will be stored separately to the data in a locked cabinet in the office of the School of Health Sciences. At the conclusion of the study, all data will be downloaded to CD and stored in a locked cabinet in an office of the School of Health Sciences at the University of Newcastle. All information will be stored in the School of Health Sciences at the University of Newcastle for 15 years, after which time it will be appropriately destroyed.

How will the information collected be used?

The results of this study will form part of the Masters thesis of the student researcher, Peter Farmer, and will be submitted for publication in scientific journals. Information from this study will also be presented at university seminars related to the student researcher's Masters program and at professional conferences. Individual participants will not be identified in any reports arising from the project. A summary of the study results can be provided to you, if you wish to receive this, at the completion of the study.

What do you need to do to participate?

Please read this Information Statement and be sure you understand its contents before you consent to participate. If there is anything you do not understand, or you have questions, contact the researchers. The researchers will answer any questions you have about the study prior to your participation, and you may keep this copy of the information statement. You are also free to consult others before agreeing to participate in this research if you wish.

If you would like to participate, please contact one of the researchers either by telephone, email or in person. They will then answer any further queries, and confirm an appointment time for you to attend your data collection session.

Further information

If you would like further information concerning this research project, you may contact the researchers directly:

Peter Farmer - tel: 43650227 or 0404490406, email: Peter.Farmer@studentmail.newcastle.edu.au

Associate Professor Darren Rivett - tel.49217220, email: Darren.Rivett@newcastle.edu.au

Thank you for considering this invitation to participate in physiotherapy research.

Kindest regards,

Peter Farmer
BAppSc(Physio), Physiotherapy Masters Student.

Associate Professor Darren Rivett

Project Supervisor

BAppSc(Phty), GradDip(ManipTher), MAppSc(ManipPhty), PhD.

Suzanne Snodgrass
Project Supervisor
BSc(Phys Ther), ATC, MMedSC (Physio).

Complaints about this research

This project has been approved by the University's Human Research Ethics Committee,

Approval No. *H-2008-0196*.

Should you have concerns about your rights as a participant in this research, or you have a complaint about the manner in which the research is conducted, it may be given to the researcher, or, if an independent person is preferred, to the Human Research Ethics Officer, Research Office, The Chancellery, The University of Newcastle, University Drive, Callaghan NSW 2308, Australia, telephone (02) 49216333, email Human-Ethics@newcastle.edu.au.

Appendix D Phone Call Screening Questionnaire

GENERAL PHONE CALL SCREENING QUESTIONS

To be asked of all potential participants who inquire about participation in the study entitled 'An investigation of the association between upper cervical spine posture and cervicogenic headache'.

Name:

Age:

Sex: M F

Contact details:

1) Do you have any of the following medical conditions?

YES/NO

Inflammatory, infectious or rheumatological diseases (eg, rheumatoid arthritis) affecting the neck	
Neurological conditions (eg, stroke)	
History of cancer	
History of osteoporosis (weak bones)	
Congenital abnormalities or instability in the neck	
Severe neck pain extending down the arm or pins & needles, weakness or numbness in the arm	
Dizziness on turning your neck or looking up? Or trouble swallowing or speaking, double vision or episodes of unconsciousness?	

If YES to any of these conditions, then EXCLUDED.

2) Are you pregnant or is there a possibility that you could be pregnant?

Yes/no

If YES, then excluded.

NON-HEADACHE GROUP POTENTIAL PARTICIPANTS – ADDITIONAL SCREENING QUESTIONS

3) Have you had any neck pain or headache for which you sought treatment in the previous 12 months?

If YES, then excluded.

Yes/no

4) Do you have a history of major trauma to your head or neck?

Yes/no

If YES, then excluded.

HEADACHE GROUP POTENTIAL PARTICIPANTS – ADDITIONAL SCREENING QUESTIONS

5) Have you had any treatment by a physiotherapist, chiropractor, osteopath or any other manual therapist in the last 2 months for your headaches?

If YES, then excluded.

Yes/no

6) Are your headaches on:

a) One side or both sides (but one side is always worse)

Yes/no

b) Both sides

Yes/no

c) Either side

Yes/no

If YES to 'b' or 'c' then excluded.

7) Do you get neck pain associated with your headache (before, during or following)?

If NO, then excluded.

Yes/no

8) Do movements of your neck, or the position of your head or neck, change or aggravate the headache?

If NO, then excluded.

Yes/no

9) How often do you get headaches per week? _____

10) For how long have your headaches been occurring? _____

If less than 1 headache per week over the past 2 months then EXCLUDED.

11) Are you currently involved in any workers' compensation claim, third party claim or litigation related to your headache symptoms?

If YES, then excluded.

Yes/no

12) Do you experience an aura (an aura is a visual phenomenon that that can include seeing flashing lights or geometric patterns) with your headache?

If YES, then excluded.

Yes/no

Appendix E Examiner Recording Sheet for Palpation for Reproduction of Familiar Headache

PARTICIPANT NUMBER _____

TENDERNESS PALPATION

The Participant reports precipitation of head pain, similar to the usually occurring one, by external pressure over the cervical or occipital region on the symptomatic side

☐ YES

☐ NO

Predominant level or finding _____

Appendix F Examiner Recording Sheet for Postural Palpation Assessment

PARTICIPANT NUMBER_____

1. C2 – Spinous process and articular pillar symmetry:
 - ☐ Normal
 - ☐ Spinous deviation left (equal prominence of articular pillars)
 - ☐ Spinous deviation right (equal prominence of articular pillars)
 - ☐ C2 rotation left (Spinous right / left pillar prominence / right pillar depression)
 - ☐ C2 rotation right (Spinous left / right pillar prominence / left pillar depression)
 - ☐ Other_____

2. Upper cervical lordosis
 - ☐ Normal
 - ☐ Hyper –lordosis
 - ☐ Hypo-lordosis
 - ☐ Other_____

3. General cervical lordosis
 - ☐ Normal
 - ☐ Hyper –lordosis
 - ☐ Hypo-lordosis
 - ☐ Other_____

Appendix G Data for postural palpation assessment

C2 spinous process		Examiner 1					
		Dev L*	Dev R*	Normal	Rot L*	Rot R*	Total
Examiner 2	Dev L*	0	0	0	1	0	1
	Dev R*	0	0	2	1	0	3
	Normal	2	3	18	12	8	43
	Rot L*	1	0	3	3	3	10
	Rot R*	1	0	0	1	1	3
	Total	4	3	23	18	12	60

* Dev L = Left deviation of C2 spinous process

Dev R = Right deviation of C2 spinous process

Rot L = Left rotation of the C2 vertebra

Rot R = Right rotation of the C2 vertebra

General cervical lordosis		Examiner 1					
		Cervical Kyphosis	Hyperlordosis	Hypolordosis	Normal	Increased Thoracic kyphosis	Total
Examiner 2	Cervical Kyphosis	0	0	0	1	0	1
	Hyperlordosis	0	8	0	8	0	16
	Hypolordosis	0	0	4	7	0	11
	Normal	0	7	9	15	0	31
	Increased Thoracic kyphosis	0	0	0	0	1	1
	Total	0	15	13	31	1	60

Upper cervical lordosis		Examiner 1			
		Hyperlordosis	Hypolordosis	Normal	Total
Examiner 2	Hyperlordosis	3	2	7	12
	Hypolordosis	0	5	4	9
	Normal	6	7	26	39
	Total	9	14	37	60