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Correlation between the Lumbar Lordosis Curve and the Temperature Difference of the Lower Extremity Regions in Patients Lumbar Herniated Nucleus Pulposus

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Abstract. [Purpose] The purpose of this study was to evaluate the correlation between the lumbar lordosis curve (LLC) and temperature differences of the lower extremity regions in lumbar herniated nucleus pulposus (L-HNP) cases. [Subjects] We divided the study subjects into patients with L-HNP (n=15) and normal persons (n=15). [Methods] Both the L-HNP group and control group were measured for LLC and temperature differences of the lower extremity regions by X-ray and digital infrared thermal imaging (DITI). [Results] The LLC and temperature differences of the lower extremity regions of the L-HNP group were significantly different from the control group. The LLC and temperature differences of the lower extremity regions of the L-HNP group showed strong positive correlations. [Conclusion] We found that as the LLC decreased, the difference in the temperature of the lower extremity regions in the L-HNP cases increased.
Key words: L-HNP, Infrared thermographic imaging, Lumbar lordosis curve

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INTRODUCTION

Humans have an optimal spinal curvature for evenly distributing the static or dynamic center of body weight load. Lumbar lordosis is an important factor that determines flexibility when lifting or lowering an object and at the time of motion[1)]. As the importance of lumbar lordosis has become recognized, studies on lumbar lordosis of back pain patients[2)], pregnant women[3)], and herniated nucleus pulposus (HNP) patients have been conducted. Infrared thermographic imaging was first reported in 1956 by Lawson who showed its effects by applying it to a breast cancer patient[4)]. In 1982, Pochaczevsky et al. reported that infrared thermographic imaging was also effective for HNP diagnosis[5)]. However, since thermographic diagnosis uses liquid crystal thermography, which is ineffective for detailed thermographic diagnosis, we adopted the digital infrared thermal imaging method. Studies have been conducted on lumbar lordosis and temperature differences of the lower extremity region that represent the nerve compression symptoms of lumbar HNP (L-HNP) patients[5,6)]. However, limited research has been conducted on the degree of lumbar lordosis and temperature differences of the lower extremity regions of lumbar HNP patients. In this study, we examined the correlation between the degree of lumbar lordosis and the temperature difference of the lumbar region and lower extremity regions.

SUBJECTS AND METHODS

The subjects of this study were 15 L_{4-5} HNP patients in S Hospital, Daejeon, Korea, whose condition had been verified by magnetic resonance imaging (MRI) by radiologists and neurosurgeons, and 15 normal adults, the control group. The age of the subjects ranged from 15 to 45 years. Lumbar lateral surface radiographic images of the 30 subjects were taken, and the left and right temperature differences between the lumbar region and the lower extremity regions were measured with digital infrared thermal imaging (DITI). Patients with a history of surgical treatment of the lumbar region, patients with lumbago accompanied by systematic disease (cancer), rheumatic disease, or pressure fracture, and a patient who showed a nervous system abnormality were excluded from the experimental analysis. The objectives of the research and overall experimental procedures were sufficiently explained to the participants, and all patients voluntarily consented to participate in the study.

The average age of the L_{4-5} HNP group in the study was 35.3 ± 5.5 years: average height was 166.6 ± 8.4 cm, and

average weight was 62.7 ± 8.3 kg. The average age of the control group was 32.4 ± 4.2 years: average height was 166.2 ± 6.5 cm, and average weight was 63.6 ± 9.7 kg. Gender differences between the groups were analyzed using the chi-square test, and the independent t-test was used to analyze group differences in age, height, and weight. Based on these tests, there were no significant differences between the groups ($p>0.05$), confirming their homogeneity Using the radiographic images of the L_{4-5} HNP patients and normal adults, lumbar lordosis was determined by Cobb's angle, which is a parameter of lumbar lordosis measurement, with a Full Picture Archiving and Communications System (PACS). For radiographic imaging, subjects were asked to stand in the most comfortable and natural position, keeping the lateral gravity line vertical, and relaxing the lumbar and pelvic muscles as much as possible. The images were taken from 1 m distance by one radiographer with X-ray equipment (DLD-150 RK, Dong-A, Korea) and 14×17-inch film. The lumbar lordosis was measured by drawing extension lines backwards, parallel to the top of the superior L1 vertebral body and parallel to the top of the sacral vertebra; and Cobb's angle, angle (A) was measured as the intersection of the perpendiculars of these two lines (Fig. 1)[7].

In addition, the temperature differences between the right and left lower extremity regions of the L_{4-5} HNP patients and the normal adults were measured by DITI (IRIS-XP, medi-core, Korea). Following the standards of the U.S. International Academy of Clinical Thermology (IACT), the subjects were asked to avoid drug treatment, physical therapy, bathing, and any other factors that might induce body surface temperature change before the test. All the procedures in the experiment and infrared thermographic imaging were carried out in a sealed infrared thermographic imaging room with controlled air flows, where sunlight and heat from outside were blocked and the temperature (23–24 °C) and humidity (60%) were kept constant. Entry of unrelated persons and the movement of patients were prohibited during the experiment. After arriving at the experiment location, the subjects rested for 15 min and changed into gowns for the experiment. The temperature was measured at the lumbar erector spinae region (LESR), tibialis anterior region (TAR), ankle anterior region (AAR), calf region (CR), ankle posterior region (APR) and foot arch region (FAR), and the average body surface temperature difference of the right and the left regions was recorded (Fig. 2)[8].

The measurement data were analyzed with SPSS 12.0 KO (SPSS, Chicago, IL, USA) statistical software and are presented as means and standard deviations. The significance test of the difference between the two groups was performed using the independent t-test, and correlations between the lumbar lordosis and temperature differences at the lower extremity regions were examined with Pearsons correlation coefficient. A statistical significance level of 0.05 was used for all data.

Fig. 1. Cobb's angle was measured as the intersection of the perpendiculars of the lines drawn across the superior end-plates of L1 and S1.

RESULTS

The lateral surface radiographic images of the L_{4-5} HNP group and the control group were analyzed by Full PACS imaging, and a DITI diagnosis was carried out. The results show that LLC (lumbar lordosis curve), LESR, TAR, AAR, APR, and FAR of the L-HNP group were significantly different from those of the control group ($p<0.05$) (Table 1).

LESR, TAR, AAR, CR, APR, and FAR in the L_{4-5} HNP group showed negative correlations with LLC, indicating that the temperature differences between the right and left sides of LESR, TAR, AAR, APR, and FAR increased as lumbar lordosis decreased. Particularly, LLC and the temperature difference at the LESR showed a strong negative correlation (Table 2).

DISCUSSION

Although infrared thermographic imaging is usually used for diagnosis of inflammatory diseases, such as rheumatoid arthritis, it was recently reported that infrared thermographic imaging is reliable in the measurement of cutaneous temperature at the spinal level[9]. Another study reported that right and left body temperature correlation analysis by infrared thermographic imaging of the cervical area and the lumbar area showed strong significant correlations in the lumbar area and weaker significant correlations in the cervical area[10].

In this study, we showed that the L_{4-5} HNP group had less lumbar lordosis and greater temperature difference at the

Table 1. Comparison of LLC and right-left temperature differences of LESR, TAR, AAR, CR, APR, FAR in L_{4-5} HNP patients and normal controls(unit: °C, only LLC unit: degree)

Category	L_{4-5} HNP					Control
LLC*			34.04 ± 4.76			46.17 ± 3.49
LESR*	36.29[a]	35.89[b]	0.40 ± 0.17	36.58 [c]	36.43 [d]	0.14 ± 0.08
TAR*	34.45	33.96	0.49 ± 0.19	33.50	33.35	0.15 ± 0.10
AAR*	32.74	31.88	0.86 ± 0.69	32.11	31.95	0.16 ± 0.08
CR	33.67	33.41	0.26 ± 0.18	33.83	33.61	0.22 ± 0.10
APR*	32.10	31.37	0.73 ± 0.47	31.50	31.35	0.15 ± 0.08
FAR*	31.70	30.83	0.87 ± 1.04	31.39	31.12	0.27 ± 0.06

*: p<0.05. LLC : lumbar lordosis curve, LESR : lumbar erector spinae region, TAR : tibialis anterior region, AAR:ankle anterior region, CR : calf region, APR : ankle posterior region, FAR : foot arch region.
[a]: Unaffected side, [b]: Affected side, [c]: Left side, [d]: Right side.

Table 2. Correlations between LLC and right-left temperature differences of LESR, TAR, AAR, CR, APR, FAR in L_{4-5} HNP cases

Category	LLC	LESR	TAR	AAR	CR	APR	FAR
LLC	1.00						
LESR	–.717**	1.00					
TAR	–.601**	.379**	1.00				
AAR	–.512**	.272	.524**	1.00			
CR	–.249	.238	.016	.048	1.00		
APR	–.648**	.316	.677**	.785**	.048	1.00	
FAR	–.433**	.120	.482**	.823**	–.147	.730**	1.00

**p<0.01.

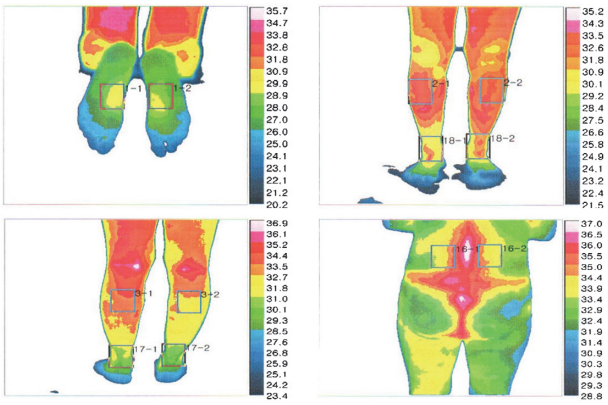

Fig. 2. Six regions of interest around the lower extremities were measured using thermography.

lumbar region and lower extremity regions than the control group. The L_{4-5} HNP group showed a temperature difference 0.4–0.9 °C at the lumbar and lower extremity regions.

Song et al. (1998) reported that central-type HNP patients had a significant temperature difference between both lower legs in contrast with a control group[11]. Pochaczevsky et al. reported that a high temperature was found in the central lumbar region when the nerve root was pressed as nerve muscle stimulation was transmitted to the skin region, while a low temperature was found at the lower legs by vasoconstriction[5]. They also reported that a temperature difference of more than 1°C between the lower legs is abnormal. However, according to Uematsu et al., even a temperature difference over 0.1 °C is significant[6].

In this study, the LESR, TAR, AAR, CR, APR, and FAR in the L_{4-5} HNP group showed negative correlations with LLC, and especially LLC and the temperature difference at LESR showed a strong negative correlation. We suggest that the body surface temperature difference at the lumbar region and lower extremity regions was caused by compression of the spinal nerve as normal lumbar lordosis was absent.

Zaproudina et al. examined correlations among a pain visual analog scale, spinal mobility tests, and infrared thermography with 24 lowback pain (LBP) patients, 41 leg pain patients, and 20 controls, and reported that pain intensity and plantar surface temperature difference in LBP patients showed a positive correlation. The plantar surface temperature difference was 0.1°C in the control group, 0.6 °C in the LBP patients with leg pain, and 2.1 °C in back-operated patients (L5-S1 disk herniation) 1 month later[12]. In addition, Wu et al. compared infrared thermography and pain intensity before and after manual therapy and short-wave diathermy and reported that they showed a strong positive correlation (r=0.67)[13].

In the above-mentioned studies, lumbar lordosis was less and the temperature difference at the lumbar and the lower extremity regions was greater in L_{4-5} HNP patients than in

normal controls. We also found that as the abnormality of lumbar lordosis of L_{4-5} HNP patients became more serious, the temperature difference at the lumbar region and the lower extremity regions became greater, especially at the lumbar region. Our results indicate that the importance of lumbar lordosis needs to be recognized in the treatment of L-HNP patients.

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