Characteristics affecting cervical sagittal alignment in patients with chronic low back pain

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Hideyuki Arima[1)], Yu Yamato[1)], Kimihito Sato[2)], Yoshihiro Uchida[3)], Toshiyuki Tsuruta [4)], Kanehisa Hashiguchi[5)], Hajime Hamamoto[6)], Eiichiro Watanabe[7)], Kaoru Yamanaka[8)], Tomohiko Hasegawa[1)], Go Yoshida[1)], Tatsuya Yasuda[1)], Tomohiro Banno[1)], Shin Oe[1)], Hiroki Ushirozako[1)], Tomohiro Yamada[1)] Koichiro Ide[1)], Yuh Watanabe[1)] Yukihiro Matsuyama[1)]

[1]*Department of Orthopaedic Surgery, Hamamatsu University School of Medicine, 1-20-1 Handayama, Higashi-Ku, Hamamatsu, Shizuoka, 431-3192 Japan*

[2] *Sato Orthopedic Clinic*

[3] *Seisen Clinic*

[4] *Tsuruta Orthopedic Clinic*

[5] *Hashiguchi Orthopedic Clinic*

[6] *Hamamoto Orthopedic Clinic*

[7] *Fuji Orthopedic Hospital*

[8] *Yamanaka Orthopedic Clinic*

Corresponding author: Hideyuki Arima, M.D., Ph.D.

1-20-1, Handayama, Higashi-ku, Hamamatsu-city, Shizuoka JAPAN 431-3192

TEL: (+81)-53-435-2299, FAX: (+81)-53-435-2296

E-mail address: arihidee@gmail.com

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AUTHOR ROLE

	Conception	Design	Acquisition of Data	Analysis of data	Interpretation of data	Drafting the manuscript	Revising it critically	Final Approval of the manuscript
Hideyuki Arima	○	○	○	○	○	○	○	○
Yu Yamato	○	○	○	○	○		○	○
Kimihito Sato			○	○	○			○
Yoshihiro Uchida			○	○	○			○
Toshiyuki Tsuruta			○	○	○			○
Kanehisa Hashiguchi			○	○	○			○
Hajime Hamamoto			○	○	○			○
Eiichiro Watanabe			○	○	○			○
Kaoru Yamanaka			○	○	○			○
Tomohiko Hasegawa			○	○	○		○	○
Go Yoshida			○	○	○		○	○
Tatsuya Yasuda			○	○	○		○	○
Tomohiro Banno			○	○	○		○	○
Shin Oe			○	○	○		○	○
Hiroki Ushirozako			○	○	○			○
Tomohiro Yamada			○	○	○			○
Koichiro Ide			○	○	○			○
Yuh Watanabe			○	○	○			○
Yukihiro Matsuyama	○		○	○	○		○	○

Structured abstract

Background. Sagittal spino-pelvic malalignment in patients with chronic low back pain (CLBP) have been reported in the past, which may also affect cervical spine lesions. The purpose of this study is to investigate the cervical alignment in patients with CLBP

Method. Of the patients who visited an orthopedic specialist due to low back pain lasting more than three months, 121 cases (average 71.5 years old, 46 male and 75 female) with whole standing spinal screening radiographs were reviewed (CLBP group). Cervical parameters included cervical lordosis (CL), C2-C7 sagittal vertical axis (C2-7 SVA), and the T1 slope minus CL (T1S-CL). Cervical spine deformity was defined as C2-7 SVA > 4 cm, CL < 0°, or T1S-CL ≧20°. We compared the cervical alignment of these patients with 121 age and gender matched volunteers (control group).

Results. The prevalence of cervical spine deformity was significantly higher in the CLBP group than in the control group (20.7% vs. 10.7%, P = 0.034). The mean CL was smaller in the CLBP group than in the control group (16.1° vs. 21.4°, P = 0.002). The mean C2-7 SVA was 17.6 mm vs. 18.7 mm in the CLBP group and in the control group, respectively (P = 0.817). The mean T1S -CL was larger in the CLBP group than in the control group (9.1° vs. 3.5°, P < 0.001). Multivariate analysis showed that people with CLBP were more likely to have cervical deformities than people without CLBP (odds ratio 2.16, 95% confidence interval 1.006 to 4.637).

Conclusions. This study results suggest that people with CLBP present with worse cervical sagittal alignment and higher prevalence of cervical spine deformities than age and gender matched volunteers with no CLBP. This means CLBP impacts cervical spine lesions negatively.

Level of Evidence :IV

Introduction

Based on the results of a large-scale survey, approximately 20% of Japanese people complain of low back pain.[1] Chronic low back pain (CLBP) is a chronic pain syndrome in the lumbar region lasting for more than three months.[2] CLBP reduces health-related quality of life (QOL) and leads to financial loss.[3] Therefore, like in other Western countries, CLBP is a socioeconomically important issue in Japan.[3, 4] The cause of CLBP is multifactorial[5], and understanding the pathophysiology of CLBP is considered useful because it leads to its treatment.[5, 6] In recent years, the importance of sagittal spino-pelvic alignment in standing position has been recognized, and spinal sagittal alignment research has been widely conducted.[7-11] Previous cohort studies have reported that lumbar lordosis decreases with age, and that sagittal alignment shifts forward as well.[9, 10] In addition to this, forward shifts in sagittal alignment are associated with poorer health-related QOL.[9, 12] In the study of CLBP, it has been reported that patients with CLBP have a decrease in lumbar lordosis (LL) and pelvic retroversion.[6, 13, 14] On the other hand, there are also reports that LL increases with CLBP[15]. With these results, the association between spino-pelvic sagittal alignment and CLBP is not yet fully understood. The decrease of LL is not only due to the structural changes secondary to degeneration, but is also due to postural control to reduce pain.[6] Sagittal malalignment may also be involved in the alignment of the thoracic and cervical spinal lesions. With regard to the thoracic spine, CLBP has been reported to decrease thoracic kyphosis.[6] However, its impact on cervical alignment and neck pain in chronic low back pain is not well understood. It has also been reported that the cervical spine is involved in the cause of low back pain in some cases. [16, 17] The purpose of this study is to investigate the sagittal plane alignment of the cervical spine and the incidence of neck pain in patients with CLBP.

Material and Methods

Participants

After obtaining institutional review board approval for the research, we obtained written informed consent from the participants to publish the data. We compared prospective CLBP cohorts with age and gender matched elderly screened data. Among the patients who visited ten orthopedic clinics for low back pain lasting more than three months from September 2015 to August 2016, 127 people agreed to participate in this study and were surveyed. Patients with neuromuscular disease, spine infections, and spine tumors were excluded. Radiographic parameters obtained from radiographic examinations with poor quality were very difficult to measure and inaccurate; hence, another six patients were also excluded. Patients with anatomical variations of four or six lumbar vertebrae were also excluded because these factors are significantly related with the variation in radiographic parameters. In the control group, we randomly extracted and surveyed the musculoskeletal examination of 121 participants out of the 316 age and gender matched participants from Toei town, Aichi prefecture, Japan in 2016.

Radiographic Measurements

In order to evaluate spinal and pelvic alignment, full-length antero-posterior and lateral spine radiographs were taken standing upright. Radiographic films were obtained with a 1.5-m distance between the X-ray tube and the radiograph for all participants. The standing posture was standardized; participants were asked to relax their heads while looking straight ahead without pulling in the chin and to place their hands on their clavicles. [18] The spino-pelvic parameters (thoracic kyphosis [TK; T5 - T12], lumbar lordosis [LL; L1- S1], pelvic tilt [PT], sacral slope [SS], pelvic incidence [PI], sagittal vertical axis [SVA], T1 slope [T1S, the angle between the horizontal plane and T1 superior endplate], cervical lordosis [CL], the Cobb angle between the C2 inferior endplate and C7 inferior endplate], C2–C7 SVA (the distance between a plumb line from the center of the C2 vertebral body and posterior superior corner of C7), and T1S minus CL were measured using standard techniques[10, 18]. The intra-and inter-observer reliabilities were previously examined using the intraclass correlation coefficient (ICC) for the SVA, PT, and PI in this cohort. Additionally, the intra-observer ICCs for SVA, PT, and PI were 0.995, 0.996, and 0.918, respectively, and the inter-observer ICCs were 0.996, 0.990, and 0.966, respectively.[9]

<u>Lumbar Spine Deformity and Cervical Spine Deformity</u>

<u>Lumbar spine deformity was defined as one of the following: PI minus LL mismatch at 10 degree or more, SVA at 40 mm or more, or PT at 20 degrees or more according to Scoliosis research society-Schwab adult spinal deformity classification.[19]</u> Cervical spine deformity was defined as one of the following: CL less than 0 degree, C2-7 SVA more than 40 mm, or T1 slope minus CL at 20 degrees or more.[10, 20] We conducted health-related QOL questionnaires [Oswestry Disability Index (ODI)[21] and EuroQol 5 dimension (EQ-5D)][22] and questionnaires about neck pain.

Data Analysis

We compared the radiographic parameters, prevalence of lumbar and cervical spine deformity, and prevalence of neck pain in the CLBP and control groups. We investigated the relationship between lumbar spine deformity and cervical spine deformity in the CLBP group. Prevalence of cervical spine deformity in group with and without neck pain was also compared in the CLBP and control groups to investigate the relationship between cervical spine deformity and neck pain. Next, the radiographic parameters and the prevalence of cervical deformity and neck pain were compared among the males and females from the 121 patients with CLBP.

Statistical Analysis

All values were expressed as mean ± standard deviations (SD). The normal distribution of the data was demonstrated the Shapiro-Wilk test. Differences between groups were evaluated using the unpaired two-sample t-test or Mann-Whitney test. Chi-square/Fisher exact test was used to test for significant differences in categorical study parameters between both groups. Binomial logistic regression analysis was used to assess the predictors of the presence of cervical spine deformity with age, sex, presence of CLBP, and LL as independent variables. A p value of < 0.05 was considered statistically significant. Statistical analyses were performed using IBM SPSS statics software (version 25.0; IBM, Chicago, IL, USA).

Results

Cervical alignment (CLBP vs. control)

CL was 16.1 ± 12.4 vs. 21.4 ± 14.1 (P = 0.002) in the CLBP and control groups, respectively, and CL was significantly smaller in the CLBP group (Table 1). C2-7 SVA was 17.6 ± 17.0 vs. 18.7 ± 53.6 (P = 0.817), T1S minus CL was 9.1 ± 9.3 vs. 3.5 ± 12.6 (P <0.001), respectively. T1S minus CL was significantly larger in the CLBP group.

TK was 25.4 ± 11.4 vs. 29.2 ± 12.2 (P = 0.011) in the CLBP and in the control group, respectively, and TK was significantly smaller in the CLBP group (Table 1). LL was 37.4 ± 16.4 vs. 42.5 ± 16.8 (P = 0.019); it was significantly smaller in the CLBP group. SS was 27.6 ± 10.5 vs. 29.0 ± 10.5 (P = 0.304), and PI was 47.8 ± 10.4 vs. 50.5 ± 10.5 (P = 0.043); PI was significantly lower in the CLBP group. PT was 20.4 ± 11.3 vs. 21.5 ± 9.6 (P = 0.392). SVA was 35.1 ± 46.7 vs. 10.3 ± 48.0 (P <0.001), and SVA was significantly larger in the CLBP group.

Prevalence of lumbar and cervical spine deformities, and prevalence of neck pain (CLBP vs. control)

The prevalence of lumbar spine deformity was not significantly different between the CLBP group and the control group (62.8% vs. 63.6%, P = 0.894) (Table2). The prevalence of cervical spine deformity was significantly higher in the CLBP group, with 20.7% vs. 10.7% (P = 0.034) in the CLBP group and in the control group, respectively. There was no significant difference between the CLBP group and the control group with regards to neck pain (31.4% vs. 24.0%, P=0.198). There was no statistically significant difference in the prevalence of cervical spine deformity with or without lumbar spine deformity in the CLBP group. (21.1% vs. 20.0%, P = 0.894)

Health related QOL

The EQ-5D was 0.73 ± 0.14 vs. 0.83 ± 0.17 (P <0.001) in the CLBP group and in the control group, respectively; it was significantly lower in the CLBP group (Table2).

ODI was 22.8 ± 11.8 vs. 12.5 ± 12.7 (P <0.001), and it was significantly higher in the CLBP group (Table2).

Prevalence of cervical spine deformities in the group with and without neck pain

In group with neck pain, there was no significant difference between the CLBP group and the control group with regards to prevalence of cervical spine deformity (13.2% vs. 10.3%, P=0.725). In group without neck pain, the prevalence of cervical spine deformity was significantly higher in the CLBP group than in the control group, with 24.1% vs. 10.9% (P = 0.027) (Table3). There was no significant difference between the group with and without neck pain with regards to prevalence of cervical spine deformity in both the CLBP and control group (Table3).

Differences of the spino- pelvic parameters among the males and females in the CLBP group

For the 46 males, the average age was 72.8 ± 10.1 years, and for the 75 females, it was 70.7 ± 9.2. CL was 17.6 ± 13.0 vs. 15.1 ± 12.0 for the males and females, respectively (P = 0.300), and C2-7 SVA was 24.8 ± 18.7 vs. 13.1 ± 14.7 (P <0.001) (Table 4). C2-7 SVA was shifted forward significantly in the males. The T1S minus CL was 11.3 ± 8.4 vs. 7.7 ± 9.6 (P = 0.033) and was significantly higher in the males. For the other spino-pelvic parameters for the males and females, TK was 27.6 ± 10.5 vs. 24.2 ± 11.8 (P =

0.093), LL was 37.5 ± 17.2 vs. 37.4 ± 16.0 (P = 0.978), SS was 26.6 ± 11.6 vs. 28.3 ± 9.7 (P = 0.391), PI was 44.2 ± 10.6 vs. 50.0 ± 9.7 (P = 0.003), PT was 18.1 ± 12.7 vs. 21.8 ± 10.2 (P = 0.084), and SVA was 28.9 ± 37.3 vs. 38.9 ± 51.5 (P = 0.255), respectively. Only PI was significantly lower in the males, but there were no statistically significant differences in the other spino-pelvic parameters.

Differences in the prevalence of cervical spine deformity and neck pain among the males and females in the CLBP group

The prevalence of cervical spine deformity was 34.8% and 12.0% for the males and females (P = 0.003), respectively, and it was significantly higher in the males (Table 5). The prevalence of neck pain was 19.6% vs. 38.7% (P = 0.028), and was significantly higher in the females.

Multivariate analysis

We performed multivariate analysis by adjusting potential confounders such as age, gender, and lumbar lordosis to evaluate whether the cervical spine deformity involved CLBP. It showed that people with CLBP were more likely to have cervical spine deformities than people without CLBP. (odds ratio 2.16, 95% confidence interval 1.006 to 4.637) (Table 6)

Representative cases

Cases 1 and 2 (Male)

The lateral view of whole-spine standing radiograph and the enlarged lateral view of cervical spine of a 67-year-old male in the CLBP group (Case 1, Figure 1) and a 67-year-old male in the Control group (Case 2, Figure 2) were obtained and compared.

The radiographic parameters in Case 1 were 8 for CL, -1 for C2-7 SVA 19 for T1S minus CL, 35 for TK, 38 for LL, 27 for SS, 44 for PI, 17 for PT, and 48 for SVA. He had no neck pain, and his ODI score was 31. The radiographic parameters in Case 2 were 25 for CL, -1 for C2-7SVA, -2 for T1S minus Cl, 21 for TK, 42 for LL, 30 for SS, 38 for PI, 8 for PT, and -5 for SVA. He had no neck pain, and his ODI was 3. The CL was decreased, and C2-7 SVA was shifted anteriorly in the patient with CLBP.

Cases 3 and 4 (Female)

The lateral view of whole-spine standing radiograph and the enlarged lateral view of cervical spine of a 64-year-old female in the CLBP group (Case 3, Figure 3) and a 63-year-old female in the Control group (Case 4, Figure 4) were obtained and compared.

The radiographic parameters in Case 3 were 7 for CL, 22 for C2-7 SVA, 21 for T1S minus CL, 24 for TK, 39 for LL, 28 for SS, 54 for PI, 26 for PT, and 39 for SVA. She had no neck pain, and her ODI score was 20. The radiographic parameters in Case 4 were 9 for CL, 8 for C2-7SVA, 6 for T1S minus Cl, 18 for TK, 41 for LL, 27 for SS, 41 for PI, 14 for PT, and -35 for SVA. She had no neck pain, and her ODI was 7. The T1S minus CL was large, and C2-7 SVA was shifted anteriorly in the patient with CLBP.

DISCUSSION

In this study, we examined the cervical alignment and the presence or absence of neck pain between patients with CLBP and age- and gender-matched volunteer cohorts. For cervical spine alignment, CL in the CLBP group showed an average decrease of 5.3 degrees as compared to the control group, and T1S minus CL mismatch was also increased on average by 5.6 degrees, suggesting that sagittal cervical malalignment may be related in patients with CLBP. CLBP was an independent risk factor for cervical spine deformity, even after adjusting for potential confounders such as age, gender, and LL. Since this has not yet been reported in the past, this study is the first report on CLBP and cervical spine deformity. It is thought that the changes in lumbar spine alignment affect cervical spine alignment. Interestingly, however, there was no statistically significant relationship between the incidence of lumbar deformity and cervical deformity in the CLBP group in this study.

Next, the prevalence of neck pain was higher in the CLBP group, but there was no statistically significant difference. This may be related to the small sample size used in this study. There is no statistically significant relationship between neck pain and cervical spine deformity, and it may be difficult to explain neck pain by alignment alone. Generally, the decrease of CL worsens with age,[10] and malalignment of the cervical spine is associated with deterioration of the Neck Disability Index.[23] With regards to sex differences, it has been reported that the deterioration of the sagittal spinal alignment results from the malalignment of the cervical spine in males.[10] This study revealed that cervical alignment was poor in the males in the CLBP group as well. Interestingly, the incidence of neck pain was higher in the females. It is considered that neck pain results not only from cervical alignment, but also from gender, occupation, weight, sarcopenia, mental health, and sports activities.[24-26] EQ-5D, a general instrument for measurement of health related QOL[27], was worse in the CLBP group; this was expected because it was thought to be associated with lower back pain disorder.[28, 29]

On average, TK was decreased by 3.8 degrees, and LL was decreased by 5.1 degrees. On the other hand, PT was not significantly different between the CLBP and control groups. Previous reports have also shown that LL decreases and PT increases in patients with CLBP[13, 14, 30]. Similar to the previous study, this study showed that LL decreased[30], but there was no significant difference in PT. PI was lower by 2.7 degrees in the CLBP group. This result is also similar to a previous report[6], and it is possible that a small PI may be related to CLBP. Considering the above results, the decrease in LL was larger than the decrease in PI, which was attributed to the decrease of thoracic kyphosis. In addition to this, SVA was shifted forward in the CLBP group, because compensation may still not be enough. Generally, the subject who has the forward-shifted sagittal global alignment has hyper cervical lordosis to maintain horizontal gaze.[31] However, in patients with CLBP, the compensation may not be sufficient, and the cervical spine may also be kyphotic. In summary, compared with the control group, the CLBP group had decreased cervical lordosis, thoracic kyphosis, and lumbar lordosis, with a near flat-back posture (Figure 5a, 5b). However, there is no significant relationship between the incidence of lumbar spine deformity and cervical spine deformity in the CLBP group, it is necessary to perform longitudinal research and to verify this issue in the future.

There are several limitations in this study. First, this study is cross-sectional. Second, this study did not take into consideration BMI or the presence of sarcopenia. Third, work or sports activities were not examined. Fourth, we could not identify the cause of CLBP. CLBP may or may not have neurological symptoms. But we couldn't completely stratify it. These may also affect cervical alignment and clinical symptoms in the neck. Despite these limitations, the characteristics of cervical spine alignment in patients with CLBP identified in this study may be important points in understanding the pathophysiology of CLBP, and we believe that the results of this study are significant.

CONCLUSION

This study results suggest that patients with CLBP present with worse cervical sagittal alignment and higher prevalence of cervical spine deformities than age and gender matched volunteers. This means that CLBP impacts on cervical spine lesions negatively.

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Figure caption

Figure 1

Case 1. The lateral view of whole-spine standing radiograph (a) and the enlarged lateral view of cervical spine (b) of a 67-year-old male in the CLBP group.

Figure 2

Case 2. The lateral view of whole-spine standing radiograph (a) and the enlarged lateral view of cervical spine (b) of a 67-year-old male in the control group.

Figure 3

Case 3. The lateral view of whole-spine standing radiograph (a) and the enlarged lateral view of cervical spine (b) of a 64-year-old female in the CLBP group.

Figure 4

Case 4. The lateral view of whole-spine standing radiograph (a) and the enlarged lateral view of cervical spine (b) of a 63-year-old female in the control group.

Figure 5

Illustration of CLBP group(a):Compared with the control group, the cervical lordosis, thoracic kyphosis, and lumbar lordosis of CLBP group are decreased, and their posture shows close to flat-back. Illustration of control group(b)

Figure 1

Figure 2

Figure 3

Figure 4

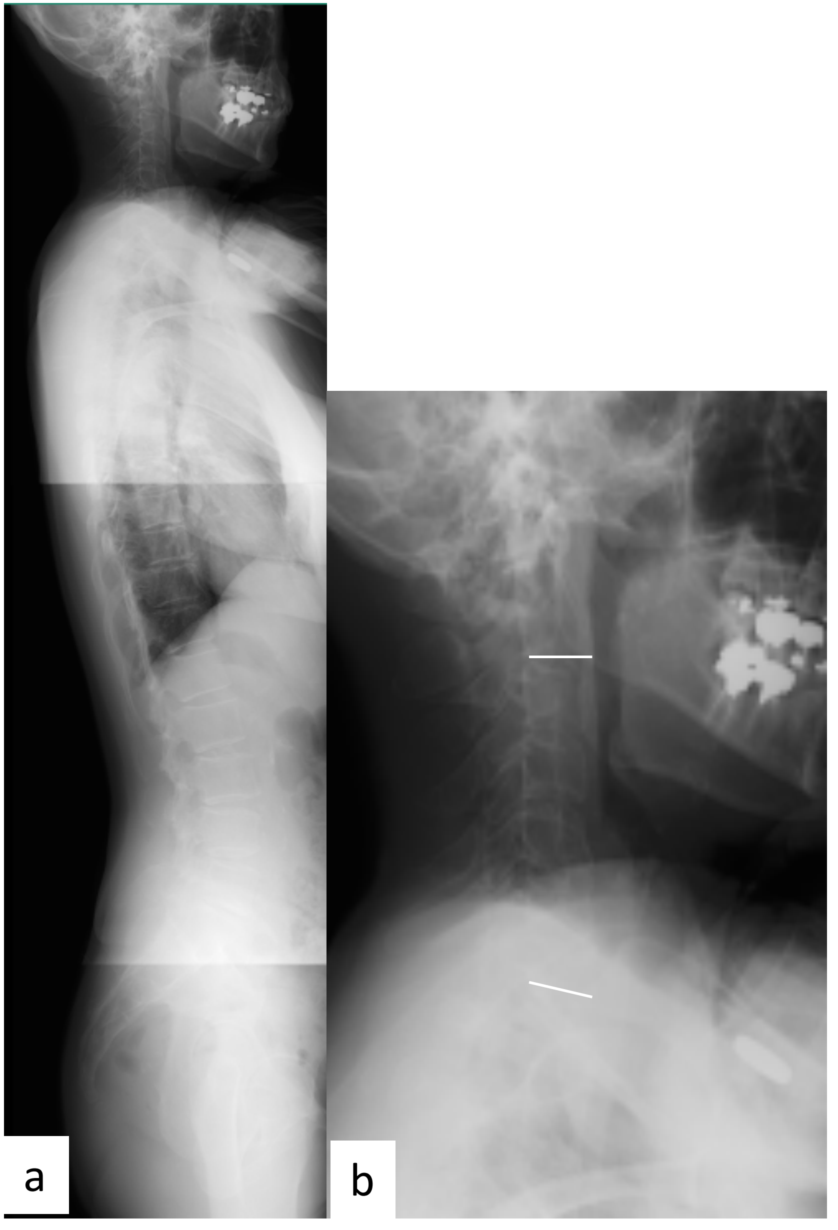
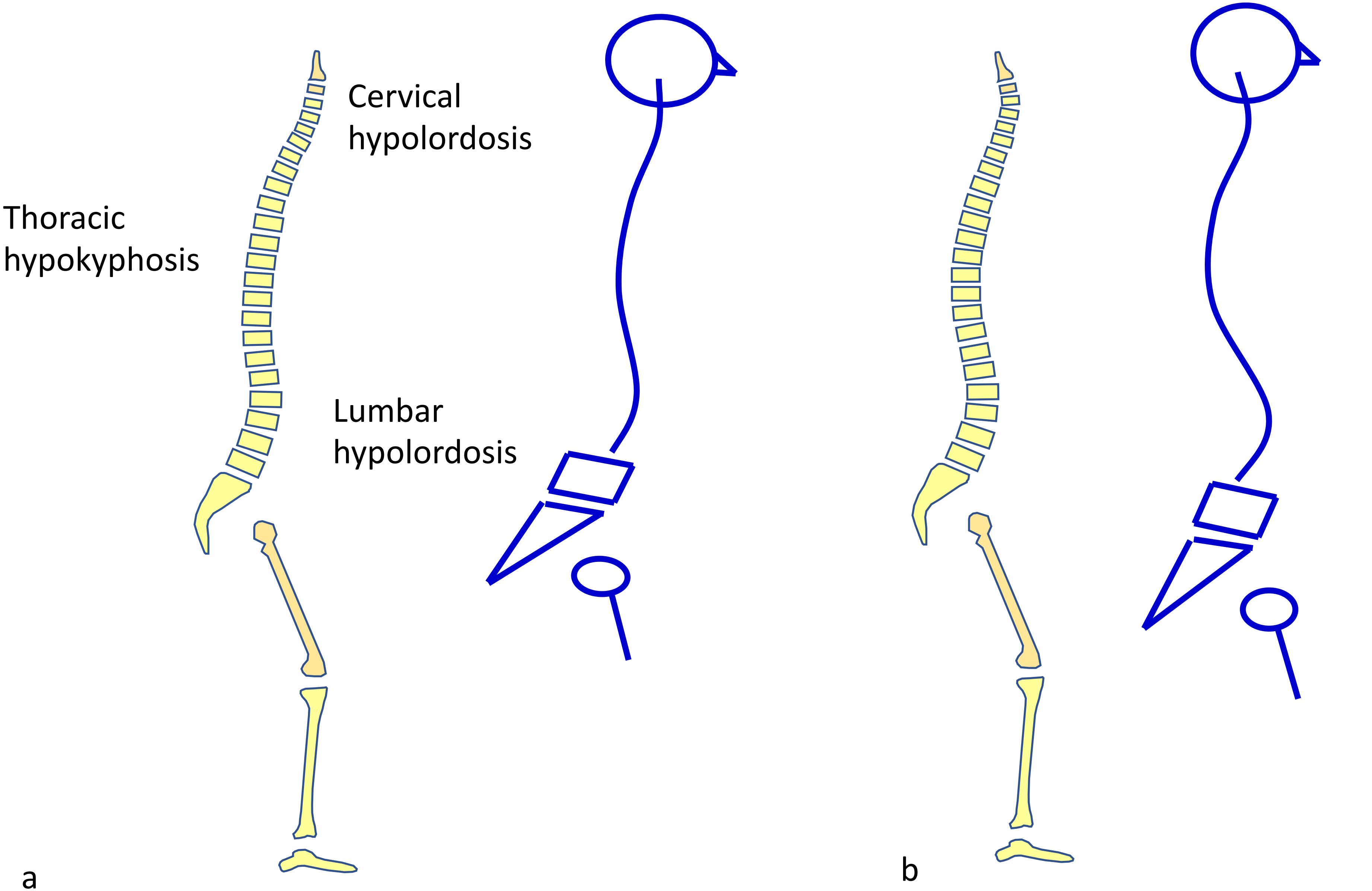


Figure 5



Cervical
hypolordosis
Thoracic
hypokyphosis
Lumbar
hypolordosis
a
b

Table 1 Spino-pelvic parameters in CLBP group and control group

	CLBP	Control	P value†
CL (°)	16.1 ± 12.4	21.4 ± 14.1	**0.002**
C2-7SVA	17.6 ± 17.0	18.7 ± 53.6	0.817
T1S-CL(°)	9.1 ± 9.3	3.5 ± 12.6	**< 0.001**
TK(°)	25.4 ± 11.4	29.2 ± 12.2	**0.011**
LL(°)	37.4 ± 16.4	42.5 ± 16.8	**0.019**
SS(°)	27.6 ± 10.5	29.0 ± 10.5	0.304
PI(°)	47.8 ± 10.4	50.5 ± 10.5	**0.043**
PT(°)	20.4 ± 11.3	21.5 ± 9.6	0.392
SVA (mm)	35.1 ± 46.7	10.3 ± 48.0	**<0.001**

± means standard deviation; C2-7 SVA, C2-C7 sagittal vertical axis; CL, cervical lordosis; CLBP, chronic low back pain; LL, lumbar lordosis; PI, pelvic incidence; PT, pelvic tilt; SS, sacral slope; SVA, sagittal vertical Axis; T1S, T1 slope; TK, Thoracic kyphosis * Bold type indicates statistical significance. †Comparison between two groups.

Table 2 Prevalence of cervical spine deformity and health related QOL in CLBP group and control group

	CLBP	Control	P value
Lumbar spine deformity	62.8%	63.6%	0.894
Cervical spine deformity	20.7%	10.7%	**0.034**
Neck Pain	31.4%	24.0%	0.198
EQ-5D	0.73 ± 0.14	0.83 ± 0.17	< **0.001**
ODI	22.8 ± 11.7	12.5 ± 12.7	< **0.001**

± means standard deviation; CLBP, chronic low back pain; ODI, Oswestry Disability Index * Bold type indicates statistical significance. †Comparison between two groups.

Table 3 Prevalence of cervical spine deformity in the group with and without neck pain

	CLBP	Control	P value†
Neck Pain (+) (N=67)			
Prevalence of cervical spine deformity	13.2%	10.3%	0.725
Neck Pain (-) (N=175)			
Prevalence of cervical spine deformity	24.1%	10.9%	**0.027**
P value††	0.168	0.937	

CLBP, chronic low back pain; * Bold type indicates statistical significance.

†Comparison between CLBP and control. ††Comparison between the group with and without neck pain

Table 4 Differences of the spino- pelvic parameters among the males and females in the CLBP group

	Male	Female	P value
CL (°)	17.6 ± 13.0	15.1 ± 12.0	0.300
C2-7SVA	24.8 ± 18.7	13.1 ± 14.7	**< 0.001**
T1S-CL(°)	11.3 ± 8.4	7.7 ± 9.6	**0.033**
TK(°)	27.6 ± 10.5	24.2 ± 11.8	0.093
LL(°)	37.5 ± 17.2	37.4 ± 16.0	0.978
SS(°)	26.6 ± 11.6	28.3 ± 9.7	0.391
PI(°)	44.2 ± 10.6	50.0 ± 9.7	**0.003**
PT(°)	18.1 ± 12.7	21.8 ± 10.2	0.084
SVA (mm)	28.9 ± 37.3	38.9 ± 51.5	0.255

± means standard deviation; C2-7 SVA, C2-C7 sagittal vertical axis; CL, cervical lordosis; CLBP, chronic low back pain; LL, lumbar lordosis; PI, pelvic incidence; PT, pelvic tilt; SS, sacral slope; SVA, sagittal vertical Axis; T1S, T1 slope; TK, Thoracic kyphosis * Bold type indicates statistical significance. †Comparison between two groups.

Table 5 Differences in the prevalence of cervical spine deformity and neck pain among the males and females in the CLBP group

	Male	Female	P value
Cervical spine deformity	34.8%	12.0%	**0.003**
Neck Pain	19.6%	38.7%	**0.028**
EQ-5D	0.70 ± 0.14	0.75 ± 0.15	0.110
ODI	23.0 ± 12.4	22.7 ± 11.5	0.866

± means standard deviation; CLBP, chronic low back pain; ODI, Oswestry Disability Index * Bold type indicates statistical significance. †Comparison between two groups.

Table 6. Results, multiple regression analysis, predictors of cervical spine deformity

Independent variable	Coefficient	P value	Odd ratio	95 % CI
Age (years)	0.019	0.366	1.019	0.978 to 1.062
Sex	-1.559	**<0.001**	0.210	0.098 to 0.449
CLBP	0.770	**0.048**	2.160	1.006 to 4.637
LL	-0.007	0.560	0.993	0.971 to 1.016

Values in boldface indicate statistical significance.
CLBP, chronic low back pain; LL, lumbar lordosis; PI, pelvic incidence; PT, pelvic tilt; SS, sacral slope; SVA, sagittal vertical Axis; 95 % CI, 95 % confidence interval
A positive value for sex indicates that females were less likely have cervical deformity than males.
A positive value for CLBP indicates that people with CLBP were more likely to have cervical deformity than people without CLBP.