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A Study on Dispersion and Rate of Fat Infiltration in the Lumbar Spine of Patients with Herniated Nucleus Polpusus

Bong-jun Kong, MS[1)]*, Jong-soo Lim, MS[1)], Kyung Kim PhD[1)]

[1)] *Department of Physical Therapy, Daegu University Graduate School of Physical Therapy, Daegu University: 15 Naeri-ri, Jinlyang, Gyeongsan-si, Kyeongsangbuk-do, Republic of Korea*

Abstract. [Purpose] This study investigated the relationship between herniated nucleus pulposus (HNP) and fat infiltration of muscles around the spine by measuring body mass index (BMI) and fat infiltration of the muscles around the spine. [Subjects and Methods] Subjects were 82 people, both men and women they were divided into two groups, a normal group and a patient group who were suffering from serious HNP between L4 and L5. Of the anthropometric measurement, and fat infiltration muscles by measuring the cross-sectional area from the center of the disc to the muscle around the spine and the cross-sectional area of fat infiltration. [Results] Fat infiltration rate of each lumbar layer in the normal group was different L34–L45 and L45–L5S1, but not between L23–L34. Fat infiltration in the muscle between the normal group and patients with HNP was different in the layers and the difference was greatest in the L5–S1 layer. [Conclusion] We performed correlation analysis of BMI and the total fat infiltration rate in each group to find the relationship between obesity and fat infiltration in the lumbar spine. Fat infiltration increased, and normal people or patients with chronic back pain are considered to be exposed to other diseases as fat infiltration in the lumbar spine increases.
Key words: Fat infiltration, Herniated nucleus pulposus, Low back pain

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INTRODUCTION

In modern society, many people lack of physical exercise, which results in high risk of back pain. As back pain occurs a lot in the working age group, it has become a public health issue because of its effect on the labor force[1, 2)].

Herniated nucleus pulposus (HNP) is a typical functional spine disease which occurs when nucleus pulposus is exposed by annular tear[3)]. It occurs due to natural aging, genetic effects, obesity, lack of exercise, bad posture, medical history, excessive work, weight overload in daily activities etc[4)]. In most cases, patients complain of radiating pain with back pain[5)]. Biomarkers which measure changes in the muscle around the spine caused by back pain are fat content in cross-sectional area of muscle, muscular strength, efficiency etc[6)]. Among them, fat infiltration of the lumbar multifidus muscle has a strong relationship accompanying with back pain in adults[7)].

Studies of patients with chronic back pain[8)] and HNP[9)] have revealed types, dispersion and arrangement changes of muscle fiber, and decrease in muscle size. Some radiological image studies[10–12)] have examined the relationship between muscle size and fat infiltration with back pain. Though the studies cited above focused on the correlation between back pain and muscle morphological changes, it is necessary to confirm the definitions used in muscle observation. Most studies of the fat infiltration of muscles around the spine have been limited to the examination of the cross-section of muscles around the spine between lumbar levels 4 and 5. It is necessary to know if there is a significant difference of fat infiltration between patients with HNP and a control group (normal people) and the characteristics of any differences. The purpose of this study was to find the differences in fat infiltration of the muscles around each lumbar vertebra between healthy subjects and patients diagnosed with HNP between lumbar levels 4 and 5.

SUBJECTS AND METHOD

Subjects

The subjects were selected from among the patients who visited K hospital in Ku-mi, Korea, from Aug. 2010 to May 2012, because of back pain. We used preoperative radiologic images of the patients who had microdisectomy (MIMD) after diagnosis of with HNP between lumbar levels 4 and 5. We excluded patients who had tumor, inflammation, metabolic disorder or musculoskeletal disease caused by structural spine anomalies. The subjects performed exercises using the muscles around the lumbar spine before proceeding with imaging. All of the subject understood the purpose of this study and gave their written informed consent to

*Corresponding author. Bong-jun Kong (e-mail: Kongbj76@gmail.com)

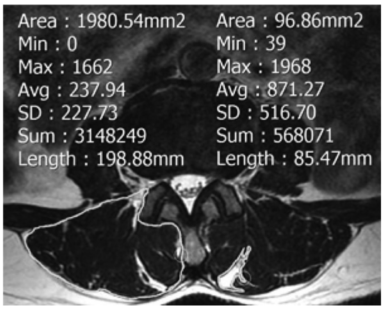

Fig. 1. Cross section of fat from PACS

participation before experimental involvement. The study was performed following the principles of the Declaration of Helsinki, and ethical approval was granted by the local committee of the Institutional Review Board. The subjects were men and women between the ages of 21 and 65, and their physical characteristics are listed in Table 1.

Methods

After MRI-scanning of the lumbar region, we measured the cross-sectional area of the erector spinae and multifidus muscles and their fat infiltration areas using Free Line ROI (region of interest) in the PACS menu on the Axial view of the T2 screen. The measurements were automatically computerized by PACS and appeared on the screen as shown in Fig. 1. To ensure the objectivity of the measurement, each measurer checked the measurement twice, and we adopted the mean value. Subjects' weight and height were measured after fasting, while they were wearing light clothing, and we calculated the body mass index (BMI) by dividing the weight (kg) with the square of height (m).

Statistical analysis was performed using SPSS ver. 18.0. The general characteristics of the subjects are presented as the mean±SD of each group. (1) The significance of the dispersion of fat infiltration at each level of the lumbar spine was examined using the paired t-test at each inter-vertebral level of the lumbar spine in each group. To compare the increase of fat infiltration rate between patients with HNP and the normal group subjects, we performed the independent t-test, and to find the correlation of obesity with fat infiltration in the lumbar region we conducted correlation analysis of total fat infiltration rate and BMI for each group.

RESULTS

The fat infiltration rate of each lumbar layer in the normal group was different between L34–L45 and L45–L5S1, but not between L23–L34, and the patients with HNP had different fat infiltration rates at all levels (Table 2).

Fat infiltration of the muscle between the normal group and patients with HNP was different at all the layers, and the difference was greatest at the L5–S1 layer (Table 3).

According to the paired t-test, there were significant differences between the normal group and the HNP group. When comparing infiltration rates at each level of the lumbar spine, we found the mean value of fat infiltration increased in the lower part of the lumbar spine. According to the independent t-test, there were significant differences in fat infiltration rate between the normal group and the HNP group.

Table 1. General characteristics of the subjects (Mean±SD)

	Normal (n=42)	HNP (n=40)
sex (male/female)	28/14	20/20
height (cm)	169.3±6.9	167.5±8.6
age (yrs)	42.2±10.9	41.9±7.9
weight (kg)	65.8±9.6	66.3±12.6
BMI (kg/m^2)	22.8±2.0	23.4±2.7

Table 2. Results of the between level comparisons (Mean±SD)

	Lumbar level	Fat infiltration
Normal group	L23–L34	−0.26±1.98
	L34–L45	−1.37±2.82*
	L45–L5S1	−2.43±3.03**
HNP group	L23–L34	−2.21±3.24**
	L34–L45	−3.55±3.35**
	L45–L5S1	−4.62±6.37**

* $p<0.05$, ** $p<0.001$, paired t-test (Unit: mm^2)

Table 3. Results of the between group comparison (Mean±SD)

	Normal (n=42)	HNP (n=40)
	Mean±SD	Mean±SD
L23	3.71±2.81	5.52±3.68*
L34	3.97±2.92	7.73±5.12**
L45	5.35±3.97	11.28±6.13**
L5S1	7.79±3.52	15.90±7.19**
BMI	22.81±1.97	23.44±2.71

* $p<0.05$, ** $p<0.001$, independent t-test (Unit: mm^2)

DISCUSSION

The multifidus muscle is a stabilizer muscle which is important for maintaining the neutral posture of the lumbar spine[13]. The multifidus muscle is posteriomedial and is distributed in two or four segments. It plays a key role in stabilization of the spine, and shrinking of the multifidus muscle and segmental dysfunction of the spine are a highly correlated with chronic back pain[14, 15]. Thus, the purpose of this study was to examine the difference between a normal group of subjects and patients with HNP by measuring fat infiltration rate of the multifidus in the lumbar, region, as it has a high correlation with the stabilization of spine in the neutral position and lumbar disc diseases.

BMI is commonly used to determine obesity. It is calculated from weight and height and is used around the world. BMI is universally used as an index of obesity. Changes in BMI influence body shape, moving the center of gravity forward or backward, increasing the mechanical load on the lumbar spine, changing the curvature of the lumbar spine or causing back pain[16]. Fabris de Souza et al. showed that the degree of forward bending increases when obese people sit or stand, and they emphasized the load increase on the disc[17]. They examined the correlation between physical changes in the body based on the BMI and back pain. We aimed to determine the correlation between BMI and fat infiltration in the lumbar spine, and the difference in the fat infiltration of the muscles around the lumbar spine between normal subjects and HNP patients. Prior studies reported high prevalence of fat infiltration in patients[15] and controls[18], and fat infiltration was more common in old people[11]. Kjaer[7] found that adults usually had fat infiltration of the multifidus around the lumbar spine. Kader[15] reported that 80% of patients with back pain had weakness in the multifidus in an MRI study. Danneel[14] also found a significant difference in the strength of the multifidus between healthy people and patients with chronic back pain. Kamaz[19] reported that there was a significant weakness in the multifidus when the paraspinal muscle, lumbar quadrate muscle or major psoas muscle showed various degrees of weakness. It is reported that patients with HNP had a weakened multifidus after surgery[20].

In the comparison of fat infiltration between each lumbar level, the difference of fat infiltration between each segmental level was significant ($p<0.05$) and the rate of increase between L34 and L45 was the greatest. This is because HNP increases in higher segmental levels, and the rate of increase is greater in the lower segmental levels. This may the result of a decrease in movement because of lower back pain. This is in agreement with the research results we cited above.

Regarding fat infiltration of the muscles around the paraspinal muscle, patients with HNP and the normal group subjects showed significant differences at all levels ($p<0.05$). The difference was especially great at L23, L45 and L5S1. This agrees with the study results of Danneels[14]. Fat infiltration of the muscles of patients with HNP might be greater than that of the normal group subjects, because pain and inflammation initiate the reflex-inhibition mechanism, limiting the movement of flexor and extensor muscles[18].

When comparing fat infiltration rate between each layer of the HNP group with that of the normal group, we found the greatest difference in L5S1. In general, flexion, extension, lateral flextion etc. are more active in L45 and L5S1[21], and in order to activate these movements, paraspinal muscle tones are widely dispersed around L5[22]. Because pain activates the spinal reflex inhibition system, the HNP group can't move immediately at L45. When such movements are accompanied by continuous pain, these movements would decrease to protect the damaged tissue, and the fat infiltration rate would increases more in the lower part, which would explain why the greatest difference was seen at L5S1.

Among patients who received discectomy, Meredith[23] found a significant difference between BMIs of relapsed patients and normal patients, and the relapse rate of HNP among patients with +BMI 30 (considered clinically obese) requiring reoperation was found to be highly correlated in multi-variate crossover analysis. However, we didn't find a correlation. This result agrees with the research of Kjaer[7]. BMI appears to be unrelated to fat infiltration of the multifidus. Fat infiltration would appear in all muscles, but it only appeared a lot in L5. Besides, there is a limit to analyzing fat between muscles and bones using BMI.

Currently, it is hard to conclude that the fat infiltration of the paraspinal muscles is the main cause in HNP, but we confirmed that fat infiltration increased, and normal subjects or patients with chronic back pain are considered to be exposed to other diseases as fat infiltration in lumbar spine increases. To prevent HNP, we need to stop fat infiltration and try various therapies in order to slow the degenerative changes. Especially, we need to find a direct method of order to decreasing the fat infiltration rate of the paraspinal muscles.

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