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Corresponding author
E-mail: jaebumlee@mju.ac.kr

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E-mail: kinesiology@j-institute.jp

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Effects of FUNCTIONAL CORRECTION on Foot Pressure Balance, Pelvic Displacement and Spinal Displacement in Patients with Low Back Pain

Yang Seo-jun[1]
Myongji University, Seoul, Republic of Korea
Lee Jae-bum[2*]
Myongji University, Seoul, Republic of Korea
Kim Hyun-woo[3]
Dongbang Culture University, Seoul, Republic of Korea

Abstract

Purpose: After 8 weeks of functional orthodontic treatment on the subjects of twelve worker patients with back pain in their 30s, this study attempted to investigate the effect of pelvic tilt, pelvic rotation, lumbar lordotic angle and ferguson's angle on pelvic floor balance and pelvic displacement.

Method: First, to investigate the change in foot pressure balance after functional correction of participants, the foot pressure balance was measured by dividing it into three stages before, during, and after treatment. Second, Pelvic AP View and Lumbar Lateral view were measured before and after treatment to examine X-ray changes in pelvic displacement and spinal displacement after functional correction of participants.

Results: To examine the results of analyzing the changes in foot pressure according to the functional correction of the study participants, the changes in the foot pressure of the left and right and the front and back sides showed a more balanced form of foot pressure after conducting functional correction than before conducting functional correction, which is analyzed that there is a statistically significant difference. There was no statistically significant difference between the lumbar lordotic angle's pre and post displacement among the participants' spinal displacement, but the pre- and post-displacement of Ferguson's Angle showed that there was a statistically significant difference($p<.05$).

Conclusion: This study confirmed that functional correction treatment had a significant effect on pelvic displacement and spinal displacement overall, positively affecting the balance between the trunk and lower limbs, improving the difference in foot pressure and improving body stability.

***[Keywords]* Functional Correction, Foot Pressure Balance, Pelvic Displacement, Spinal Displacement, Low Back Pain**

1. Introductions

In modern society, due to rapid industrial development and social structure changes, limited physical activity, bad posture and stress in daily life, and long-standing sitting postures cause gradual changes in the musculoskeletal system and diseases. In addition, due to repetition of wrong habits and lack of exercise, the pelvic misalignment, deformation of the natural spinal pelvic curvature, and dysfunction occur, there is difficulty in maintaining the correct posture, and the displacement of the spine and pelvis, and muscle imbalance, etc. cause an imbalance of the body.

In particular, low back pain is a common disease in modern society that is experienced at least once in a life time, and is a widespread disease that can occur around the lumbar spine, including back pain. When low back pain lasts more than several months, physical activity is limited and social and psychological atrophy occurs. According to a report from the Ministry of

Health and Welfare(2015) in Korea, of the total disease treatment(81.8%) classification, lesions of the musculoskeletal system associated with low back pain accounted for more than 22%, with 6.6% of low back pain, 6.7% of lumbar sprains, 4.1% of discs, and 4.6% of neuralgia. Surgery for low back pain is also gradually increasing, which is a serious situation[1], and the incidence of low back pain is on the rise due to poor lifestyle, irregular physical activity, and lack of exercise.

In a study examining the correlation between pelvic displacement and foot pressure in patients with low back pain, it has been reported that foot pressure was found to be high mainly in the left and rear when standing, and that the left-right foot pressure imbalance is greater than the front-rear foot pressure imbalance. In particular, it is said that as in patients with low back pain with instability in the body, changes in the trunk and pelvis cause a change in foot pressure and show an asymmetric weight distribution[2].

In addition, when walking in patients with chronic back pain, the knee joint and hip joint are bent, and the angle of the lumbar lordosis increases, and so the range of motion the front and rear pelvis is reduced and the plantar flexion of the foot is increased, causing changes in normal over and backward motions, which is said to increase the vertical impact and the foot pressure of the forefoot[3].

With regard to the treatment of low back pain, there are self-care such as following advice around, acquiring knowledge through books, and applying heat to the surface, the medical surgery or medication, and the conservative therapy, that is, non-drug treatment such as spine correction, exercise therapy, massage, acupuncture, yoga, and cognitive behavioral therapy[4]. Among them, the conservative therapy can cure back pain within 10 to 12 weeks[5], 90% of patients with low back pain are improving with the conservative therapy, and surgical treatment requires only 1-2%[6].

Manual therapy is one of the most frequently used non-surgical methods of physical therapies for the treatment of low back pain. The treatment of pain and dysfunction caused by disease or injury using physical factors can be referred to as the definition of physical therapy. As a dynamic force among physical factors, manual therapy is the overall process in which physical therapists use their hands for examination and treatment. The characteristic of manual correction therapy is natural therapy that does not depend on drugs or surgery, and it is a study that treats the human body based on the whole rather than a part by finding the root cause rather than treating the symptoms of the disease. It is a medicine that treats nerves, muscles, or skeletons, including exercise, in a complex way, based on prevention purposes and maintaining optimal health, and is a study that treats the pelvic and spinal centers in tissues with the kinematic functions of the human body[7].

Functional correction, a technique of manual therapy used in this study based on basic medicine and anatomical diagnosis, is a study that systematizes seven diagnostic methods such as existing manual therapy techniques, chiropractic diagnostics, ROM analysis, radiographic analysis, and leg length analysis and uses two or more test methods to treat them. The principle of functional correction is to correct the dislocation of the displaced vertebrae to the normal range, thereby increasing the misalignment and mobility of the joint area, smoothing the passage of nerves, and to restore the body normally by maximizing the natural healing power by adjusting the balance of the musculoskeletal system.

Therefore, this study is aimed to explore the effects of the non-surgical functional correction therapy through the existing chiropractic diagnosis method and ROM analysis method on foot pressure balance, pelvic displacement, and spinal displacement for patients with low back pain.

2. Methods

2.1. Participant

This study was conducted on 12 participants(five men, seven women, and an average age of 33 years old) with chronic low back pain who were in their 30s who visited Y Hospital in G-do, Korea. Participants were those who had no history of surgery related to disc prolapse, no neurological abnormalities, and no specific diseases other than low back pain, the purpose of this experimental study was fully explained to them in advance and they agreed to participate in the study, and the changes in foot pressure, pelvic displacement, and spinal changes were compared and analyzed through functional correction treatment three times a week for 8 weeks.

2.1. Instruments

The foot pressure was measured using a foot pressure meter(GHF-550, Korea). The standard of the numerical value is that 50:50 becomes the center of the balance of foot pressure. X-ray analysis was performed using Median International, Inc.'s MS-TSF(D) Model radiograph imaging machine, and participants were photographed in a straight posture and analyzed using the Gonstead technique. To measure pelvic tilt and pelvic rotation, AP view was taken based on sacral number 2(S2). To measure the lumbar lordotic angle and Ferguson's Angle, a lateral view of the lumbar 5(L5) was taken from the standing posture. Wiz Pacs were used for reading after imaging.

2.3. Procedure and program

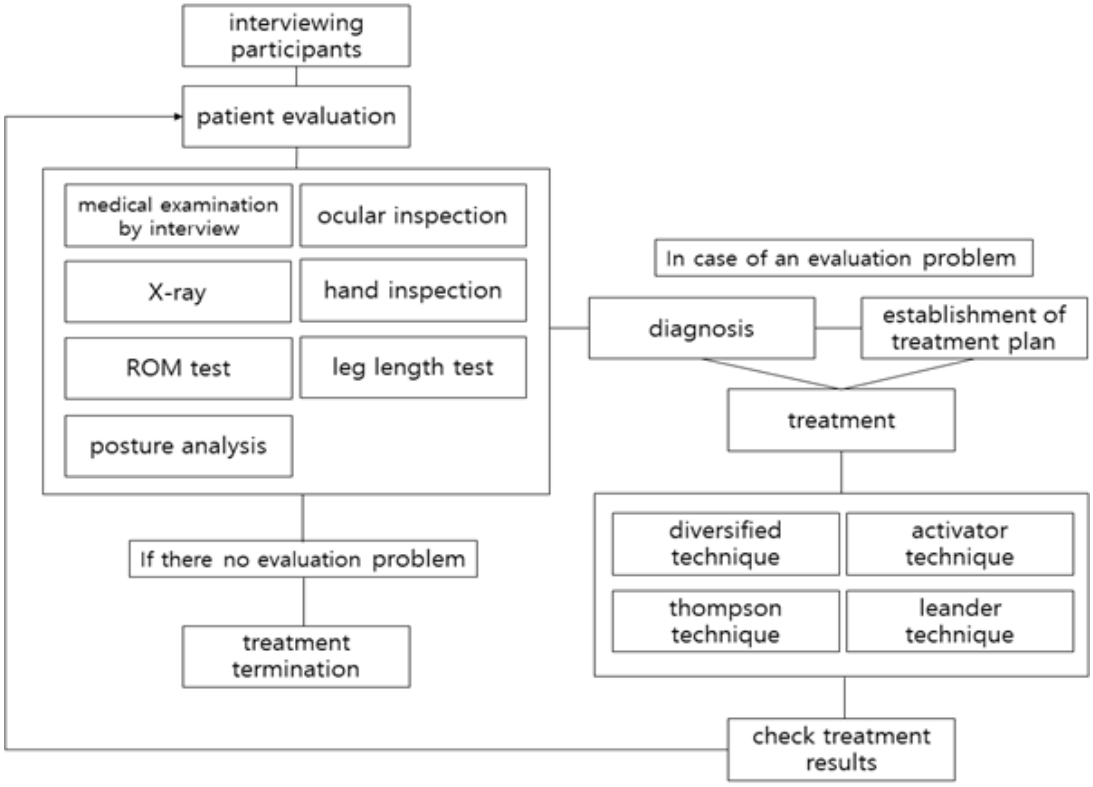
To proceed with this study, first, review of previous studies and literatures on research issues was conducted, and after selecting the participants and filling out the consent form, the contents of the experiment and the treatment process were described. <Figure 1> illustrates the functional correction process conducted in this study[8].

2.4. Data analysis

To compare and analyze the foot pressure balance, pelvic displacement, and spinal displacement after functional correction in patients with low back pain, the foot pressure and X-rays of 12 participants were investigated, and specifically, the methods for data analysis are as follows.

First, to investigate the change in foot pressure balance after functional correction of participants, the foot pressure balance was measured by dividing it into three stages before, during, and after treatment. Second, Pelvic AP View and Lumbar Lateral view were measured before and after treatment to examine X-ray changes in pelvic displacement and spinal displacement after functional correction of participants. Third, a paired sample t-test was conducted to analyze how participants' functional correction affects foot pressure using the SPSS 21.0 statistical program for Windows. Fourth, Pearson's correlation coefficient, which is a parameter test, was used for correlation analysis by indexes. Fifth, all statistical significance levels were $p<.05$.

Figure 1. Therapeutic process of functional adjustment procedure.



3. Results

3.1. Measurement of foot pressure change before and after functional correction

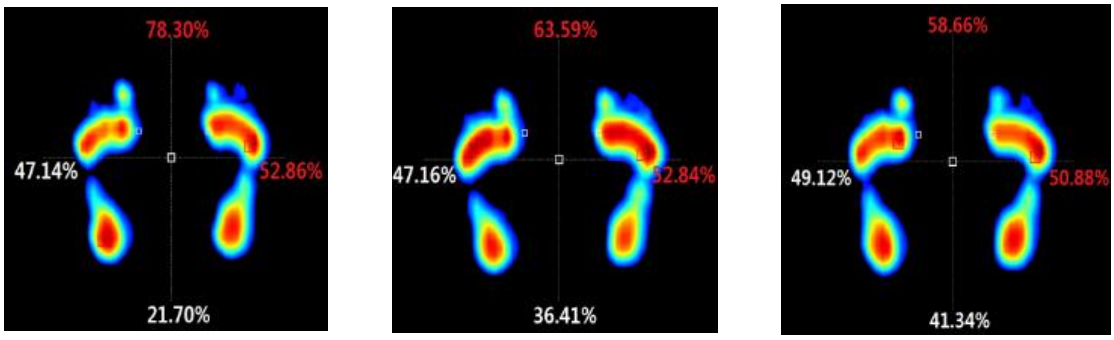
The measures and changes of the left and right foot pressure for the participants in this study before and after treatment, 4 weeks of treatment, and 8 weeks of treatment are as shown in <Table 1>, and the measurements and changes of the front and back foot pressure are as shown in <Figure 2>. To examine the results of analyzing the changes in foot pressure according to the functional correction of the study participants, the changes in the foot pressure of the left and right and the front and back sides showed a more balanced form of foot pressure after conducting functional correction than before conducting functional correction, which is analyzed that there is a statistically significant difference.

Table 1. Analysis of foot pressure change before and after functional correction(unit : %).

Category	Pre	4 weeks	8 weeks	4 weeks		8 weeks	
				t	P-value	t	P-value
Foot pressure (left/light)	10.41±4.70	6.25±3.31	1.70±0.84	4.005	0.002	6.315	0.000
Foot pressure (front/back)	38.25±20.19	27.76±18.02	14.56±12.22	1.972	0.074	4.259	0.001

Note: n=12.

Figure 2. Comparative analysis of foot pressure change of participants 3.



3.2. Measurement of changes in pelvic and spinal displacements of participants

In relation to the pelvic displacement of the participants in this study, the changes of the left and right of the pelvic tilt and pelvic rotation were measured as shown in <Figure 2>, <Figure 3>. In addition, for participants' spinal displacement, the sacrum(Ferguson's Angle) and lumbar lordotic angle were measured. The results of mean, standard deviation, and corresponding sample t-test for the participants' pelvic displacement and spinal displacement are shown in <Table 2> below. There was no statistically significant difference between the lumbar lordotic angle's pre and post displacement among the participants' spinal displacement, but the pre- and post-displacement of Ferguson's Angle showed that there was a statistically significant difference($p<.05$).

Table 2. Pelvic and spinal displacements of participants(unit : mm).

Category	Pre	8 weeks	t	P-value
Left pelvic tilt	222.53±10.60	222.13±11.28	0.479	0.641
Right pelvic tilt	221.86±10.42	222.48±10.65	-7.68	0.459
Pelvic rotation	6.41±3.86	3.38±3.14	3.611	0.004
Ferguson's angle	37.83±5.11	40.50±4.34	-4.257	0.001
Lumbar lordotic angle	37.75±7.88	39.50±5.22	-0.922	0.377

Note: n=12.

Figure 3. Thermography comparative analysis before and after x-ray of pelvic displacement of participant 11.

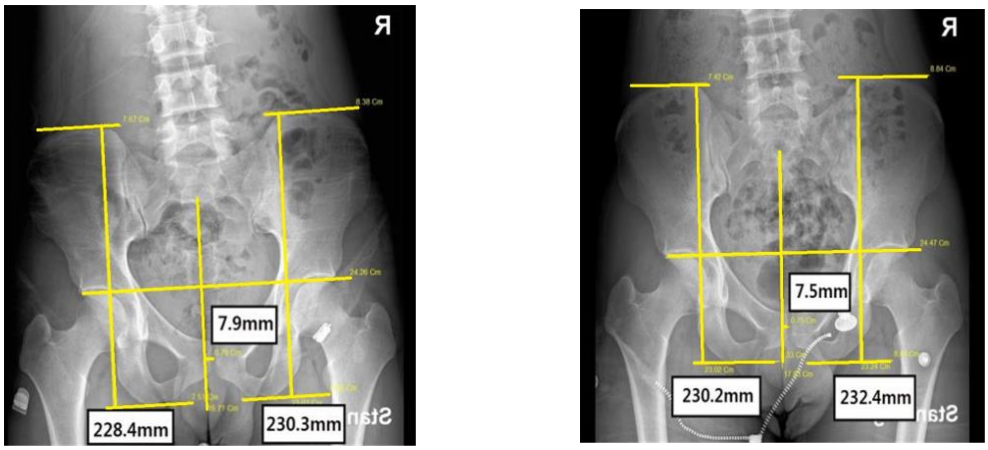
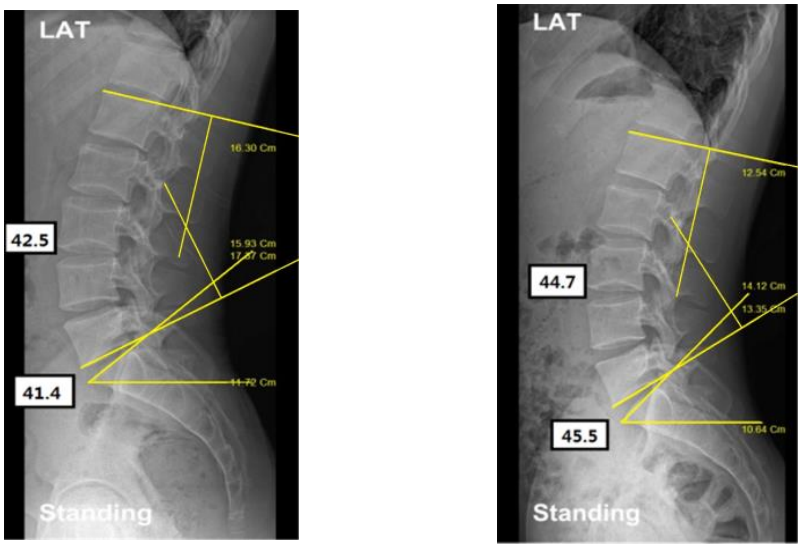


Figure 4. Thermography comparative analysis before and after x-ray of spine displacement of participant 11.



3.3. Correlation between participant's foot pressure, pelvic displacement and spinal displacement

Pearson correlation analysis was performed to examine the relationship between pelvic displacement and spinal displacement and foot pressure ratio left-right, front-back after study participants' functional correction. According to the analysis results, the left pelvic tilt among the pelvic displacements showed a significant relationship with the foot pressure left-right ratio($p<.01$), and there was also a significant relationship with the foot pressure front-to-back ratio($p<.01$, $p<.05$). Among pelvic displacements, the right pelvic tilt showed no significant relationship with foot pressure left-right ratio, and among the front and back foot pressure ratios, there was a significant correlation with the front ratio($p<.05$).

Among the pelvic displacements, pelvic rotation showed a significant relationship in both foot pressure left-right ratio and foot pressure front-to-back ratio($p<.01$). Meanwhile, among spinal displacements, Ferguson's Angle showed a significant relationship in both the foot pressure left-right ratio and the foot pressure front-to-back ratio($p<.01$). The lumbar lordotic angle showed a statistical significance only in the foot pressure left-right ratio($p<.01$).

Table 3. Correlation between participant's foot pressure, pelvic displacement and spinal displacement.

Category		After functional correction			
		Ratio		Ratio	
		Left	Right	Front	Back
Pelvic displacement	Left pelvic tilt	-.233(**) .005	.231(**) .005	-.223(**) .007	.203(*) .015
	Right pelvic tilt	-.151 .071	.148 .076	-.176(*) .035	.160 .055
	Pelvic rotation	.234(**) .005	-.235(**) .005	-.532(**) .000	.530(**) .000
Spinal displacement	Ferguson's angle	-.261(**) .002	.263(**) .001	.315(**) .000	-.314(**) .000
	Lumbar lordotic angle	-.293(**) .000	.293(**) .000	-.117 .161	.105 .210

Note: *p<.05, **p<.01.

4. Conclusion

This study started with the hypothesis that functional correction can bring positive changes in foot pressure and X-rays. About the results obtained for the participants, this study attempts to elaborate them by dividing them into three categories such as changes in foot pressure, pelvic displacement and spinal displacement analysis through X-ray, and changes in the correlation between foot pressure ratio and pelvic and spinal displacement.

First, in the results of conducting the t-test of the corresponding sample to find out the difference between the post-treatment(4 weeks, 8 weeks), it was found that after 4 weeks of functional correction, the left and right foot pressures and after 8 weeks of functional correction, there was a significant difference between the left-right and front-back foot pressures in the pre and post displacements. According to a previous study[9], the greater the degree of scoliosis, the larger the left-right body imbalance, which affects foot pressure, and foot balance is closely related to posture balance, and abnormal movement of the center of gravity affects spinal deformity and postural imbalance. A study comparing weight support rates on both lower extremities when standing up in patients with low back pain[10] showed that weight support rates were lower in the lower extremities with no pain than those of the painless side. According to another study[11], it was reported that supporting the weight mainly toward the painless side appeared to reduce the pain caused by muscle contraction around the lumbar spine and pelvic when standing with the painful lower limb.

Second, this is the content analyzed by numerating in values the changes of pelvic tilt and pelvic rotation among pelvic displacements before and after functional correction. Looking at the results of the study, statistical differences in functional correction treatment were found in measuring pelvic rotation rather than pelvic tilt, and previous studies[3][12][13] also show similar research results.

Among the vertebral displacements, when the angle change for Ferguson's Angle and lumbar lordotic angle is quantified, and the results after functional correction analyzed before and after functional correction are examined, a statistical difference in functional correction treatment was found in the measurement of Ferguson's Angle. The mean of male and female lumbar lordotic angles in Korea is about 41.7°, and that of the normal group's lumbar lordotic angles is 44.5°[14][15].

The increase of the lumbar lordotic angle requires greater weight support for the hip joint, and the reduction of lumbar lordotic angle requires greater weight support on the intervertebral disc, the degree of degenerative change occurs earlier than the other area, and it is said to be an important cause of clinical low back pain[16].

Ferguson's Angle is generally a reference range from 30° to 57°, and this range is so wide that it is known to have little clinical significance. However, increasing Ferguson's Angle increases lumbar lordosis, and its decrease lumbar lordosis and increases shearing force, so that it is a factor inducing back pain by applying pressure to the back ligament and facet joint [17][18]. In this study, however, compared to before the functional correction, the mean of Ferguson's Angle and lumbar lordotic angle increased when it comes closer to the second half, but statistical significance was higher in Ferguson's Angle than in lumbar lordotic angle($p<.05$).

Third, it is about the analysis of the correlation between foot pressure ratio and pelvic displacement and vertebral displacement before and after functional correction. According to studies on the relationship between scoliosis and foot pressure, the deviation of the tendency of the center of foot pressure in both feet was significantly correlated with the degree of scoliosis, and scoliosis only affects foot imbalance[19]. In the relationship between foot pressure distribution and spinal alignment in a static standing position, the lumbar lordotic

angle was significantly correlated with the mean pressure of the right foot and the foot pressure of the area behind the left foot[20]. In this study, the correlation between pelvic displacement and vertebral displacement before functional correction was found to have a significant relationship only with the lumbar lordotic angle, the vertebral displacement item, and the left-right and front-back foot pressure ratios.

What we can derive from the above is that the pelvic indicators in chronic low back pain patients are more related to the foot pressure imbalance in the walking state than the foot pressure imbalance in the standing state[21]. It can be seen that the results of these studies are similar to those of[3][19] as a result of studying the correlation between pelvic displacement and foot pressure in patients with low back pain.

This study confirmed that functional correction treatment had a significant effect on pelvic displacement and spinal displacement overall, positively affecting the balance between the trunk and lower limbs, improving the difference in foot pressure and improving body stability. Low back pain impairs the ability to maintain balance, distorts normal signals from the muscles and the highly soluble sensory organs, leading to an increase in the physiological and mechanical stress of the musculoskeletal system. Due to this, it is judged that the correct performance mechanism for distribution of weight load is different, and more detailed studies will be needed in the future.

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6. Contribution

6.1. Authors contribution

	Initial name	Contribution
Lead Author	YSJ	-Set of concepts ☑ -Design ☑ -Getting results ☑ -Analysis ☑ -Make a significant contribution to collection ☑ -Final approval of the paper ☑
Corresponding Author*	LJB	-Corresponding ☑ -Play a decisive role in modification ☑
Co-Author	KHW	-Significant contributions to concepts, designs, practices, analysis and interpretation of data ☑ -Participants in Drafting and Revising Papers ☑ -Someone who can explain all aspects of the paper ☑

6.2. Authors profile

Lead Author
Yang Seo-jun / Myongji University Researcher
B.A. Sunlin University
M.A. Myoungji University

Research field
- Effect of Functional Correction on Foot Pressure Balance, Pelvic Displacement and Spinal Displacement in Patients with Low Back Pain, Kinesiology, 5(1) (2020).

Major career
- 2020~present. International Society for Kinesiology, Member

Corresponding Author
Lee Jae-bum / Myoungji University Professor
B.A. Myoungji University
M.A. Myoungji University
Ph.D. Myoungji University

Research field
- Effects of Motion Taping on Muscle Tone, Muscle Stiffness, and Pain in Middle-aged Women with Shoulder Impingement Syndrome, Journal of PNF and Movement, 17(3) (2019).
- Effect of Functional Adjustment Procedure on Pain, Dysfunction and, Health-related Quality of Life in Patients with Chronic Low Back Pain, Journal of Korean Society of Medical Physics, 15(2) (2020).

Major career
- 2012~2018. Gimpo Community Health Center, Healt Care Examiner
- 2018~present. Korea Health Qigong Association, Special Advisor

Co-Author
Kim Hyun-woo / Dongbang Culture University Researcher
B.A. Kyungwoon University
M.A. Namseoul University

Research field
- A Study on the Application of Prescriptions Blended Angelicae Pubescentis Radix in Dongeuibogam, Namseoul University, Master's Thesis (2016).

Major career
- 2020~present. International Society for Kinesiology, Member