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Original Research

# Cervical Spine Alignment; Observation Over a Ten-Year Period Using Measurement of Cobb Angle and a Modified Pfirrmann Grade

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## Abstract

**Background and Aim:** We sought to explore whether or not this excessive use of smart technology may be associated with a generational change in the cervical spine over time.

**Methods and Results:** All those patients who underwent cervical spine MRI aged 15 to 30 years over the years June 2007 to 2008 and June 2017 to 2018 were considered for evaluation. Each patient had measurement of their Cobb angle and a modified Pfirrmann grade. 217 patients - 83 (2007-2008) and 134 (2017-2018) were evaluated. There was no difference in cervical alignment over time, but males tended to have a greater lordosis($p<0.001$). Using the modified Pfirrmann grading system a difference over time was noted most noticeable at C2/3 ($p=0.004$); C3/4 ($p=0.019$ and C7/8 ($p=0.003$).

**Conclusion:** There was no change in the structural integrity of the cervical spine between the two groups over time. A worsening degenerative disease without a structural change was observed, an effect was more apparent in the males.

***Keywords:*** *Cervical Spine, Lordosis, Cobb Angle*

## Introduction

Since the first generation iPhone in 2007, there has been a gradual evolution in mobile technology and usage, from simply making a call or text to a multitude of functions in the modern world.

A generation of young people communicates in this novel way. A glance in cafes, waiting rooms, busses etc. will reveal the ubiquitous seated position with an acute forward flexion of the cervical spine. This observation and the impression that there may be associated structural changes in this area led us to investigate if this is a real or perceived phenomenon. [5-15]

Measurement of the spinal curvature is complex and antero-posterior or lateral measurements are possible. As our MRI scans however were acquired in a two-dimensional manner with sagittal and axial planes, we focused on an antero-posterior projection. Cobb, an orthopaedic surgeon, measured deformity on X Rays with this view typically measured from C-1 to C-7 or C-2 to C-7. The 4-line method includes drawing a line either parallel to the inferior endplate of C-2 or extending from the anterior tubercle of C-1 to the posterior margin of the spinous process, and another line parallel to the inferior endplate of C-7. One can also analyse each disc space.

## Material and Methods

### Study participants

All patients between 15 and 30 years of age who underwent cervical spine MRI over the years June 2007 to 2008 and June 2017 to 2018 were considered for evaluation.

### Cobb angle

Measurements were made using the Cobb Angle tool on PACs at C2 and C7. A line was drawn along the inferior endplate at C2 and C7. A perpendicular line was obtained and the angle between being the Cobb angle. If the angle was anterior to the perpendicular line (i.e. $<0^0$) the cervical morphology was classified as lordotic. If posterior (i.e. $\geq 0^0$) the cervical morphology was classified as an abnormal loss of lordosis.[1]

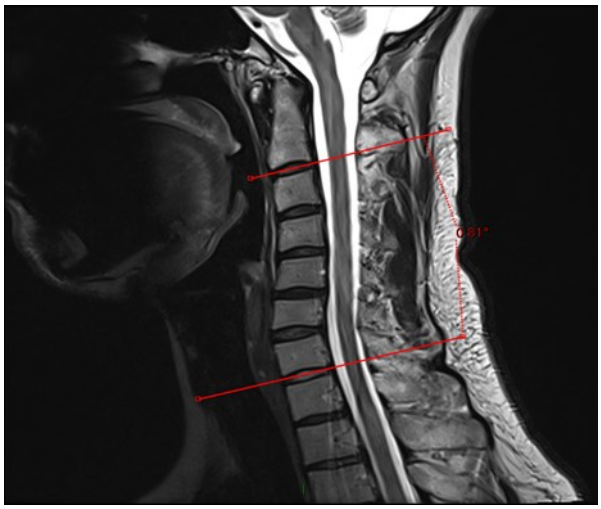


***Figure 1.*** *Sagittal T2 weighted MRI with measurement of Cobb angle between the lower border of C2 and C7. In this example the angle is + 0.81°. Using the modified grading system proposed by Pfirrmann C2/3 – 2, C3/2 – 2, C4/5 – 2, C5/6 – 3, C7/8 – 1.*

### Modified Pfirrmann grade

This was graded on MRI T2 spin-echo weighted images using a modified grading system proposed by Pfirrmann.[3]

*Grade I:* disc is homogeneous with bright hyperintense white signal intensity and normal disc height

*Grade II*

- disc is inhomogeneous but keeping the hyperintense white signal
- nucleus and annulus are clearly differentiated, and a grey horizontal band could be present
- disc height is normal

*Grade III*

- disc is inhomogeneous with an intermittent grey signal intensity
- distinction between nucleus and annulus is unclear
- disc height is normal or slightly decreased

*Grade IV*

- disc is inhomogeneous with a hypointense dark grey signal intensity
- there is no more distinction between the nucleus and annulus
- disc height is slightly or moderately decreased

*Grade V*

- disc is inhomogeneous with a hypointense black signal intensity
- there is no more difference between the nucleus and annulus
- the disc space is collapsed

Age, gender, scan indication and past medical history were also captured.

Patients were excluded if there was a history of trauma, scoliosis, syringomyelia or their anatomy was deemed exaggerated by a consensus of the observers.

### Statistical analyses

All statistical analyses were performed via Statistical Package for the Social Sciences (SPSS) V.28.0.

Each cohort year group was then split into 3 separate age categories. [15-20; 21-25; 26-30]

The difference in Cobb angle were calculated using independent sample t-tests. Chi-Squared Test was used to determine the proportion of male to female gender between the 2007-2008 cohort and 2017-2018 cohort. All p-values were evaluated as significant if $p<0.05$.

## Results

A total of 244 patients were considered for the evaluation, 86 (2007-2008) and 158 (2017-2018). Individuals not fulfilling the inclusion criteria were excluded, leaving 217 patients - 83 (2007-2008) and 134 (2017-2018) in each group, respectively.

For 2007-2008 percentage indications for scanning were demyelination (33), pain and paraesthesia (30), radiculopathy (18), functional (6), myelopathy (8) and miscellaneous (5). For 2017 – 2018 indications were demyelination (35), pain and paraesthesia (26), radiculopathy (6), functional (7), myelopathy (14) and miscellaneous (12).

The minimum and maximum ages for both cohorts were 15 and 30, respectively. The mean age in 2007-2008 and 2017-2018 groups are 23.96 and 23.87.

In relation to indications for performing imaging we did not find any statistical differences between the groups. We did not have data on individual levels of physical activity.

A two-tailed test was used to analyse the Cobb angle difference between the 2007-2008 cohort and the 2017-2018 cohort, showing an insignificant change in mean Cobb angle with $p=0.18$ ($p>0.05$). The SE of the difference between means was 1.50 (95% CI = -4.96-0.96). The 2017-2018 cohort had a greater mean Cobb angle (2.92 degree), indicating an abnormal loss of lordosis in comparison to the 2007-2008 cohort.

**Table 1.** Independent sample t-test on the difference in Cobb angle between the 2007-2008 cohort and the 2017-2018 cohort in 217 participants.

| Group | N | Min (Cobb angle) | Max (Cobb angle) | Mean (Cobb angle) | SD |
|---|---|---|---|---|---|
| 2007-2008 | 83 | -16.80 | 23.45 | 0.92 | 4.06 |
| 2017-2018 | 134 | -22.31 | 26.60 | 2.92 | 11.18 |
| Total | 217 | -22.31 | 26.60 | 2.15 | 10.77 |

Subsequently, each cohort was split into 3 separate age categories (15-20, 21-25, 26-30 years old), and the corresponding mean Cobb angles were compared.

**Table 2.** Cobb angle between 2007-2008 and the 2017-2018 cohorts by age category (15-20; 21-25; 26-30).

| **15-20 yr old** | | | |
|---|---|---|---|
| **2007-2008** | 18 | 1.87 | 8.70 |
| **2017-2018** | 29 | 3.33 | 11.69 |
| **Total** | 47 | 2.15 | 10.54 |
| **21-25 yr old** | | | |
| **Group** | **N** | **Mean (Cobb angle, degree)** | **SD** |
| **2007-2008** | 35 | -0.80 | 10.83 |
| **2017-2018** | 44 | 3.46 | 10.32 |
| **Total** | 79 | 1.57 | 10.70 |
| **26-30 yr old** | | | |
| **Group** | **N** | **Mean (Cobb angle, degree)** | **SD** |
| **2007-2008** | 30 | 2.35 | 9.74 |
| **2017-2018** | 61 | 2.81 | 11.69 |
| **Total** | 91 | 2.66 | 11.03 |

For each age group while there was a small loss of cervical lordosis between the groups none were statically significant.

We also explored gender effects on Cobb angle measurement. Overall, the Cobb angle was significantly less in female participants than in male participants; mean difference of 6.73 ($p<0.001$ (two-tailed) (SE = 1.53, 95% CI = 3.71-9.94)). In other words there was a significantly greater loss of lordosis in males. It is unclear why this may be. A possible explanation may be that the male group are taller and so are inclined to exhibit a greater degree of cervical flexion when bending down and/or forward in performing daily tasks *(e.g., reading, texting, checking social media on mobile phones etc.).* However, we did not have relevant data on 217 participants' heights to explore this hypothesis further.

For both cohorts there was a statistically significant difference in Cobb angle between the sexes. For 2007-2008 the mean Cobb angle for male participants was 5.36, and -1.00 in female participants. [$p=0.007$ (SE = 2.30, 95% CI = 1.78-10.94)].

Similarly for 2017-2018 this difference was also significant (Table 6). (7.81, and 0.84 [$p<0.001$ (SE = 2.03, 95% CI = 2.95-10.89)].

The gender distribution in both cohorts was comparable with a male/female ratio of 0.43 in both groups.

Finally when we looked at male and female Cobb angles over the two time periods while there was a trend in both groups towards a loss of cervical lordosis none was statistically significant.

**Modified Pfirrmann grade.**

Using the modified Pfirrmann grading system there was a significant difference between the groups when all levels were included ( p-value of 0.029). [3] At an individual disc level this was most noticeable at C2/3 (1.75 vs 2.08, $p=0.004$, SE =-0.34 (95% CI = -0.56 - -0.17)); C3/4 (1.88 vs 2.14, $p=0.019$, SE = 0.26 (95% CI = -0.47 - -0.04)); and C7/8 (1.12 vs 1.33, $p=0.003$, SE = 0.12 (95% CI = -0.35 - -0.07)) but there was no difference at any other level.

**Table 3**. C-spine disc grading of 2007-2008 and 2017-2018 cohorts.

| Disc | Group | N | Mean | SD | p-value | SE | 95% CI |
|---|---|---|---|---|---|---|---|
| C2/3 | 2007-2008 | 83 | 1.7470 | .74643 | 0.004 | -0.335 | -0.56- -0.17 - |
| | 2017-2018 | 133 | 2.0827 | .87944 | | | |
| C3/4 | 2007-2008 | 83 | 1.8795 | .77140 | 0.019 | -0.255 | 0.47 - -0.04 |
| | 2017-2018 | 133 | 2.1353 | .77637 | | | |
| C4/5 | 2007-2008 | 83 | 1.8434 | .77274 | 0.083 | -0.194 | -0.41 - 0.03 |
| | 2017-2018 | 133 | 2.0376 | .81097 | | | |
| C5/6 | 2007-2008 | 83 | 1.9518 | .76355 | 0.242 | -0.130 | -0.35 - 0.09 |
| | 2017-2018 | 133 | 2.0827 | .81692 | | | |
| C6/7 | 2007-2008 | 83 | 1.6386 | .74209 | 0.895 | 0.014 | -0.20 - 0.23 |
| | 2017-2018 | 133 | 1.6241 | .80342 | | | |
| C7/8 | 2007-2008 | 83 | 1.1205 | .74643 | 0.003 | -0.210 | -0.35 - -0.07 |
| | 2017-2018 | 133 | 1.3308 | .87944 | | | |
| **Overall mean** | 2007-2008 | 83 | 1.6968 | .55956 | 0.029 | -0.347 | -0.35 - -0.02 |
| | 2017-2018 | 133 | 1.8822 | .62556 | | | |

## Discussion

Numerous factors contribute to the alteration of cervical lordosis. These include trauma, work-related postures, and degenerative diseases, all of which can impact the natural curvature of the cervical spine. Increased flexion or hyperflexion in the cervical region leads to notable changes. The continuous inclination towards flexion results in a weight-bearing effect caused by the head's weight and strain on the neck muscles, leading to degeneration in the cervical vertebrae and discs. Over time a loss of lordosis may occur. Such strain will affect our cervical muscles, and the ligamentous structures begin to deteriorate, making them as significant factors in the loss of cervical lordosis. Consequently, cervical disc degenerations, kyphotic cervical stenosis, cord tension, and radicular symptoms has becoming more common nowadays. [16-22, 25] Therefore, such deviations from the normal curvature, i.e. a loss in lordosis or the emergence of cervical kyphosis, have been commonly linked to pain and eventually disability in patients. [19-23]

In this study, we explored the possible anatomical cervical changes in younger generations due to prolonged usage of electronic devices (e.g. phones, computers, tablets). For this purpose, a comparison cervical MRI images between a 2007-2008 patient cohort and 2017-2018 patient cohort was made.

Our hypothesis that there may be a change over time was not proven. In fact, there was a greater degree of loss of cervical lordosis in the earlier cohort. There was a difference between sexes, a difference that did not translate to a loss of cervical lordosis over time. A reduced lordotic cervical spine observed in male patients could potentially be attributed to their generally taller stature, leading to a higher tendency for increased cervical flexion when using handheld devices while bending down. To gain further insights, it would be necessary to consider the influence of height on both genders and evaluate the Cobb angle relative to individual heights. We did not however capture this data.

We did however found a significant greater degree of degenerative change identified through observation through a modified Pfirrmann grade. We looked at 6 different levels and allocated a grade to the degree of degenerative change. At C2/3, C3/4 and C 7/8 there was a notable increase in findings. This did not occur at other levels and was not associated with an alteration in the level of lordosis and was independent of gender. Why this was present is unclear as one may have expected a greater difference at C 4/5 where greatest movement tends to occur. A follow up study is planned.

However, upon comparing males from the 2007-2008 cohort to males in the 2017-2018 group, the loss of lordosis did not demonstrate statistical significance. Similarly, no significant difference in the Cobb angle measurements among female participants was observed in both year cohorts. Such findings might be affected due to the unequal proportions of males to females (30% male vs. 70% female) in our study- resulted in a type II statistical error when comparing the Cobb angles between the two generations. Therefore, we suggest future studies should strive to recruit equal proportions of males and females in a substantially larger study to improve the p-values associated findings, if possible.

There are several limitations to the present study:

Firstly, it is not truly a population-based study. We looked at all patients who underwent MRI of the cervical spine in NHS Tayside between the 2 time periods. These patients were referred due to clinical concern. It should be noted the greater number of images performed in 2017-2018 reflecting a wider availability of scanners. Moreover, clinical practice will have changed and the threshold for referral possibly lower in the later time period. In addition we did not collate data on levels of physical activity.

Secondly, there may be technical issues when performing imaging. All scans were performed on a Siemens 1.5 T system but on a range of imagers. That said the cervical spine coils are all broadly similar as is the protocol for positioning.

Thirdly, there were two separate observers. We did measure a selection to standardise assessments, but all images were not doubly reported.

However, as a population-based study, there was a statistically significant correlation between loss of lordosis (more kyphotic) and the male gender. We have also illustrated a loss of lordosis between two generations. However, the significance of this finding needs to be further determined. Future studies of a larger caliber, and with controlled factors (as mentioned above) could be carried out and investigated deeper.

Despite the limitations, our work outlines the trend in loss of lordosis with respect to the male gender using the Cobb angle measurements. Such finding correlates with many studies found using the Harrison posterior tangent method. [1-4] Findings from this study should draw attention to future potential research, and a need to investigate underlying factors causing a difference in loss of cervical lordosis in females and males.

## Conclusion

A loss of cervical lordosis is more commonly observed in male patients than female patients across different year cohorts. There was greater degree of degenerative change at 3 cervical spine levels which was not associated with a change in lordosis. A further follow up study in 2028 is planned.

## Strengths and Limitations of study

**Strengths**

1. Population based study.
2. The use of Cobb angle measurement is accurate and reproducible.
3. Modified Pfirrmann grade included each level.

**Limitations**

1. There was an incremental increase in the use of Cervical spine evaluation over time.
2. Two separate evaluations were made.
3. Variables such as hours of smartphone screen time were not controlled.

## Data Availability Statement

Data are available on reasonable request. Data may be made available after reasonable request, if appropriate.

## Ethics Statements

This was an audit of images performed for clinical purposes with each patient consenting to each procedure.

## Ethics Approval

This was an audit on MRI scans already performed.

## Author Contributions

JO planned the study. JO and AK collected and analysed all MRI scans. YT and DH analysed the data using SPSS V.28.0 (SPSS). YT, DH. AK and JOR participated in manuscript production. JO was responsible for the overall supervision of the present work.

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## Competing interests

None declared.

## Patient consent for publication

Not required.

## Data availability statement

Deidentified participant data are available on reasonable request.

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