

Ultrasonography Analysis of Knee Range of Motion and the Quadriceps Femoris of Patients with Knee Osteoarthritis

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Abstract. [Purpose] This study was designed to compare ultrasonic images of knee extension range of motion and the quadriceps femoris between a healthy elderly group and a knee osteoarthritis group. [Methods] The study subjects were 30 healthy elderly people and 30 elderly people diagnosed as having knee osteoarthritis. Their knee extension range of motion in a prone position was measured with goniometer and muscle density and white area index was measured by transverse images of the rectus femoris and vastus medialis in a flexion position with the knee bent at 90 degrees using ultrasonic diagnostic equipment. [Results] There were significant differences in the knee extension range of motion and in muscle density and white area index of the rectus femoris and vastus medialis between the healthy elderly and knee osteoarthritis groups. [Conclusion] There were significant differences in the knee extension range of motion of healthy elderly people and knee osteoarthritis subjects, and the quadriceps femoris played an important role in the knee function of knee osteoarthritis.

Key words: Ultrasound, Osteoarthritis, Quadriceps femoris

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INTRODUCTION

Living standards and health conditions have improved with the development of science and technology and we live in an aging society as the average life span is extending¹⁾. The prevalence of chronic diseases due to the aging of society has also increased and one of the most frequently diagnosed chronic diseases is osteoarthritis²⁾. Osteoarthritis is mainly found in the knee and hip joints and is most frequently diagnosed in the knee joint which carries much weight and stress due to the frequent activities of the human body³⁾.

The agonist for the extension of muscles around the knee joint is the quadriceps femoris muscle, which consists of the rectus femoris, vastus lateralis, vastus medialis, and vastus intermedius, and is involved in stabilizing the lower limbs in the upright or walking positions^{4, 5)}. Slemenda et al.⁶⁾ reported that the muscle strength of the quadriceps femoris is most important in physical malfunction and an imbalance in muscle strength aggravated poor knee joint function⁴⁾, causing contracture and pain in the knee joint and reducing the range of motion^{3, 6-7)}. Since elderly patients with knee osteoarthritis experience amyotrophy and is restriction of motion due to pain, which results in decrease of muscle use, their quadriceps femoris is weakened and their range of motion is less than the normal range⁸⁾.

There have been few studies that have examined the

factors affecting decrease in range of motion of patients with knee osteoarthritis³⁾, and there has been no comparative research of ultrasonic imaging of the range of motion and the quadriceps femoris between a healthy elderly group and elderly patients with knee osteoarthritis. Also, studies of findings of ultrasonic imaging related to progress and severity of knee osteoarthritis are lacking and in particular⁹⁾, Yoon¹⁰⁾ argued that there has been no study of changes in the structural characteristics of muscle imaging. Therefore, in this study we compared the knee extension range of motion and the quadriceps femoris between healthy elderly people and elderly patients with knee osteoarthritis. We also aimed to provide basic materials for therapeutic approaches to knee osteoarthritis accompanied by weakening of the quadriceps femoris. The results suggest the need for analysis of muscle density and white area index of the quadriceps femoris using ultrasonography to provide the data necessary for physical therapy evaluation and intervention programs for knee osteoarthritis.

SUBJECTS AND METHODS

The study subjects were 60 volunteers who used B Senior Health Town in Gwangju metropolitan city who gave their consent to take part in this experiment for four weeks. The study divided the subjects into a normal group of 30 subjects (15 men and 15 women) who did not have knee

Table 1. General characteristics of the subjects

Group	Normal		Osteoarthritis	
	Male (n=15)	Female (n=15)	Male (n=15)	Female (n=15)
Sex				
Age (yrs)	75.9 ± 7.9	74.5 ± 7.2	75.2 ± 7.4	73.9 ± 8.4
Weight (kg)	65.7 ± 6.1	54.9 ± 9.2	62.8 ± 5.8	58.7 ± 6.2
Height (cm)	167.8 ± 6.6	152.7 ± 6.8	163.5 ± 6.2	154.2 ± 3.9

Mean ± Standard Deviation

osteoarthritis as diagnosed by a doctor and an osteoarthritis group of 30 subjects (15 men and 15 women) who had knee osteoarthritis as diagnosed by a doctor.

The subjects were elderly people in their sixties or older who could communicate and didn't participate in regular exercise. Subjects were excluded from the study if they had any surgical operations like herniation of intervertebral disc or total knee replacement, they could not walk by themselves, gave no consent to take part in the experiment, or had other diseases. The general characteristics of the subjects are listed in (Table 1).

Ultrasonic images measuring skeletal muscle structure were collected with an Ultrasound MyLab25 (Esaote, Italy). The frequency used was range is 12 MHz and "High" density was used for all images at a fixed value. Ultrasonic imaging was performed in the transverse plane and muscle density and the white area index were measured with transverse plane imaging¹¹⁾.

To measure muscle density, a square area was selected which did not include aponeuroses in the transverse plane image and the mean pixel value in this area was calculated. If a pixel is pure black, the pixel value is 0 and if it is pure white, it is 255¹²⁾.

Knee joint extension range of motion was measured in the prone position using a stainless steel 360 goniometer in order to exclude joint motion at the hip joint and measure pure knee joint range of motion only¹³⁾. The same tester performed three measurements repeatedly to reduce error and the mean value was used.

Data were analyzed using SPSS for Windows version 12.0. Comparison of ultrasonic images and knee joint extension range of motion between the healthy and osteoarthritis groups was conducted with independent sample t-test. A significance level, α , of 0.05 was chosen.

RESULTS

In the comparison of the knee joint extension range of motion, between the normal group and the osteoarthritis group, the right knee joint extension range of motion of the normal group was 1.63 ± 1.03 , and that of the osteoarthritis group was -6.37 ± 2.28 , and these values were significantly different ($p < 0.05$). The left knee joint extension range of motion of the normal group was 1.33 ± 1.06 , and that of the osteoarthritis group was -6.23 ± 2.84 , and these values were significantly different ($p < 0.05$).

In the comparison of the muscle density of the rectus femoris, between the normal group and the osteoarthritis

group, and the right muscle density of the rectus femoris of the normal group was 91.80 ± 24.99 , and that of osteoarthritis group was 105.44 ± 20.79 , and these values were significantly different ($p < 0.05$). The left muscle density of rectus femoris of the normal group was 84.97 ± 22.16 , and that of the osteoarthritis group was 99 ± 30.2 , and these values were significantly different ($p < 0.05$).

In the comparison of the white area index of the rectus femoris, between the normal group and the osteoarthritis group, the right white area index of the rectus femoris of the normal group was 0.0201 ± 0.0250 , and that of the osteoarthritis group was 0.0632 ± 0.1075 and these values were significantly different ($p < 0.05$). The left white area index of rectus femoris of the normal group was 0.0225 ± 0.041 , and that of the osteoarthritis group was 0.0529 ± 0.0875 . Although these values were not significantly different, the value was higher in the osteoarthritis group ($p > 0.05$).

In the comparison of the muscle density of the vastus medialis, between normal group and the osteoarthritis group, the right density of vastus medialis of the normal group was $90.1629.57$, and that of the osteoarthritis group was $107.9131.34$, and these values were significantly different ($p < 0.05$). The left muscle density of vastus medialis of the normal group was 86.68 ± 3.58 , and that of the osteoarthritis group was 103.74 ± 33.28 , and these values were significantly different ($p < 0.05$).

In the comparison of the white area index of the vastus medialis, between the normal group and the osteoarthritis group, the right white area index of the vastus medialis of the normal group was 0.063 ± 0.0767 , and that of the osteoarthritis group was 0.1187 ± 0.1318 , and these values were significantly different ($p < 0.05$). The left white area index of the vastus medialis of the normal group was 0.0478 ± 0.0659 , and that of the osteoarthritis group was 0.1088 ± 0.144 and these values were significantly different ($p < 0.05$).

DISCUSSION

Weakening of the quadriceps femoris, which is related to the stability of the lower limb in upright and walking positions, results in knee pain, progress of joint injury and physical malfunction⁶⁾. Imbalances in muscle strength which aggravate knee joint disorder⁴⁾, causing contracture and pain at the knee joint and which decrease range of motion^{3, 6, 14)}.

As a result of measuring and comparing the knee joint extension range of motion between the normal group and the knee osteoarthritis group, it was found that the active extension range of motion of the normal group was within

the range of 0–5 degrees, but the knee osteoarthritis group showed severe contracture which restricted the active extension range of motion compared to the normal group. This result was identical with the findings of Hwang¹⁵⁾ who reported that contracture and pain of the knee joint decreased the range of motion.

Weakening of the quadriceps femoris causes a decrease in the range of motion and changes in qualitative characteristics. We used ultrasonography to examine changes in qualitative characteristics of the quadriceps femoris. The muscle density of the rectus femoris and vastus medialis showed significant differences between the knee osteoarthritis group and the normal group. However, the white area index showed a significant difference only between the right rectus femoris of the knee osteoarthritis group and the normal group, whereas the vastus medialis showed significant differences in both the left and right rectus femoris. The left rectus femoris showed no statistically significant differences, but considering that the white area index of the knee osteoarthritis group was higher than that of the normal group, we think that the quadriceps femoris of the osteoarthritis group was weakened.

As knee osteoarthritis develops, it shows the same functional disorders as those of the rectus femoris and vastus medialis, and according to studies of functional disorders in the progress of knee osteoarthritis, the degree of degeneration in joint cartilage has close relations to pain and functional disorders of patients⁹⁾.

This study found significant differences in range of motion, muscle density and white area index between the normal group and the knee osteoarthritis group, and we consider the knee osteoarthritis group experienced a decrease in their range of motion, contracture of knee joint and a weakening of quadriceps femoris compared to the normal group. Therefore, we recommend knee osteoarthritis patients have regular ultrasonography and therapy to prevent contracture of the knee joint with range of motion assessment. Also, prevention of additional injury or further functional disorders and an intervention program to improve knee osteoarthritis are required. We consider that changes

in muscle strength of osteoarthritis patients can be observed through ultrasonography. Contracture of the knee joint and a weakening of the rectus femoris and vastus medialis in patients with knee osteoarthritis should be specially managed and changes in the musculoskeletal system should be evaluated using ultrasonic images.

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