

The association between cervical spine curvature and neck pain

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Abstract Degenerative changes of the cervical spine are commonly accompanied by a reduction or loss of the segmental or global lordosis, and are often considered to be a cause of neck pain. Nonetheless, such changes may also remain clinically silent. The aim of this study was to examine the correlation between the presence of neck pain and alterations of the normal cervical lordosis in people aged over 45 years. One hundred and seven volunteers, who were otherwise undergoing treatment for lower extremity problems in our hospital, took part. Sagittal radiographs of the cervical spine were taken and a questionnaire was completed, enquiring about neck pain and disability in the last 12 months. Based on the latter, subjects were divided into a group with neck pain ($N = 54$) and a group without neck pain ($N = 53$). The global curvature of the cervical spine (C2–C7) and each segmental angle were measured from the radiographs, using the posterior tangent method, and examined in relation to neck complaints. No significant difference between the two groups could be found in relation to the global curvature, the segmental angles, or the incidence of straight-spine or kyphotic deformity ($P > 0.05$). Twenty-three per cent of the people with neck pain and 17% of those without neck pain showed a segmental kyphosis deformity of more than 4° in at least one segment—most frequently at C4/5, closely followed by C5/6 and C3/4. The average segmental angle at the kyphotic level was 6.5° in the pain group and 6.3° in the group without pain, with a range of 5 – 10° in each

group. In the group with neck pain, there was no association between any of the clinical characteristics (duration, frequency, intensity of pain; radiating pain; sensory/motor disturbances; disability; healthcare utilisation) and either global cervical curvature or segmental angles. The presence of such structural abnormalities in the patient with neck pain must be considered coincidental, i.e. not necessarily indicative of the cause of pain. This should be given due consideration in the differential diagnosis of patients with neck pain.

Keywords Cervical spine · Neck pain · Sagittal profile · Lordosis · Kyphotic deformity

Introduction

Degenerative changes of the cervical spine, evident on radiographic examination, are part of the normal physiologic ageing process [16, 17]. The most typical changes observed include osteoarthritis of the facets with reduced joint space and disc space narrowing. In contrast to radicular symptomatology, which is anatomically defined and can usually be explained by the presence of osteophytes or narrowing of the intervertebral foramen at the corresponding vertebral level, there is still uncertainty as to whether more widespread clinical symptoms such as axial neck pain can be attributed to observed radiographic changes.

The prevalence of neck pain in the normal population aged over 40 is approximately 20% [7, 8] and hence the question of the clinical significance of such radiological changes is of great importance. The finding that degenerative changes of the cervical spine are

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common in asymptomatic individuals has challenged the notion of cause and effect [5]; on the other hand, systematic reviews reveal that degeneration shows a consistent (albeit weak) association with pain, at least for the lumbar spine [47]. Fewer studies have examined this phenomenon in the cervical spine: some have identified a relationship between the number of levels of cervical spine degeneration and the chronicity of the complaint or (in women only) the associated disability [37]; others have shown that asymptomatic individuals with degenerative changes of C6/7 are significantly more likely to develop neck pain in the future (10 years later) [16]; whilst others, still, have failed to find any significant relationship between degenerative changes and pain [11, 13, 17, 18].

Degenerative changes of the cervical spine are often accompanied by a shortening of the anterior or posterior vertebral column [21, 49], which results in an alteration of the sagittal profile of the cervical spine [17]. The latter may occur on a segmental basis or may involve the whole cervical spine (Figs. 1, 2). There is much discussion in the literature as to whether, from a biomechanical point of view, the loss of the physiological lordosis could be a possible cause of pain, due to muscular imbalance [34] or, in the case of kyphotic deformities, due to structural overload of the anterior



Fig. 1 Degenerative segmental kyphosis at C3/4



Fig. 2 Degenerative global kyphosis

parts of the spine [24, 26]. Most of these studies have been in vitro experiments, although a recent study showed that, in individuals of around 40 years of age and with no kyphotic deformity, the mean cervical lordotic curve was lowest in a group with chronic neck pain and greatest in normal controls, with acute pain patients lying somewhere between the two [27]. Nonetheless, this was a retrospective radiographic study, and hence the data were not necessarily collected using standardised procedures.

The aim of the present study was to examine whether the sagittal profile of the cervical spine and individual segments (in particular, the presence of kyphotic segments) show any association with the presence and severity of axial neck pain in volunteers over 45 years of age.

Methods

Participants

One hundred and seven volunteers (47 males), with an average age of 68 (range, 45–90) years, agreed to participate in the study, which was approved by the local Ethics Committee. The volunteers were patients over

45 years of age that were visiting the outpatient clinic of our hospital due to orthopaedic problems of the lower extremities. Seventy-three per cent of those who were asked agreed to participate. To obtain a representative group of “non-neck-pain-patients” and to increase the incidence of degenerative changes without prior trauma or serious spinal disease, the exclusion criteria were defined as follows:

- previous trauma of the cervical spine;
- currently undergoing medical treatment for neck pain;
- systemic disease involving the cervical spine (e.g. rheumatoid arthritis);
- age under 45 years.

Hence, the study was considered to be monitoring the prevalence and severity of “non-specific neck pain” rather than “cervical spine illness/spinal disease.”

Radiological assessment

The subject stood in a relaxed position, holding onto a support at the level of the chest (Fig. 3). Using the light beam of the X-ray machine, the shadow of a metal wire was projected onto the lateral aspect of the head and



Fig. 3 Setup for the lateral cervical radiograph: a wire is stretched at 20° on an adjustable height pole and the *shadow* of this is projected onto the head, enabling standardisation of the head position in all participants

this was used to define the angle of inclination of the head. The angle to the horizontal line was adjusted to 20° and the head was orientated such that this line projected from the external opening of the ear to the eye (Fig. 3). The beam of the radiograph was centred 15 cm below the ear at a distance of 150 cm to the film plate.

Cervical spine segmental angles were evaluated from the radiographs according to the posterior tangent technique originally described by Albers [2] and Gore et al. [17]. Harrison et al. [23] re-examined this technique and reported good inter- and intraobserver reliability, with a lower standard error of measurement (less than 2°) than that typically reported for Cobb angle measurements. The angle between the posterior wall of the vertebral body of C2 and C7 gave the total cervical curvature (Fig. 4), and the angles between the posterior walls of neighbouring segments gave the segmental angles. In four patients it was not possible to visualise C7 due to unfavourable anatomical conditions.

As no standard values for “normal” curvature could be found in the literature, we defined the curvatures as follows (negative = lordotic; positive = kyphotic), based on the typical error of measurement (with 95% confidence intervals) [29] for radiographic segmental angles [14, 23, 42]:

Total curvature:

- Straight: -4° to $+4^\circ$;
- Lordotic: less than -4° ;
- Kyphotic: more than $+4^\circ$.

Segmental curvature:

- Straight: 0° to $+4^\circ$;
- Lordotic: less than -0° ;
- Kyphotic: more than $+4^\circ$.

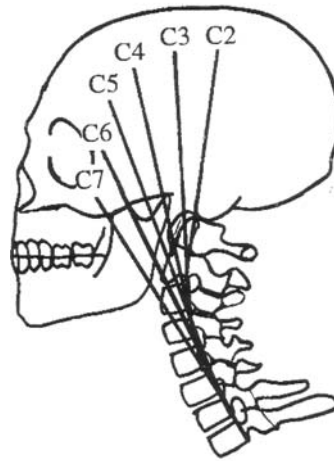
The proportion of segments (%) showing kyphosis was also calculated.

Subjective assessment

At the time of the investigation, no standardised and universally accepted self-rating questionnaires for the multidimensional assessment of cervical spine problems were available in the German language. As such, a custom-made questionnaire was used. It included questions on:

- the presence or absence of neck pain in the last 12 months (yes/no). This was used to dichotomise patients into a PAIN and NO PAIN group for further analysis (see Sect. “Discussion”);

Fig. 4 a Schematic diagram of the posterior tangent method of Harrison et al. [23]; **b** tangent lines at the posterior vertebral body margins (here of C2 and C7) are drawn and the angle of these intersecting lines is measured



- the duration (in months) and frequency (occasionally, often, constant) of neck pain;
- the intensity of neck pain [0–10 numerical rating scale (NRS)] when at its worst, at its best and on average;
- the frequency (occasionally, often, constant) and intensity (0–10 NRS) of radiating pain;
- difficulties swallowing (yes/no);
- concurrent headache (yes/no);
- sensory disturbances in the arm/hand (yes/no);
- impairment of manual dexterity (yes/no);
- difficulties getting to sleep/waking in the night due to neck pain (for each: never, occasionally, often, constant);
- social restrictions due to neck pain (never, occasionally, often, constant);
- restricted ability to do housework due to neck pain (never, occasionally, often, constant);
- restricted work capacity due to neck pain (never, occasionally, often, constant);
- use of over-the-counter analgesics for neck pain (yes/no);
- medical treatment for neck pain (visit to the doctor, conservative treatment, surgical treatment; each yes/no).

Statistical analysis

Descriptive data are given as means (SD), or absolute numbers and percentages. Differences in continuous

variables between the PAIN and NO PAIN group were examined using unpaired *t*-tests. Relationships between continuous variables were examined with Pearson correlation coefficients. Associations between pairs of categorical variables [e.g. the different categories of sagittal profile (straight–lordotic–kyphotic) and various clinical parameters listed in Table 1] were examined using the Chi-square test and Fisher’s exact test.

The data were analysed using the statistics program Statview 5.0 (SAS Institute, San Francisco, CA, USA). Significance was accepted at the 5% level.

Results

Comparability of the study groups

Fifty-four out of 107 volunteers declared having had neck pain in the last 12 months and these constituted the “pain group” (PAIN); 53 individuals had had no neck pain (NO PAIN) in the last 12 months.

The PAIN and NO PAIN groups were of comparable age [67.4 (SD 11.0, range 45–90) vs 68.7 (SD 10.0, range 50–86) years, respectively; $P = 0.52$], but differed significantly with regard to their gender distribution [39/54 (72%) vs 21/53 (40%) females, respectively; $P=0.0007$]. As such, in subsequent PAIN vs NO PAIN group comparisons, additional analyses were carried out for men and women separately, to ensure that gender was not acting as a confounding variable.

Table 1 Pain and disability data for patients with neck pain

Variable	Mean (SD) or number (%)
Duration of pain (months)	67 (63)
Frequency of pain	Occasionally 22/54 (41%) Often 26/54 (48%) Constant 6/54 (11%)
Neck pain intensity, when at worst (0–10 NRS)	4.4 (2.2)
Neck pain intensity, when at best (0–10 NRS)	1.9 (1.5)
Neck pain intensity, average (0–10 NRS)	2.8 (1.5)
Neck pain intensity at end of busy day (0–10 NRS)	3.5 (2.2)
Radiating pain	22/54 (41%)
Frequency of radiating pain (if present; <i>N</i> = 22)	Occasionally 11/22 (50%) Often 9/22 (41%) Constant 2/22 (9%)
Radiating pain intensity (if present; <i>N</i> = 22)	3.0 (1.0)
Difficulties swallowing	2/53 (4%)
Concurrent headache	19/53 (36%)
Sensory disturbances in arm or hand	24/53 (46%)
Impairment of motor function/manual dexterity	6/53 (11%)
Difficulties getting to sleep due to neck pain	Never 18/52 (35%) Occasionally 26/52 (50%) Often 7/52 (13%) Constant 1/52 (2%)
Waking in the night due to neck pain	Never 38/52 (73%) Occasionally 12/52 (23%) Often 2/52 (4%) Constant 0/52 (0%)
Restricted social life due to neck pain	Never 38/52 (73%) Occasionally 12/52 (23%) Often 2/52 (4%) Constant 0/52 (0%)
Restricted ability to do housework due to neck pain	Never 29/52 (56%) Occasionally 21/52 (40%) Often 2/52 (4%) Constant 0/52 (0%)
Restricted work capacity due to neck pain (where applicable, <i>N</i> = 27)	Never 23/27 (85%) Occasionally 4/27 (15%) Often 0/27 (0%) Constant 0/27 (0%)
Use of over-the-counter analgesics	17/54 (31%)
Visit to the doctor in the last 6 months due to neck pain	8/52 (15%)
Conservative treatment for neck pain in last 6 months	11/52 (21%)
Operative treatment for neck pain in last 12 months	0/52 (0%)

Data are from a maximum *N* = 54; where *N* < 54 this was due to occasional missing answers within the questionnaire

Pain characteristics of the PAIN group

Details of the pain history, clinical symptoms, pain and disability of the subjects in the PAIN group are shown in Table 1. Most had chronic mild to moderate pain, and the average duration was 67 (SD 63, range 1–360) months. The majority suffered with neck pain either often or occasionally; just under half of them also had radiating pain. Concurrent headache was reported in about one-third and sensory disturbances in almost half. Approximately two-thirds declared at least occasionally having difficulties getting to sleep due to neck pain; and about a quarter woke in the night due to pain. Just over a quarter felt their social life was somewhat restricted as a result of their neck pain, and

almost half were restricted in their ability to do housework; few (15%) of those working reported work-related restrictions. About a third used over-the-counter pain medication. A minority (15%) had visited the doctor for neck pain, and approximately one-fifth had had some sort of conservative treatment. No one had undergone surgery of the cervical spine in the preceding 12 months.

Gender differences in pain characteristics

In the individuals reporting pain, there were no significant gender differences for the following parameters: frequency of pain ($P = 0.76$); duration of pain ($P = 0.11$); pain intensity (each $P > 0.10$); presence of

radiating pain ($P = 0.95$); difficulties swallowing ($P = 0.37$); sensory disturbances ($P = 0.13$); impairment of motor function ($P = 0.17$); difficulties getting to sleep ($P = 0.75$) or being woken from sleep ($P = 0.49$); restrictions in social life ($P = 0.71$), housework ($P = 0.68$), and work capacity ($P = 0.26$); and use of analgesics ($P = 0.99$).

There was, however, a significant gender difference in the frequency of headaches ($P = 0.009$) and the use of non-operative treatment modalities ($P = 0.025$), with women reporting a higher frequency than men in each case; there was a slight, non-significant tendency for more medical consultations in women than men ($P = 0.09$).

Influence of gender and age on spinal curvature

There was no significant difference between men and women for either the global curvature C2–C7 [-23.0° (SD 13.1) and -24.1° (SD 10.3), respectively; $P = 0.63$] or individual segmental angles (all $P > 0.05$).

For the women, but not the men, the degree of lordosis (negative curvature) from C2–C7 showed a significant increase with increasing age ($r = -0.44$, $P = 0.0006$).

Influence of pain history on total and segmental curvature

There were no significant differences between the PAIN and NO PAIN groups for either the total (C2–C7) curvature (Table 2) or the segmental curvature at any level (Fig. 5). When the sexes were examined separately, there were still no differences between PAIN and NO PAIN groups for the total curve but, in the men only, C2/3 was slightly less lordotic (by about 3° ; $P = 0.049$) and C6/7 more lordotic (by about 4° ; $P = 0.04$) in the PAIN group.

In the PAIN group, there were no significant correlations between the total or segmental curvature and any of the clinical features of the pain shown in Table 1.

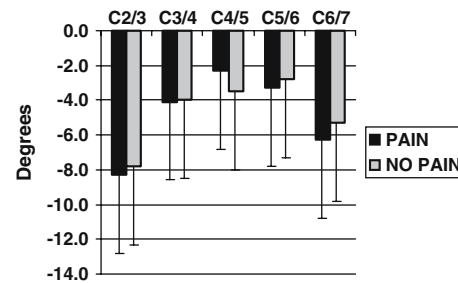


Fig. 5 Mean (SD) segmental angles in the PAIN and NO PAIN groups. No significant differences at any level

Curvature categories vs neck pain group

There was no significant difference in the distribution of curvature categories between the PAIN and NO PAIN groups, for either the whole curve or the segmental angles (Table 3). This was also the case for all comparisons when the sexes were considered separately, with the exception of one level (C2/3), in women only, for which significantly ($P = 0.01$) more people in the NO PAIN (19%) than in the PAIN (0%) group were categorised as having a straight as opposed to lordotic segment (no kyphotic segments were recorded in either group).

A segmental kyphotic deformity of $>+4^\circ$ in at least one segment was found in 12/52 (23%) individuals in the PAIN group vs 9/53 (17%) in the NO PAIN group ($P = 0.47$). In each case, the segment C4/5 was most commonly affected (9% of cases), followed by C3/4 (7%) and C5/6 (5%). Where kyphosis was observed, the mean kyphotic angle (6.5° vs 6.3° , in the PAIN and NO PAIN groups, respectively) and range of values for the kyphotic angle ($+5^\circ$ to $+10^\circ$ in both groups) did not differ between the groups ($P > 0.05$).

Other radiographic abnormalities

Amongst the whole volunteer group, one case of assimilation of the atlas and one congenital fusion of C2/3 were observed. Both of these were in the NO PAIN group.

Table 2 Mean global cervical curvature (C2–C7) in the PAIN and NO PAIN groups: for all subjects together, and then split according to those with a lordotic spine, a straight spine or a kyphotic spine (see definitions in the text)

Category of cervical curvature	Cervical spine curvature (deg)				
	PAIN group		NO PAIN group		P value
	Mean (SD)	Count	Mean (SD)	Count	
All	-24.3 (11.2)	50	-23.0 (12.0)	53	0.57
Lordotic	-25.2 (10.5)	48	-25.2 (10.1)	48	0.98
Straight	-3.0 (1.4)	2	-3.0 (2.0)	4	–
Kyphotic		0	+5.0	1	–

Table 3 Proportion of patients with each category of cervical curvature (lordotic, straight, kyphotic) in PAIN and NO PAIN groups

Spinal segment	Group	Lordotic	Straight	Kyphotic	Chi-square P value
C2/3	PAIN	51/54 (94%)	2/54 (4%)	1/54 (2%)	0.31
	NO PAIN	48/53 (91%)	5/53 (9%)	0/53 (0%)	
C3/4	PAIN	41/54 (76%)	10/54 (18%)	13/54 (6%)	0.77
	NO PAIN	37/53 (70%)	12/53 (23%)	4/53 (7%)	
C4/5	PAIN	35/54 (65%)	14/54 (26%)	5/54 (9%)	0.82
	NO PAIN	37/53 (70%)	11/53 (21%)	5/53 (9%)	
C5/6	PAIN	38/54 (70%)	13/54 (24%)	3/54 (6%)	0.89
	NO PAIN	37/53 (70%)	14/53 (26%)	2/53 (4%)	
C6/7	PAIN	43/54 (86%)	7/54 (14%)	0/54 (0%)	0.68
	NO PAIN	47/53 (89%)	6/53 (11%)	0/53 (0%)	
C2–C7 whole curve	PAIN	48/50 (96%)	2/50 (4%)	0/50 (0%)	0.45
	NO PAIN	48/53 (91%)	4/53 (7%)	1/53 (2%)	

Discussion

The methods described in the literature for the radiographic assessment of spinal curvature vary widely. There is general agreement that a lordotic curvature represents the “normal” or “ideal” situation for the cervical spine [22], but there is only vague information regarding the exact values and the recommended methods of measurement. In general, normal values have been reported to range from 20° to 35° for C2 to C7 [6, 17, 19, 30, 40] (see Table 4), but these appear to be highly dependent on the method of measurement used. Many studies in the literature report only a subjective classification, “kyphotic, straight or lordotic,” but this method of assessment has proven to be

unreliable [28]. As such, we developed a new standard for assessment in the present study. We chose a tolerance of ±4° to accept as possible measurement error with 95% confidence intervals [14, 42], i.e. as the “minimal detectable change” [4], and hence defined “straight” for the global curvature as +4° to -4°, and lordotic and kyphotic as <-4° and >+4°, respectively.

In most previous studies, the positioning of the volunteer during the radiograph has not been mentioned when interpreting the results. However, it is well known that factors such as the tilt of the pelvis, the adoption of a sitting or standing position, the shape of the backrest when sitting, and the head position can all influence the sagittal curve of the cervical spine [12, 28, 30, 33, 35, 45, 50]. We found that the angle between the

Table 4 The lordosis angles and incidence of straight or kyphotic curves in the various populations examined in the literature

Study	No. of people	Symptoms	Age	Method	Cervical spine curvature(negative values indicate lordotic curvatures)	% Straight	% Kyphotic
Gore et al. [17]	200	No	20–65	C2–C7 (pT)	-23° (±21°) (higher in older women)		9
Gore et al. [18]	205	Yes	43 (±12)	C2–C7 (pT)	-24° (±14°)		6.3
Harrison et al. [25]	250	No	35	C2–C7 (pT)	-34° (-16.5 to -66°)		35
Nojiri et al. [40]	313	No	11–77	C2–C7 (pT)	-16.2° (±12.9°); -10.5° (±10.3°)		
Owens and Hoiriis [41]	113	Yes and no (no influence of trauma/cervical complaint)	28.8	C2–C7 (pT)	-22.3° (±11.5°)		
Wiegand et al. [51]	186	Yes	38 (±13)	C2–C7 (pT)	-18.9 ± 12.3°		
Plaughner et al. [44]	48	Yes	44	C2–C7 (Cobb)	-6.1 ± 11.4° (-53 to +17°)		
Takeshima et al. [46]	48	Yes	33	C2–C7 (Cobb)	-17.5 ± 7.0°		
Borden et al. [6]	180	No	21–80	C2–C7 (Kt)	90%	7.2	2
Juhl et al. [30]	116	No	10–65	Aspect	60%	19	21
Hald et al. [19]	10,922	No	17–25	Aspect	-	7.4	3.3

N.B. the methodology is not always consistent across studies

pT posterior tangent method, Cobb Cobb method, Kt depth of curvature, Aspect categorisation in relation to the aspect

horizontal line and the ear–eye line was easy to identify and lay mostly between 15° and 20° when the subject was encouraged to stand comfortably and fixate on a point at eye level. Hence, we defined and standardised this angle for all the tests at 20° . In most individuals, little adjustment from their natural position was required to achieve this 20° position. It is conceivable that certain deformities may have been masked and yet others may have been accentuated by constraining the head position this way; however, especially as it was close to the natural position for most individuals, it was considered that the benefits of standardisation would outweigh any possible disadvantages in this respect.

The results of our study showed no association between the sagittal alignment of the cervical spine (or its individual segments) and the presence of neck pain. Similarly, in the group with neck pain, there was no relationship between curvature and any index of symptom severity, such as pain intensity, disability, healthcare utilisation, etc. To the best of our knowledge, this is the first study to explicitly examine these relationships in detail, although the findings concur with those of a literature review that found little evidence to suggest that altered cervical curvatures are of prognostic or diagnostic significance [15]. In contrast, one recently published retrospective study found that the degree of lordosis as measured with the posterior tangent technique was able to distinguish, with moderate diagnostic accuracy, between individuals with and without chronic neck pain (sensitivity 0.46, specificity 0.97), and between those with and without acute neck pain (sensitivity 0.67, specificity 0.61) [27]. In the latter study, individuals who did not have a normal lordotic curve (i.e. any with a straight or kyphotic curve) were excluded; however, even excluding such patients from our data (see second row in Table 2), we still observed no significant difference between the PAIN and NO PAIN groups. The comparison study of Harrison et al. [27] was retrospective, and the control radiographic data were collected a good 10 years earlier (1988–1992) than those of the patients (collected 1997–2003). It was not stated whether identical methods were used in each case, and, in particular, whether positioning of the volunteer during imaging was carried out using standardised procedures (see discussion above, regarding the potential consequences of this). Interestingly, the mean curvatures for their control group (34.5°) were considerably higher than those previously reported for asymptomatic individuals in the literature (see Table 4), whereas their patients' mean values (22.0° and 28.6° , for chronic and acute, respectively) were comparable to those reported for “normals” in other studies and for both groups in the present study.

Overall, our findings for the cervical spine appear to mirror the majority of those reported for the lumbar spine: whilst there is some suggestion that individuals with a flatter spine (reduced lordosis) have a slightly higher risk of developing low back pain [1], the vast majority of cross-sectional studies conclude that there is no significant difference in the degree of lordosis in people with and without back pain [20, 36, 39].

The lordotic shape is accepted as the “physiological” form [22], but the tolerance of the system is not well known and the point where a kyphotic deformity might start to cause problems remains unclear. This should be kept in mind when surgical procedures are planned. Some studies have highlighted the negative consequences of kyphotic cervical configurations after surgery, in terms of axial pain [32] or accelerated adjacent segment degeneration [31]. However, this may simply reflect the introduction of sudden change in a previously “balanced” profile. The fact that groups of individuals with and without neck pain do not show differences in their degree of lordosis at a global or segmental level does not mean that, for *any given individual*, a sudden alteration of his/her spinal curvature would not be detrimental. Hence, the risk and benefit of not only removing the pain source but also restoring “normal” alignment (i.e. normal for that individual) should be weighed-up carefully.

Certain limitations of the present study are worthy of mention. For ethical reasons, it was not possible to investigate the sagittal profile of the whole spine and, hence, any influence of the curvature of the lower spinal regions, a possible determinant of cervical spine curvature [6], remains uncertain. Another drawback was the initial selection of the volunteers. As they were patients from the lower extremities outpatient clinic, they likely represented a specific selection rather than a random sample of the normal population. None of them were specifically seeking treatment for neck pain in the hospital, and the study group was therefore considered to represent two comparable groups of patients with other musculoskeletal problems, differing in their history of “non-specific” neck pain. The symptoms in the PAIN group were generally of a mild to moderate, mostly chronic nature. It is possible that, had we taken patients who were actually seeking treatment for neck pain, and compared these with a completely asymptomatic group, we may have seen differences between the groups. Nonetheless, the fact that absolutely no relationships were observed between symptom severity—measured with a multidimensional array of items—and cervical spine curvature, tends to challenge this notion.

Group membership was decided on the basis of neck pain experienced in the preceding 12 months. In the age-group studied, it was considered that enquiring about “lifetime neck pain” may lead to recall bias [10, 38], and data on “current pain” may obscure any relationships with structural changes, a longer-term cumulative phenomenon. Hence, a period of 12 months was chosen as a compromise between the two. This has been shown to be a relevant time-span in previous studies concerning the clinical significance of structural abnormalities of the spine (e.g. [48]). In view of the recurrent and persistent nature of common neck pain [9], it can be assumed that if someone >45 years old is typically a “neck pain sufferer,” they will have experienced at least one episode in the last year; however we cannot rule out the possibility that some patients with no pain in the last 12 months were, indeed, at one-time, neck pain sufferers. In future studies, it may be of interest to enquire about lifetime pain experience and also pain on the day of the examination in relation to these deformities.

A further consideration in any study with “negative results” is the possibility that a type II error occurred, i.e. the study failed to identify “real” differences between the groups due to small group sizes and inadequate power. However, this seems an unlikely explanation of the current results, since with approximately 50 in each group there was sufficient power (85%) to detect a “clinically relevant” difference, i.e. with a moderate effect size (0.55), had one existed [3]. The only exception may have been for some of the secondary sub-group analyses of men and women separately, for which the group sizes were clearly smaller. Finally, with regards to the statistical analysis, we cannot rule out the possibility that the odd significant differences between the PAIN and NO PAIN groups (e.g. for men only, in relation to the segmental curvature at C2/3 and C6/7), may have represented spurious findings on account of the multiple testing carried out; this always increases the chances of committing a type I error. Although it is possible to correct for this with, for example, Bonferroni adjustments, there are equally good arguments to suggest that such corrections are not only unnecessary, but also inappropriate [43]. We hence chose not to make such corrections but, instead, to weigh up the likely biological plausibility of the incidental findings; in doing so, we found no convincing interpretation to indicate that our main conclusions did not hold—namely, that there was no significant association between deviations from the normal cervical spine lordosis and the presence, frequency or intensity of neck pain.

In conclusion, we suggest that when so-called “abnormalities” of the sagittal profile are observed in the older patient with neck pain they must be considered coincidental, i.e. not necessarily indicative of the cause of pain. This should be given due consideration in the differential diagnosis of patients with non-specific neck pain.

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