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Comparison of Pressure of the Sole Distribution between Individuals with and Without Genu Recurvatum

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***Abstract* - Although change of knee alignment can affect the pressure distribution of the sole of the foot, there are no studies on changes in the pressure of the soles in the genu recurvatum. The purpose of this study was to compare the pressure of the sole distribution between with and without genu recurvatum. Among the 56 legs that were recruited, 15 legs were recruited as the genu recurvatum group and 18 legs were recruited as the control group. In both groups, pressure of the sole distribution (forefoot, backfoot) and the knee joint angle was measured. The pressure distribution of forefoot, backfoot, and difference value between forefoot and backfoot were significantly difference between with and without genu recurvatum. We confirmed that individuals with genu recurvatum supported excessive weight on the backfoot compared to individuals without genu recurvatum. And this information can be applied when intervening patients with genu recurvatum.**

Index Terms – Genu Recurvatum, Knee Joint, Osgood-Schlatter, Sole Distribution.

INTRODUCTION

Genu recurvatum, called hyperextended knee, is defined as the case of having a knee joint angle of 170 degrees or less at knee extension, and the cause of occurrence is caused by traumatic injury, stroke, polio, osgood-schlatter disease, or prolonged casting [1-3]. The main symptoms experienced by these patients include pain, weakness, instability, decreased range of motion, and changes in appearance [4, 5].

In the case of congenital or bone deformity, surgical treatment is used, but genu recurvatum due to laxity of soft tissue caused by trauma or misalignment/motion focuses on strengthening the muscles that support the alignment of the knee joint [2, 6]. When it comes to maintaining alignment, it is also necessary to strengthen certain muscles, but it is difficult to solve these problems by maximizing muscle strength [7]. The treatment of genu recurvatum, which is caused by continuous accumulation of bad posture due to the laxity of surrounding tissues, does not receive appropriate information on the body alignment [8, 9].

In a previous study, subjects with genu recurvatum showed excessive knee extension posture and excessive use of the gastrocnemius muscle in an upright position compared to subjects with normal alignment [10]. Excessive use of the Gastrocnemius muscle acts as a force to move the knee further back in a close chain condition such as a standing position [11]. It has been mentioned that excessive knee extension can affect not only the alignment of the knee, but also the pressure distribution of the sole of the foot, and since the movement of the weight is mechanically moved backward, the pressure distribution of the sole of the foot (Forefoot VS. backfoot) is changed [8]. The change in weight distribution of the sole can be applied not only as an indicator that can characterize patient with genu-recurvatum, but it is believed that normalizing the pressure change in the sole will help correct alignment of the knee joint [12].

However, until now, no studies have been conducted on changes in the pressure of the soles due to excessive extension of the knee. It is considered necessary to study how overextension of the knee affects weight support or the form of body balance through studies on changes in foot pressure. Therefore, the purpose of this study was to compare the pressure of the sole distribution between individuals with and without genu recurvatum.

METHOD

Participants

56 legs were recruited and the knee joint angle was measured. The knee joint angle of 56 legs was 171.24±3.51. In order to divide into the control group and the genu recurvatum group according to the knee joint angle, the average of the knee joint angles and 1/2 standard deviation value were used. The legs with a 172.99 (mean + 1/2

standard deviation) or higher were recruited as a control group, and the legs with a 169.48 (mean - 1/2 standard deviation) or less were recruited into the genu recurvatum group. The inclusion criteria for the genu recurvatum group are consistent with Devan et al study (2004) [3]. Of the 56 legs, 15 legs were recruited as the genu recurvatum group and 18 legs were recruited as the control group, and the characteristics of the subjects are described in Table 1.

TABLE 1. SUMMARY OF THE SUBJECTS' DEMOGRAPHICS

	Genu recurvatum	Control	t	p
Age (y)	23.27±1.58	23.56±1.85	-0.476	0.637
Height (㎝)	166.60±7.82	165.33±9.04	0.426	0.673
Weight (㎏)	62.20±15.52	61.28±14.58	0.176	0.862
Angle of knee joint (º)	166.97±2.37	175.07±1.53	-11.838	<0.001

Instruments

Pressure distribution measuring plate

The distribution of the plantar foot measured the Zebris FDM-S (Zebris Medical GmbH, Germany). This system measures the pressure distribution using 2560 sensors. The signal processing board acquires data for 100Hz sampling frequency. Information on the distribution of the plantar foot is provided with the average force of forefoot and backfoot (Figure 1).

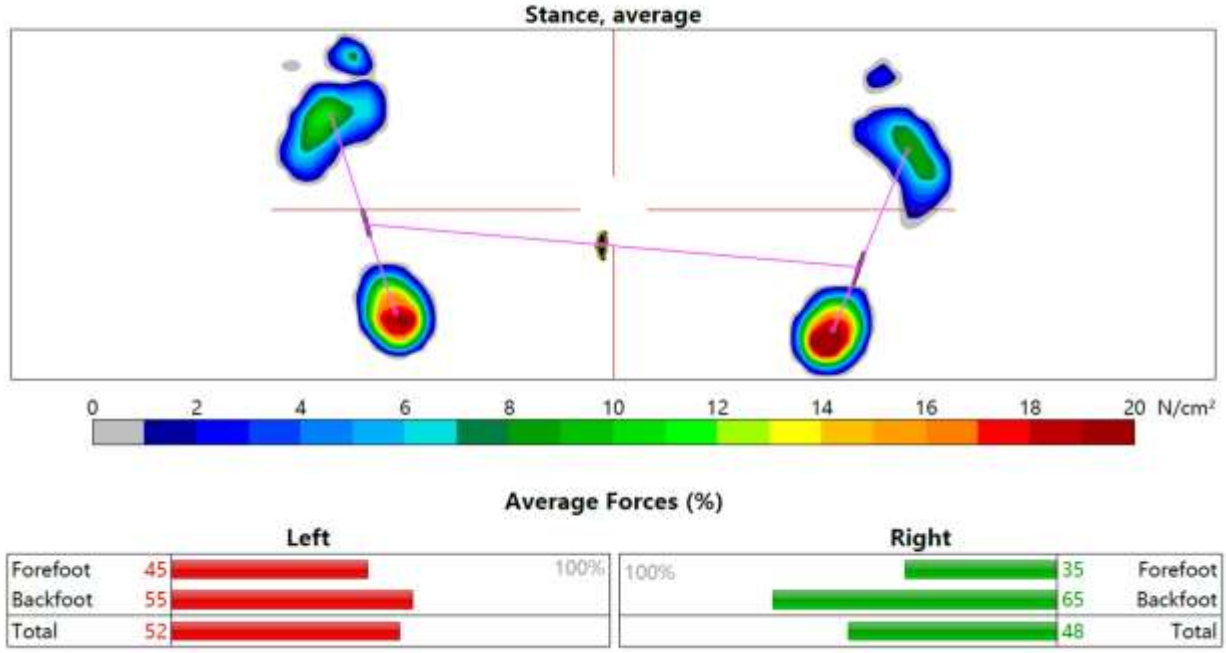

FIGURE 1. INFORMATION ON THE DISTRIBUTION OF THE PLANTAR FOOT

Camera

The knee joint angle measured a smartphone camera (Galaxy S6, Samsung, Korea). The smartphone is fixed at knee level using a tripod. The distance between the subject and the smartphone placed 1m. For angular analysis, a reflective surface marker is attached to the greater trochanter, lateral femoral epicondyle, and lateral malleolus of dominant side leg [10, 13]. The subject faces the front and stands for 30 seconds with all muscles relaxed, and the examiner measures it at 30 seconds. The angles are analyzed using image analysis, which uses Image J software (U.S. National Institutes of Health, Maryland, USA) (Figure 2).

FIGURE 2. MEASUREMENT OF THE KNEE JOINT ANGLE

Statistical analysis

The Shapiro-Wilk test was used to confirm the normality of the distribution. If the normal distribution of the variables was confirmed, an independent t test was used to compare the pressure distribution between with and without genu recurvatum. A p value of <0.05 was considered indicative of statistical significance. Statistical analyses were performed using the SPSS software (ver. 20.0; SPSS, Inc., Chicago, IL, USA).

RESULT

All pressure distribution variables showed a normal distribution in Shapiro-Wilk test ($p>0.05$). The result for the independent t-test between with and without genu recurvatum is shown in Table 2. The pressure distribution of forefoot, backfoot, and difference value between forefoot and backfoot were significantly difference between with and without genu recurvatum ($p<0.01$).

DISCUSSION

The change in knee alignment acts as a limitation in maintaining normal alignment by degrading the function of various body receptors that give correct information about the position of the knee joint. Individuals with genu recurvatum showed excessive knee extension compared to the normal group. In addition, it was confirmed that gastrocnemius, which plays the role of pulling the knee backward, showed excessive muscle activity. Such a change means that the movement of the center line of the body or a change in the pressure distribution of the soles of the feet occurs. Most of the studies have not dealt with these areas of mechanical change. therefore, purpose of this study was to compare the pressure of the sole distribution between with and without genu recurvatum.

Based on the results of this study, it was confirmed that individuals with genu recurvatum supported excessive weight on the back foot compared to those with normal knee alignment. This change in weight distribution causes excessive pressure on the knee joint and the front part of the joint. It also causes a problem that causes the deformation of tibia [14]. Mechanical loads and stresses and strains on bones affect their shape, whether by deterioration or exostosis [15]. When a structural change occurs in which the tibia is curved backwards, even if it tries to maintain the correct alignment, it continues to have a hyperextended knee shape due to the structural change [16].

TABLE 2. THE PRESSURE DISTRIBUTION BETWEEN GENU RECURVATUM AND CONTROL

	Genu recurvatum	Control	t	p
Forefoot (%)	31.27±6.10	39.00±8.20	-3.020	0.005
Backfoot (%)	68.73±6.10	61.00±8.20	3.020	0.005
Difference value	37.47±12.20	22.00±16.39	3.020	0.005

Many studies on hyperextended kneed to date have suggested braces, taping and exercise methods for correcting the alignment of the knee joint [1, 17, 18]. However, when applying a brace and taping, it is uncomfortable and is not preferred outwardly [19, 20]. In addition, muscle strengthening exercise methods for knee alignment had limitations in improving the alignment of the hyperextended knee [1]. In order to solve this problem, sensory-motor training is necessary to develop the ability to control the position of the knee by the patient himself [21-23]. In order to prepare the basis for such training, this study confirmed that the difference in weight support distribution between normal subjects and subjects with knee hyperextension occurred significantly.

This study was conducted only to compare the differences in the distribution of weight support of the soles between normal subjects and subjects with hyperextension knee. In future studies, based on the results of this study, it is considered necessary to provide information on the pressure distribution of the soles of the foot and to study the

effect of knee alignment correction that occurs when the patient changes the pressure distribution of the soles by himself.

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