ISSN 2733-6441 / eISSN 2733-645X
http://dx.doi.org/10.26862/jkpts.2025.12.32.4.95

대한물리치료과학회지
Journal of Korean Physical Therapy Science
2025. 12. Vol. 32, No 4, pp.95-110

Comparison of Effects of Core Stabilization Exercise according to Mirror Visual Feedback and Video Visual Feedback on Static and Dynamic Balance in College students with Low Back Pain

Kyung Tae Yoo, Ph.D., P.T., Prof.

Dept. of Physical therapy, Namseoul University, Republic of Korea

Abstract

Background: The purpose of this study was to compare the effects of core stabilization exercises according to mirror visual feedback (MVF) and video visual feedback (VVF) on static balance and dynamic balance in college students with low back pain (LBP).

Design: Randomized Controlled Trial.

Methods: The subjects were 20 college students with LBP. They were randomly devided into two groups: MVF group (n=10) and VVF group (n=10). They performed core stabilization exercises for 30 minutes, three times a week for four weeks. The exercises of three times included once in face to face and twice non-face to face. They measured the static balance and dynamic balance before and after exercise.

Results: In static balance, 90% confidence elliptical area (C90 area), which is the range of movement of the center of pressure, with eyes open in the MVF group was significantly lower than in VVF group. Trace length with eyes open and C90 area and trace length with eyes closed were significantly higher in the MVF group than in the VVF group. C90 area and trace length with eyes open and closed were significantly decreased in both groups after the exercises. In dynamic balance, there was no significant difference.

Conclusion: Core stabilization exercises with MVF and VVF may help increase static balance. And the MVF is more effective in improving balance than VVF in college students with LBP.

Key words: Dynamic balance, Low back pain, Mirror visual feedback, Static balance, Video visual feedback

Corresponding author
Prof. Kyung Tae Yoo
31020 91 Daehak-ro, Seonghwan-eup, Seobuk-gu, Cheonan-si, Chungcheongnam-do, Namseoul University
T: 041-580-2533, E: taeyoo88@nsu.ac.kr

Received 2025-03-10 / Revised 2025-04-20 / Accepted 2025-05-03

Ⅰ. Introduction

Everyone experiences low back pain (LBP) at least once in their lives (Lee, 2013). Low back pain is generally defined as muscle tension or stiffness pain localized between the costal margin and the inferior gluteal fold, regardless of leg pain. LBP is classified as non-specific pain, in which the physiopathological cause cannot be identified, and specific pain, mainly caused by hernia, fracture, osteoporosis, rheumatic disease, spinal arthrosis, infection, or cancer. Also, LBP is classified as acute for less than 6 weeks, subacute for between 6 weeks and 3 months, or chronic for more than 3 months based on the duration of the disease (Koes et al., 2006; Lippi & Mattiuzzi et al., 2020). The causes of LBP include muscle weakness due to lack of exercise and spinal instability due to improper posture (Choi, 2007; Park, 2001; Anthony, 1995). Conversely, LBP causes muscle atrophy, and muscle atrophy can reduce postural balance ability (Yang et al., 2004). In addition, various biopsychosocial factors lead to chronic LBP (CLBP) disorders (Kim et al., 2020; Steelman et al., 2018). In particular, students have a habit of sitting too long, maintaining uncomfortable postures for long periods of time, which results in high static muscle loads (Mozafari et al., 2015; Casas et al., 2016; Anggiat, et al., 2018). Students with LBP were unable to perform academic activities, which negatively impacts their LBP (Casas et al., 2016; Anggiat, et al., 2018). Long-term, severe LBP also impact the quality of life (QOL) of the college student population. The impact of CLBP on QOL, symptoms of depression and anxiety, impairment impairment in work and daily activities, and use of heath care increased with the severity of pain (Montgomery et al., 2016).

Core stabilization exercises have been suggested to improve LBP. Core stabilization exercises strengthen the lumbar muscles, restore the ability to control movement and muscles, and increase the stability of the back area (Hyung, 2008). Core stabilization exercises that strengthen deep muscles are correlated with the prevention of LBP (Yoon & Park, 2020), and are widely used as a lumbar stabilization exercise program for patients with LBP among musculoskeletal diseases (Moon et al., 2020). Core stabilization exercises performed on patients with CLBP can improve functional activities along with hospital-based treatment for pain reduction (Jung et al., 2020). Visual feedback for people suffering from chronic neck pain and CLBP is a novel approach based on an individual's perception of the painful area. In particular, visual feedback is an innovative therapeutic approach whose effectiveness has not yet been systematically reviewed for people with CLBP and chronic neck pain (Heinrich et al., 2020). It is very effective in motor learning to confirm the movements applied to the subject through visual stimulation (Schuett et al., 2008).

Action observation (AO) is an effective way to promote motor skill learning (Bähr et al., 2018), and feedback strategies that guide motor movements have been extensively studied to improve movement interaction (Cavalcanti et al., 2019). Feedback is divided into intrinsic feedback or sensory feedback and extrinsic feedback or augmented feedback depending on the source of information. The extrinsic feedback is used for motor learning (Sin et al., 2015). The extrinsic feedback includes current feedback, which provides information during motor performance, and knowledge of result and knowledge of performance, which provide information after the response is completed (Cynn et al., 2004). Among various feedback strategies, both intrinsic and extrinsic visual feedback can affect balance control, and extrinsic visual feedback can provide individuals with more information, such as knowledge of result and knowledge of performance, for balance control (Hung, 2022). Among various types of visual feedback, mirror visual therapy (MVF) is well known as mirror therapy and has been studied based on motor learning strategies (Bai et al., 2020) and is a pshychophysiological technique for the rehabilitation of people with chronic regional pain syndrome, stroke, and other types of motor disorder, with the aim of improving motor function or releasing pain (Reissig et al., 2015). A mirror is a source of visual information that allows one to see one's own form at any point in the movement, and enables self-analysis and self-correction (Lynch, 2006). Video visual feedback (VVF) is an effective educational tool (Halim et al., 2021; Cope et al., 2015) and improved an accuracy of self-assessments (Halim et al., 2021; Rizan, et al., 2015). The VVF is a more effective method than verbal feedback (Schoenmaker et al., 2023), and its use is increasing due to the advantages of video communication as remote technology develops (Eriksson et al., 2009).

Balance plays an important role in daily life as it is necessary for our activities such as maintaining stable posture, performing physical exercises, and responding appropriately to various stimuli (Wang et al., 2022; Pollock et al., 2000). Maintaining balance is closely related to vision, equilibrium, proprioception, and lower extremity muscle stability (Russo et al., 2008), and asymmetric gait patterns may appear due to spinal instability caused by changes in muscle strength due to LBP (Kang & Jeong., 2013). Interventions using visual feedback on trunk movements in patients with LBP have been shown to improve proprioception (Alemanno et al., 2019).

Core stabilization exercise programs for patients with CLBP improved functional activities, which could relieve pain and contribute to a stable role in functional activities including daily living abilities (Park, 2012). Core stabilization exercise reduced the pain index of patients with CLBP and significantly increased lumbar stabilization balance ability (Jeon, 2021). In addition, core stabilization exercise contributed to trunk stability as it significantly improved static and dynamic balance ability after exercise (Choi et al., 2018). And mat Pilates exercise including core stabilization exercise with visual feedback using a mirror significantly increased static and dynamic balance ability in patients with chronic stroke (Lim et al., 2019).

Although there have been many studies on core stabilization exercise programs for people with LBP and studies on core stabilization using visual feedback, there are most studies on the presence or absence of visual feedback and on targeted neurological patients performing core stabilization exercises with visual feedback. The results of these studies have limitations in utilizing them according to the type visual feedback for musculoskeletal disorders and in applying them to musculoskeletal disorders such as LBP. Therefore, the purpose of this study was to perform core stabilization exercises using MVF and VVF to college students with LBP in their 20s and compare the effect of theses visual feedback types on static and dynamic balance.

II. Methods

1. Subjects

This study selected 20 people in their 20s who were students at N University in Cheonan and met the criteria for mild LBP. Korean version of Oswestry Disability Index (K-ODI) classifies disability into minimal disability (0–20%), moderate disability (21–40%), severe disability (41–60%), crippling back pain (61–80%), and bed-bound or an exaggeration of their symptoms (81–100%) (Bryndal et al., 2020; Jeon et al., 2005). In this study, the subjects corresponding to 'minimal disability' were selected (Revord et al., 2016).

The number of subjects in this study was calculated to be based on a previous study that applied exercise to patients with CLBP, using G*power software version 3.1.9.7 (Universität Kiel, Düsseldorf, Germany) with an effect size of 1.690108, a significance level of .05, and a power of .08 for an independent sample T-test (Mun et al., 2022). The calculated number was 18, and considering the dropout rate of 10%, two more subjects were added, making a total of 20 subjects. They heard an explanation of the experimental procedure and fully understood it, had no problem performing the experimental procedure, and voluntarily agreed to participate in the experiment in advance and signed the informed consent form in accordance with the declaration of Helsinki.

The exclusion criteria were (1) those who with musculoskeletal diseases that could affect the experiment, (2) those who with neurological diseases that could affect the experiment, (3) those who with a history of surgery that could affect the experiment, (4) those who with a use of drugs that could affect the experiment, and (5) those whose LBP condition could not be classified.

2. Apparatus

In this study, a body composition analyzer (Inbody, Biospace Co. Ltd, Seoul, Republic of Korea) was used to determine the general characteristics of the subjects. A professional balance assessment and training system (Balance trainer BT4, HUR labs Oy., Tampere, Finland) was used to measure the subjects' balance ability.

3. Study procedure

1) Study design

In this study, 20 people with mild LBP who fully understood the purpose and content of the experiment and agreed to the research informed consent form participate. To select subjects with mild LBP, ODI-K questionnaire was used, and their physical characteristics were measured. Among them, 10 were randomly divided into a mirror visual feedback (MVF) group and 10 were divided into a video visual feedback (VVF) group.

The core stabilization exercise program with visual feedback using mirrors and images was conducted for 30 minutes, three times a week for four weeks. The face-to-face method was applied once out of the three times a week, and the non-face-to-face method was applied twice a week. In the non-face-to-face exercise, the subject filmed the exercise video from the side and the researcher provided feedback. The MVF group exercised while checking their postural alignment with a full-length mirror at the side, and the VVF group exercised while watching video materials on their personal devices (Choi & Yoon, 2020). Each group measured static and dynamic balance before and after exercise.

2) Measurement methods

(1) ODI

ODI was used to select subjects who met the criteria for LBP. ODI was developed as a patient-centered and patient-life evaluation method. It is a clinical evaluation tool expressed as a percentage of the estimated disability and consists of 10 items: pain, personal management, lifting, walking, sitting, standing, sleeping, sex life, social life, and traveling (Pekkanen et al., 2011; Davidson, 2008). In this study, nine items were surveyed except for the section eight – sex life. The reliability of K-ODI is .9168 (Cronbach's α=.9168), the reliability coefficient for each annotation is .7 or higher (r>.7), and the test-retest reliability coefficient of K-ODI is .9331 (test-retest reliability, r=.93) (Jeon et al., 2005).

(2) Balance

Static balance ability and dynamic balance ability were measured using a balance trainer BT4. The reliability of the BT4 is excellent reliability (ICC=.77-.94) (Granacher et al., 2011). For static balance ability, the Romberg test with eyes open and eyes closed was used. The measurement posture was one-leg stance posture with the non-dominant foot with barefoot and then stand as stable as possible with the other leg with 30 degrees of knee flexion. The measurement time was measured for 30 seconds both with eyes open and eyes closed (Chae et al., 2018). The non-dominant foot was defined as the opposite foot that kicked a ball (Chowning et al., 2021).

For dynamic balance ability, a test of the limits of stability (LOS) was used. The LOS is measured the maximum limit of voluntary movement that can be maintained by measuring the extent to which the center of pressure moves in the forward, backward, left, and right directions from a two-leg stance posture (Kang et al., 2014). The subject kept two-leg stance posture with his bare feet aligned with the gradations on the platform and was able to recognize his own degree of inclination while watching the real-time target on the monitor. The subject performed movements in which they tilted their bodies as much as possible in the forward, backward, left, and right directions for 8 seconds each (Chae et al., 2018).

3) Exercise program

The core stabilization exercise program was modified and supplemented from previous studies (Jeon, 2021; Kim, 2021; Ifeyinwa et al., 2021; Kwon et al., 2019; Lee et al., 2019), and consisted of a total of 30 minutes, five minutes of warm-up exercise, 20 minutes of main exercise, and five minutes of cool-down exercise. Stretching exercises were performed as warm-up exercises (Jeon, 2021), and abdominal breathing was performed as cool-down exercises (Choi, 2018). The main exercise was consisted of five exercises: bridge exercise, dead bug exercise, bird dog exercise (Lee, 2019), crunch exercise, and leg raise exercise (Ifeyinwa et al., 2021). To prevent the subjects from adapting, the difficulty was adjusted. Two sets were performed in the 1st and 2nd weeks, and three sets were performed in 3rd and 4th weeks with an increased number of repetitions (Kwon et al., 2019) (Table 1).

Table 1. Core exercise program (for four weeks)

Exercise	Contents	Intensity		Time
Warm-up	Stretching exercise			5 min
Main	1. Bridge exercise 2. Dead bug exercise 3. Bird dog exercise 4. Crunch exercise 5. Leg raise exercise	1-2 weeks	10 times * 2 sets 10 s rest between the sets	20 min
		3-4 weeks	10 times * 3 sets 10 s rest between the sets	30 min
Cool-down	Abdominal breathing			5 min

4. Statistical analysis

The data measured were analyzed using SPSS (Statistical Package for the Social Sciences) version 23.0 (IBM Corp., Chicago, Illinois, USA). Shapiro-Wilk test was used to verify normality. Levene F-test was used to verify homogeneity. Independent T-test was used to compare the changes in static and dynamic balance between the two groups. Paired T-test was used to compare the changes in static and dynamic balance within each group. Statistical significance level α was set at .05.

Ⅲ Results

1. General characteristics of the subjects

The subjects of this study were 20 people with mild LBP (ODI (%) = 9.10±4.72). In the MVF group, mean age was 21.60±3.20 years, mean height was 169.14±7.42 cm, mean weight was 68.09±11.03 kg, mean BMI was 23.96±4.76 kg/m^2, and mean ODI was 7.99±3.50 %. In the VVF group, mean age was 20.10±1.96 years, mean height was 172.74±5.37 cm, mean weight was 76.35±14.06 kg, mean BMI was 25.48±3.99 kg/m^2, and mean ODI was 7.99±3.50 %. Homogeneity was demonstrated in gender, age, height, BMI, and ODI (Table 2).

Table 2. General characteristics of the subjects (n=20)

Variables	MVF (n=10)	VVF (n=10)	F	p
Gender (F/M)	3/7	2/8	.987	.334
Age (years)	21.60±3.20	20.10±1.96	.469	.502
Height (cm)	169.14±7.42	172.74±5.37	1.044	.320
Weight (kg)	68.09±11.03	76.35±14.06	.753	.753
BMI (kg/m^2)	23.96±4.76	25.48±3.99	.028	.870
ODI (%)	7.99±3.50	10.21±5.66	2.567	.127

Expressed as mean±SD; ODI=Oswestry disability index; BMI=body mass index; MVF=mirror visual feedback group; VVF=video visual feedback group

2. Balance

1) Static balance

As a result of comparing static balance between groups, in the eyes open, the 90% confidence elliptical area (C90 area), which is the range of movement of center of pressure, in the MVF group was significantly lower than in the VVF group (p<.05). The trace length in the MVF group was significantly higher than in the VVF group (p<.05). In the eyes closed, the C90 area and the trace length in the MVF group was significantly higher than in the VVF group (p<.05).

As a result of comparing static balance within each group, in the eyes open, the C90 area and trace length in both the MVF group and the VVF group showed significant decreases after exercise compared to before exercise (p<.05). In the eyes-closed state, the C90 area and trace length in both the MVF group and the VVF group showed significant decreases after exercise compared to before exercise (p<.05) (Table 3).

Table 3. Result of change of static balance

Variables		Group	Pre-test	Post-test	Change	t	p
Eyes open	C90 area (mm^2)	MVF	853.70±175.13	674.11±159.46†	-176.58±176.95	-2.250	.046*
		VVF	886.99±114.37	575.281±115.59†	-311.71±56.30		
	Trace length (mm)	MVF	1164.39±173.74	713.72±191.13†	-450.67±234.93	.947	.045*
		VVF	1116.79±283.93	879.621±277.30†	-237.16±208.12		
Eyes closed	C90 area (mm^2)	MVF	2465.01±455.61	1576.29±269.81†	-888.72±235.00	2.174	.043*
		VVF	2274.89±416.47	1612.74±419.77†	-662.15±230.89		
	Trace length (mm)	MVF	2024.86±286.85	1428.00±210.17†	-596.85±286.39	2.538	.022*
		VVF	1905.93±359.32	1587.07±365.33†	-318.86±194.63		

Expressed as mean±SD; *p<.05 significant difference between groups; †p<.05 significant difference within group; C90 area=90% confidence elliptical area; MVF=mirror visual feedback group; VVF=video visual feedback group

2) Dynamic balance

As a result of comparing dynamic balance between groups, no significant difference was found in Forward, Rearward, Leftward, and Rightward for both groups.

As a result of comparing static balance within each group, no significant difference was found in Forward, Rearward, Leftward, and Rightward for both groups (Table 4).

Table 4. Result of change of dynamic balance

Variables	Group	Pre-test	Post-test	Change	t	p
Forward (degrees)	MVF	4.66±2.44	5.05±1.84	0.39±3.05	0.857	0.403
	VVF	5.32±1.84	6.79±1.60	1.47±2.57		
Rearward (degrees)	MVF	3.24±2.37	5.24±1.75	1.99±3.78	-0.824	0.423
	VVF	3.70±1.66	4.56±1.37	0.86±2.14		
Leftward (degrees)	MVF	12.37±15.42	5.83±0.77	-6.54±15.71	1.487	0.154
	VVF	5.10±1.26	5.98±1.46	0.87±1.36		
Rightward (degrees)	MVF	10.49±10.62	6.21±0.81	-4.27±10.86	1.475	0.157
	VVF	5.06±0.88	5.89±1.90	0.82±1.34		

Expressed as Mean±SD; $^{*}p<.05$ significant difference between groups; $^{\dagger}p<.05$ significant difference within group; MVF=mirror visual feedback group; VVF=video visual feedback group

Ⅳ. Discussion

Core stabilization exercises maximize the mobility and stability of the spine (Brill and Couzen, 2002). Core stabilization exercises can be applied to patients with various diseases and improve muscle strength, balance, back pain reduction, and walking ability, allowing them to live a better life (Choi et al., 2012). In addition, lumbar stabilization exercises with visual feedback have a correlation with the prevention of back pain and exercise rehabilitation (Yoon & Park, 2020). In this study, 20 college students with LBP in their 20s were divided into the MVF group and the VVF group and they performed a core stabilization exercise program for 30 minutes, three times a week, for four weeks, once face-to-face and twice non-face-to-face, to compare the effects of these visual feedback types on static and dynamic balance.

1. Static balance

In this study, the results of the comparison of static balance between groups showed that the C90 area with eyes open the MVF group was significantly lower than in the VVF group. The VVF provides information on the kinematic characteristics of movement and is very effective in learning multi-degree-of-freedom movements that require coordination of body segments. When verbal transitional information and VVF were provided together, the learning effect was significantly more useful than when only verbal transitional information was provided. It was reported because the VVF was additionally provided through a mobile phone after the transitional information was given, learners could more usefully detect their movement errors by using the kinematic information of the video (Ko & Seo, 2012). For VVF to provide a more positive learning effect, attention cues, error correction information, and expert model videos should be provided together (Ko, 2013). As a result of muscle strengthening exercise using video for frail elderly people, static balance and grip strength significantly increased in the exercise group, and dynamic balance ability and walking function also significantly improved. It was reported because exercise programs using videos are useful in improved exercise performance (Lee & Park, 2013). Therefore, in this study, the reason why the C90 area with eyes open in the MVF group showed a significantly lower than in the VVF group is thought to be because the VVF provides information related to kinematic characteristics, which is effective for learning multi-degree-of-freedom movements related to the coordination of the subjects' body segments. And, unlike MVF, the information provided through the VVF allows them to recognize their movement errors, it offers error correction through face-to-face and non-face-to-face methods and provided verbal and visual an additional information about the video together after core stabilizatin exercise, so the learning effect is improved through repeated feedback, motor performance ability was improved. It thought to be contributed to increasing balance ability for the subjects.

In this study, the results of the comparison of the static balance between groups showed that the trace length with eyes open and the C90 area and trace length with eyes closed in MVF group was significantly higher than in the VVF group. In a previous study, it was reported that the most effective approach for improving the performance of the target effector was MVF among MVF, VVF, and a combination of the two as the motion observation methods of the non-dominant hand. It was reported because during execution in front of a mirror, visual-motor and sensorimotor inputs are mediated only by observing one's own movement through the mirror. Due to the optical illusion during observation, the action observation network (AON) is supplied with information that matches the execution of the resting target effector. At the same time, sensorimotor inputs are transmitted through additional networks as result of the actual execution with the performing non-target effector. As a result of, a more holistic schema is constructed than the simple observation training video, and this is reflected in the greater motor performance of the untrained hand after training with MVF (Bähr et al., 2016). Although visual-motor and sensorimotor inputs via the AO alone cannot fully explain the positive effects during MVF training, inter-regional interactions are more important than inter-hemispheric interactions between primary motor cortices for performance enhancement when mirror visual feedback is used (Hamzei et al., 2012; Lappchen et al., 2012). Trunk flexion exercises with VVF via a virtual mirror avatar were effective in improving body awareness and abnormal movement in patients with CLBP while MVF was moving (Roosink et al., 2015). When visual feedback was provided through an avatar projecting one's own image in real time, movement errors among the adults in their 20s, were significantly reduced. It was reported because the visual feedback enabled the subjects to recognize and control their own movements, thereby reducing errors and creating accurate movements (Kim et al., 2011). Therefore, the reason why trace length with eyes open and C90 area and trace length with eyes closed in the MVF group showed significantly higher than in the VVF is thought to be because MVF acts as a source of simultaneous visual information enables self-analysis and correction through visual stimulation via a mirror, helps improve body awareness and movement, and has a positive effect on motor learning. In addition, this study also provided feedback to the VVF group, but unlike the VVF that provides information only through the observed video, the advantage of MVF is that it provides holistic training by combining the input received through the AON and sensorimotor input through actual execution, which it enhances the interaction between areas of the primary motor cortex. Thus, it is thought that because the MVF group was improved balance more effectively balance ability than the VVF group because controlling movements and decreasing movement errors resulted in improving abnormal movements and producing accurate movements in the MVF group.

In this study, the results of the comparison of the static balance within groups showed that the C90 area and the trace length with eyes open and eyes closed was significantly decreased in both groups. As a result of performing core stabilization exercise for patients with CLBP, static balance ability significantly increased as trunk muscle strength improved. It was reported that this was because the core stabilization exercise enable the trunk muscles to support the trunk well (Choi et al., 2018). And static balance ability significantly increased as spinal shape and fall-related physical strength improved after performing core stabilization exercise for elderly women (An & Ahn, 2016). A previous study that performed an exercise therapy program with MVF for stroke patients reported that by replacing the reduced proprioceptive information with positive visual feedback while observing the non-paretic upper limb performing normal movements through a mirror, the premotor cortex to accompany the rehabilitation of the motor area (Uhm, 2015). Trunk stabilization exercise program with a face-to-face and non-face-to-face groups in their 20 showed statistically significant decreases in length and area before and after exercise with eyes open and closed. This was reported to be because trunk stabilization exercise using a non-face-to-face method improved balance, even though it was not face-to-face method (Lee & Jeong, 2021). Pilates exercise applied face-to-face and non-face-to-face together through a video conference program targeting in healthy adult women was effective for flexibility, joint range of motion, and muscle endurance (Hwang et al., 2023). Therefore, the fact that both groups showed significant improvement in static balance before and after exercise in this study is thought to be because the core stabilization exercise with visual feedback using mirrors and videos had a positive effect on improving strengthening trunk muscles that provided trunk support, and lower extremity stability in subjects with LBP. And the visual feedback contributed to postural control by integrating afferent information from the vestibular and somatosensory senses and helped reduce postural sway, thereby improving postural control ability.

2. Dynamic balance

In this study, there was no significant difference in dynamic balance between groups. AO is a clearly effective method to improve motor skill learning (Bähr et al., 2016). The greatest advantage of the AO concept is that it has the effect of improving motor performance before actual execution occurs, because the actions depicted in the video convey visualmotor and sensorimotor information to the observer, which includes the goal of the action on the one hand and how to perform the action correctly on the other hand (Bähr et al., 2016; McGregor et al., 2016; Williams & Gribble, 2012; Mattar &

Gribble, 2005). MVF enables correct execution by seeing one's own actions in relation to the mirror neural system area (Steinberg et al., 2016). In a previous study that performed Pilates exercises including core stabilization exercises according to use a mirror, body alignment was improved within the group regardless of the presence of a mirror after exercises. Thus, including MVF in the learning environment to provide immediate visual feedback did not necessarily improve performance of subsequent skills compared to when it was not included. It was reported because a mirror is just one of many practice elements that influence skill performance (Lynch, 2009). Therefore, the no significant difference in dynamic balance between the groups is thought to be because visual feedback types using a mirror and a video were acted as one of severeal practice factors affecting balance performance, thus MVF and VVF did not improve subsequent skills enough to affect the difference in dynamic balance between the groups.

There were no significant differences in dynamic balance within both groups. In a previous study that performed core stabilization exercise in college athletes, there was no statistically significant increase in dynamic balance ability due to exercise on a stable support surface (Shin et al., 2020). When spinal stabilization exercise was performed for patients with scoliosis, the anterior, posterior, left, and right sway distance was significantly decreased only in the unstable support surface group (Lee et al., 2012). Dynamic balance ability significantly increased only in the unstable support surface group after Bulgarian split squat exercise using visual block and an unstable support surface in healthy men in their 20s. It was reported because a method using the unstable support surface increased balance ability (Yang et al., 2023). Therefore, the reason why no significant difference was found is thought to be because, unlike methods of adjusting difficulty, such as applying an unstable support surface, which can affect the improvement of dynamic balance ability, the method of adjusting difficulty in this study did not affect the improvement of dynamic balance ability in the young adults with mild LBP despite the use of visual feedback.

The limitations of this study were first, it was limited to generalizing the results by applying it for a short period of time for 20 young adults with mild LBP. Second, it was not possible to provide feedback on the kinematic aspect in the overall direction for each session. Third, a method of increasing the number of sets was applied instead of a method of using an unstable support surface in adjusting the difficulty level in order to prevent the subject from adapting. Fourth, the environmental factors of the individual where the exercise learning took place were not controlled. Therefore, future studies are needed to supplement these points and conduct better research.

V. Conclusion

This study compared the effects of core stabilization exercises using MVF and VVF on static and dynamic balance in adults in their 20s with mild LBP by applying face-to-face and non-face-to-face methods.

In the results of the comparison of static balance between groups, the C90 area with eyes open in the

MVF group was significantly lower than in the VVF group. And the trace length with eyes open and the C90 area and trace length with eyes closed in MVF group was significantly higher than in the VVF group. In the results of comparing static balance within groups, there was significant differences in the C90 area and the Trace length with the eyes open and eyes closed in both MVF group and MVF group. In the result of the comparison of dynamic balance between and within groups, there was no significant difference in either group.

These results suggest that both MVF and VVF through face-to-face and non-face-to-face methods can improve the subject's static balance. And MVF can increase brain interaction and reduce movement errors by providing real-time visual feedback by observing one's own movements. MVF can improve motor performance and be more effective than video visual feedback in increasing static balance of college students with LBP.

【 Acknowledgements 】

Funding for this paper was provided by Namseoul University year 2024.

Reference

An SS, Ahn YD. The Effects of Core Stability Training on SFT Physical Fitness and Balance Ability in Elderly Women. KJS. 2016;14(3):511-524.

Alemanno F, Houdayer E, Emedoli D, et al. Efficacy of virtual reality to reduce chronic low back pain: proof-of-concept of a non-pharmacological approach on pain, quality of life, neuropsychological and functional outcome. PLoS One. 2019;14(5):1-15.e0216858.

Anggiat L, Hon WHC, Baait SN. The incidence of low back pain among university students. Pro-Life. 2018;5(3):677-687.

Anthony HW. Diagnosis and management of low back pain and sciatica. American Family Physician. 1995;52(5):133-134. Choi JH. Effects of Ultrasound and Laser Therapy in Patients With Sub-Acute Lower Back Pain. PTK, 2007;14(2):76-84.

Bähr F, Ritter A, Seidel G, et al. Boosting the motor outcome of the untrained hand by action observation: mirror visual feedback, video therapy, or both Combined—What is more effective?. Neural plasticity, 2018;1:1-10.

Bai Z, Fong KN, Zhang J,et al. Cortical mapping of mirror visual feedback training for unilateral upper extremity: A functional near-infrared spectroscopy study. Brain and behav. 2020;10(1):1-13.

Brill PW, Couzen GS. The core program. 1st ed. New York: Bantam Book. 2002.

Bryndal A, Majchrzycki M, Grochulska A, et al. Risk Factors Associated with Low Back Pain among A Group of 1510 Pregnant Women. Journal of personalized medicine, 2020;10(2):51.

Casas SAS, Patiño SMS, Camargo LDM. Association between the sitting posture and back pain in college students. Revista de la Universidad Industrial de Santander. Salud. 2016;48(4):446-454.

Cavalcanti VC, de Santana Ferreira MI, Teichrieb V, Barioni RR, Correia WFM, & Da Gama AEF. Usability and effects of text, image and audio feedback on exercise correction during augmented reality based motor rehabilitation. Computers & Graphics. 2019;85(12):100-110.

Chae BW, Hwang PH, Lee HY, et al. Effects of 12-week Pilates mat Exercise on Balance of the Elderly Women. KSSS. 2018;27(3):1301-1310.

Choi BG, Yoon HG. (2020). The Effects of a Video Circuit Exercise on Body Compositions and Health-Related Fitness in Obese Middle-aged Women. KSSS, 2020;29(5):1343-1350.

Choi SM, Lim JH, Cho HW, et al. The Effects of Trunk Stabilization Exercise Using Swiss Ball and Core Stabilization Exercise on Balance and Gait in Elderly Women. J Korean Soc Phys Med. 2021;7(1):49-58.

Choi WJ, Park BS, Yo BK, et al. The Effects of Core Program Exercise on Balance in Patients with Chronic Low Back Pain. JKPTS. 2018;25(1):1-10.

Chowning L, Krzyszkowski J, Nunley B, et al. Biomechanical comparison of dominant and non-dominant limbs during leap-landings in contemporary style female dancers. JDMS. 2021;25(4):231-237.

Cope AC, Mavroveli S, Bezemer J, et al. Making meaning from sensory cues: a qualitative investigation of postgraduate learning in the operating room. Acad Med. 2015;90(8):1125-1131.

Cynn WS, Choi HS, Kim TH, et al. The Influence of Different Quantitative Knowledge of Results on Performance Error During Lumbar Proprioceptive Sensation Training. PTK. 2004;11(3):11-18.

Davidson M. Rasch analysis of three versions of the Oswestry Disability Questionnaire. Manual therapy, 2008;13(3), 222–231.

Ehni HJ, Wiesing U. The Declaration of Helsinki in bioethics literature since the last revision in 2013. Bioethics. 2024;38(4):335-43.

Eriksson L, Lindström B, Gard G, et al. Physiotherapy at a distance: a controlled study of rehabilitation at home after a shoulder joint operation. J Telemed Telecare. 2009;15(5):215-220.

Granacher U, Bridenbaugh SA, Muehlbauer T, et al. Age-related effects on postural control under multi-task conditions. Gerontology. 2011;57(3):247-255.

Halim J., Jelley J, Zhang, N, et al. The effect of verbal feedback, video feedback, and self-assessment on laparoscopic intracorporeal suturing skills in novices: a randomized trial. Surg Endosc. 2021;35(7):3787-3795.

Hamzei F, Lappchen C. H., Glauche V., et al. Functional plasticity induced by mirror training: the mirror as the element connecting both hands to one hemisphere, Neurorehabilitation and Neural Repair. (2012) 26, no. 5, 484–496,

Heinrich M, Steiner S, Bauer CM. The effect of visual feedback on people suffering from chronic back and neck pain–a systematic review. Physiother Theory Pract. 2020;36(11):1220-1231.

Hung YJ. The Effects of Compression Garments and Extrinsic Visual Feedback on Single-leg Balance Control. Topics in Exerci Sci and Kinesiol. 2022;3(1).1-8.

Hwang JA, Yoon JH, Park HS, et al. Effect of Face-to-Face and Untact Pilates Exercises during 12 Weeks on Physical Fitness, Range of Motion, and Quality of Life in Young Women. Korea J Sport. 2023;21(1):447-458.

Hyoung HK. Effects of a Strengthening Program for Lower Back in Older Women with Chronic Low Back Pain. J Korean Acad Nurs. 2008;38(6):902-913.

Ifeyinwa NV, Nneka IC, Theophilus IK, et al. Analysis of the effects of double straight leg raise and abdominal crunch exercises on core stability. IJCMSDR. 2021;4(4):36-44.

Jeon CH, Kim DJ, Kim DJ, et al. Cross-cultural Adaptation of the Korean Version Of the Oswestry Disability Index (ODI). J Kor Spine Sur. 2005;12(2):146-152.

Jeon YK. Effects of Core Stabilization Exercise on Lumbar Stabilization Balance and Pain Reduction in Patients with Chronic Back Pain. KSSS. 2021;30(3):1007-1016.

Jung JY, Kim TG, Kim SY. The Effects of Trunk Stability Exercise on Functional Movement, Dynamic Balance Ability and Trunk Stability in Patients with Chronic Back Pain. Korea Convergence Society, 2020;11(3):245-252.

Kang JI, Jeong DK. The Effect of Lumbosacral Stabilization Exercise on Oswestry Disability Index and Gait Velocity of Patients with Chronic Low Back Pain. Journal of Digital Convergence. 2013;11(8):243-250.

Kang JI, Park JS, Park SK, et al. Effects of Exercise Program by Type on Balance Ability and Muscle Activity In A Standing Posture. Journal of Digital Convergence. 2014;12(7):411-418.

Kim AY, Jo HD, Kim MK. Effects of Eight-week Non-face-to-face Pilates Exercise Program on Functional Movement and Quantity and Quality of Core Muscles. J Coach Development. 2022;24(5):204-214.

Kim HS, Wu PH, Jang IT. Lumbar degenerative disease part 1: anatomy and pathophysiology of intervertebral discogenic pain and radiofrequency ablation of basivertebral and sinuvertebral nerve treatment for chronic discogenic back pain: a prospective case series and review of literature. International journal of molecular sciences. 2020;21(4):1483.

Kim JJ, Kim YS, Kim DH, et al. The Comparison of Motion Errors with and without Visual Feedback during Hip Exercise in Environment of Virtual Reality. Journal of sport and leisure studies. 2011;45(2):947-953.

Ko YG. Mobile Phone Video Feedback: How Should It Be Delivered to Maximize Motor Learning Effect?. Korean Journal of Sport Psychology. 2013;24(4):11-23.

Ko YG, Seo YW. The effectiveness of Transitional Information and Video Feedback on Learning of a Multiple-Degree-of-Freedom Movement. Journal of Sport Psychology. 2012;23(4):41-53.

Koes BW, van Tulder MW. Thomas S. Diagnosis and treatment of low back pain. BMJ. 2006;332(7555):1430–1434.

Kwon SW, Kim DH, Lee SK. The influence of core training on the athletic stamina capability of middle-school soccer sthletes. JKSSPE, 2019;24(2):199-207.

Lappchen CH, Ringer T, Blessin J, et al. Optical illusion alters M1 excitability after mirror therapy: a TMS study. J Neurophysiol. 2012;108(10):2857–2861,

Lee B, Liebenson C, Sidorkewicz N. Rehabilitation of the Spine. 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 2019.p.1-59.

Lee DW, Jeong MB. Effect of the Untact Trunk Stabilization Exercise Program on Muscle Thickness, Trunk Strength, Maximal Expiratory Flow, and Static Balance. J Korean Soc Phys Med. 2021;16(1):73-81.

Lee HK, Cho YH, Lee JC. The Effect of Improve the Waist Flexibility, the Waist Muscular Strength and the Waist Balance which Grafted in William & McKenzie Exercise with Swiss Ball. J Korean Soc Phys Med. 2013:8(4):479-487.

Lee SG, Park SK. The effects of a video strength exercise on grip strength, balance, TUG in the frail elderly womenc J Korean Soc Phys Med. 2013;8(1):91-98.

Lee WJ, Park S, Park JW. Influence of Trunk Stabilization Exercise upon the Lumbar Stabilization and Foot Pressure in Patients with Back Pain. JKPT. 2014;26(1):21-26.

Lim HS, Yoon SH, Kim JY. Effects of a mat-pilates exercise with mirror visual feedback on balance in chronic stroke patients. Korean Journal of Adapted Physical Activity. 2019;27(2):33-47.

Loughlin PJ, Redfern MS. Spectral characteristics of visually induced postural sway in healthy elderly and healthy young subjects. IEEE Trans Neural Syst Rehabil Eng. 2001;9(1):24-30.

Lynch JA. The effect of mirror feedback in learning a frontal plane motor skill on students in a pilates mat program. 2006.

Lynch JA, Chalmers GR, Knutzen KM, et al. Effect on performance of learning a Pilates skill with or without a mirror. J Bodyw Mov Ther. 2009;13(3):283-290.

Mattar AAG, Gribble PL. Motor learning by observing. Neuron. 2005;46(1):153–160.

McGregor HR, Cashaback JGA, Gribble PL. Functional plasticity in somatosensory cortex supports motor learning by observing, Curr Bio. 2016;26(7):921-927.

Montgomery W, Vietri J, Shi J, et al. The relationship between pain severity and patient-reported outcomes among patients with chronic low back pain in Japan. J Pain Res. 2016;9:337-344.

Moon SM, Chae WS, Jung JH. The effects of togu-jumper use on core muscle activity during plank exercise. KJSS, 2020;31(4):672-679.

Mozafari A, Vahedian M, Mohebi S, et al. Work-related musculoskeletal disorders in truck drivers and official workers. Acta Medica Iranica, 2015;53(7):432-438.

Mun DJ, Oh HJ, Lee SH. Effects of sling exercise on pain, trunk strength, and balance in patients with chronic low back pain. J Kor Phys Ther. 2022;34(3):110-115.

Park JY. Diagnosis and management of chronic low back pain. J Korean Acad Fam Med, 2001;22(9):1349-1362.

Park SY. The Effect of 12 Weeks Core Exercise Program on Lumbar Extension Strength and Stability of Chronic Low Back Pain Patients. KSSS, 2012;21(3):1221-1230.

Pekkanen L, Kautiainen H, Ylinen J, et al. Reliability and validity study of the Finnish version 2.0 of the Oswestry Disability Index. Spine. 2011;6(4):332-338.

Pollock AS, Durward BR, Rowe PJ, et al. What is balance?. Clin Rehabili. 2000;14(4):402-406.

Reissig P, Puri R, Garry MI, et al. The influence of mirror-visual feedback on training-induced motor performance gains in the untrained hand. PLoS One, 2015;10(10):1-12.e0141828.

Revord LP, Lomond KV, Loubert PV, et al. Acute effects of walking with Nordic poles in persons with mild to moderate low-back pain. Int J Exerc Sci. 2016;9(4):507–513.

Rizan C, Ansell J, Tilston TW, et al. Are general surgeons able to accurately self-assess their level of technical skills?. Ann R Coll Surg Engl. 2015;97(8):549-555.

Roosink M, McFadyen BJ, Hébert LJ, et al. Assessing the perception of trunk movements in military personnel with chronic non-specific low back pain using a virtual mirror. PLoS One, 2015;10(3):1-14.

Russo A, Bragonzoni L, Trozzi C, et al. Recurrence of varus/valgus deformity after TKR at 3 years' follow-up. The Knee. 2008;15(1):20-25.

Schoenmaker J, Houdijk H, Steenbergen B, et al. Effectiveness of different extrinsic feedback forms on motor learning in children with cerebral palsy: a systematic review. Disability and Rehabilitation. 2023;45(8):1271-1284.

Schuett S, Heywood CA, Kentridge RW, et al. The significance of visual information processing in reading: Insights from hemianopic dyslexia. Neuropsychologia. 2008;46(10):2445-2462.

Shin MC, Kim BC, Choi BJ. Effects of 8week core stability training on oswestry disability index, dynamic balance ability and trunk isokinetic muscle function in combat sport athletes with chronic low back pain. Sport Science. 2020;38(1):113-124.

Sin BR, Beck DE, Kim HD. Effect of Physical Training with Visual and Auditory Feedback for Throwing Skill in 20's Women. J Clin Mov Sci Human. 2015;19(3):23-28.

Steelman T, Lewandowski L, Helgeson M, et al. Population-based risk factors for the development of degenerative disk disease. Clin Spine Surg. 2018;31(8):409-412.

Steinberg F, Pixa NH, Doppelmayr M. Mirror Visual Feedback Training Improves Intermanual Transfer in a Sport-Specific Task: A Comparison between Different Skill Levels. Neural plasticity, 2016;1:1-11.

Uhm YH. The Feedback Mirror Therapy in Stroke Patients Effect of Muscle Activity and Function of the Upper Extremity. Journal of Digital Convergence. 2015;13(6):205-212.

Wang W, Shadiev R. Improving static balance ability with trainings supported by somatosensory-based feedback system. Smart learn environ. 2022;9(1):34.1-18.

Williams A, Gribble PL. Observed effector-independent motor learning by observing, J Neurophysiol. 2012;107(6):1564–1570.

Yang DJ, Song TH, Lim HY, et al. A Study of Postural Sway and Dynamic Standing Balance with Low Back Pain. The journal of Korean academy of physical therapist. 2004;11(2),18-26.

Yang JH, Lee GH, Park KH, et al. Comparison of Dynamic Balance Ability and Leg Muscle Properties during Bulgarian Split Squat Exercises using the Visual Block and Unstable Support Plane. Kor Acad Ortho Man Phys Ther. 2023;29(1):41-52.

Yoon SD, Park GD. Literature review on the effect of the Core muscle in Low Back Pain. KSSS. 2020;29(6):1217-1230.