Effect of Interventions for Improving Lumbar Motor Control on Low Back Pain in Sedentary Office Workers: A Randomized Controlled Trials

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ABSTRACT. Objective: To clarify the effect of intervention with dynamic motor control exercise (DMCE) for the lumbar region on low back pain in sedentary office workers (SOWs). Methods: The participants comprised 32 SOWs with low back pain who were randomly categorized into two groups: the DMCE group and the normal trunk exercise (NTE) group. Both groups performed each exercise for three days per week for 8 weeks. The primary endpoints were evaluated for the lumbar and hip flexion angles during trunk forward bending, effect of low back pain on activities of daily living (using the Oswestry Disability Index), and intensity of low back pain (using the Visual Analog Scale) pre- and post-intervention. The extent of changes was calculated by subtracting the pre-intervention value from the post-intervention value and was compared between the two groups using an unpaired t-test. Results: The extent of changes in the lumbar flexion and hip flexion angles at 10° of trunk forward bending were significantly greater in the DMCE group than in the NTE group, and no significant differences were noted between the two groups at other angles of trunk forward bending. The extent of changes in the Oswestry Disability Index and the Visual Analog Scale scores were significantly greater in the DMCE group than in the NTE group. Conclusion: DMCE is effective in improving motor control in the lumbar region and hip joints, thereby ameliorating low back pain in SOWs. Key words: Low back pain, Dynamic motor control exercise, Sedentary office workers (Phys Ther Res 00: 00-00, 0000)
SOWs are forced to sit for long periods of time because of the nature of their work. The sitting posture of SOWs tends to include trunk forward bending. Due to the flexion-relaxation phenomenon of the erector spinae, support from passive tissues (such as the posterior spinal ligament) in the final stages of trunk forward bending predominates over support from lumbar erector spinae in the middle region of the trunk. Therefore, SOWs are habituated to posture maintenance using passive support mechanisms such as ligaments instead of active support mechanisms from lumbar muscle groups, and it is assumed that they have a low ability to control excessive lumbar region movements during trunk movement. Lumbar motor control impairment in SOWs may be one of the factors that cause low back pain. One treatment for lumbar motor control impairment that has been attracting attention is dynamic motor control exercise (DMCE), which helps control the lumbar region movement during trunk and lower extremity movements. Van Dillen et al. reported that DMCE for the lumbar region reduced low back pain in participants with reduced lumbar motor control ability. Therefore, DMCE for low back pain in SOWs may improve low back pain by improving lumbar motor control. However, there is insufficient evidence on the effect of DMCE on low back pain in SOWs. Thus, this study aimed to clarify the effect of DMCE of the lumbar region on low back pain in SOWs and to find an effective treatment strategy for the same. This study was based on the hypothesis that compared to normal trunk exercise (NTE), DMCE of the lumbar region allows for a greater improvement in lumbar motor control and low back pain.

Method

1. Participants

This study was approved by the ethics committee of the Nanto City Home-Visit Nursing Station (approval number: 2020.NHS.1). The purpose of the study was explained to all participants verbally and in writing, and written consent was obtained from them before inclusion in this study. This trial was registered with the University Hospital Medical Information Network (UMIN; registration number UMIN000041318).

SOWs with low back pain living in Toyama and Ishikawa prefectures, Japan, were recruited between July and August 2020. The number of recruits was determined using a previous study for guidance. The eligibility criteria for this study were as follows: (1) low back pain without organic factors, (2) low back pain lasting for more than 3 months, and (3) SOWs who spent more than 80% of their working hours in a sitting posture. A physiotherapist confirmed that there was no disease caused by low back pain for each participant. Participants with a history of lumbar vertebrae or hip surgery and those with severe spinal deformities (such as kyphosis) were excluded.

2. Study design

This study was a double-blinded randomized controlled trial. Randomization was achieved by stratified random allocation and permuted block method using a random number table in Microsoft Excel 2016 to ensure equal proportions of males and females in each group. The participants were blinded by providing exercise instructions to each study group separately; this ensured that they remained unaware of the group to which they were assigned for the entirety of the study period. A physiotherapist performed the measurements, and the measurement data were processed so that the group to which the participants belonged was not known to the data analyst. The processed data were then analyzed by a different person to ensure blinding of the data analysis.

3. Process

This study was conducted between September and December 2020. The participants were randomly divided into two groups: the DMCE group (n=16; lumbar region movements were controlled during trunk and lower extremity movements) and the NTE group (n=16; trunk movements were performed without lumbar region movements). The examiners provided individual exercise instructions to participants after baseline measurement. To ensure the level and consistency of the instructional content, a physical therapist with sufficient clinical experience (11 years) provided instructions to the participants. All measurements were conducted at local community centers and at the participants’ workplaces. The exercise instructions were relayed to the participants using instruction sheets and exercise videos. The examiner instructed the participants to continue exercising for three days a week for eight weeks. Furthermore, the examiner distributed exercise record sheets to the participants and instructed them to return the updated sheets by mail or e-mail once every two weeks. The examiner confirmed the exercise record table and exercise implementation status of the participants. Only participants who were able to complete the 8-week exercise schedule were included in the final evaluation.

4. Intervention

The DMCE group

In accordance with the McGill method, the participants exercised while maintaining awareness of the hip joint movement and without moving the lumbar region. Three types of exercises were performed: quadruped rock back, squats, and hip extension in the prone position. In the quadruped rock back, participants started in the quadruped position with the shoulder, hip, and knee joints in 90° flexion; from there the buttocks were moved backward. The participant stayed conscious of this hip flexion
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Fig. 1. Location of the inertial sensor (a) and trunk forward bending (b, c)

- a-1: The top edge of the sensor was placed at the top edge of the first lumbar vertebra.
- a-2: The top edge of the sensor was placed at the top edge of the first sacral vertebra.
- a-3: Midpoint of the sciatic tuberosity and the popliteal fossa.
- b: Starting position
- c: Maximum trunk forward bending position

while maintaining the lumbar region in neutral position\textsuperscript{10,18}. The squat was performed in a standing position with both lower extremities placed shoulder-width apart and the neutral position of the lumbar region maintained, and the participants focused their awareness on the hip flexion movements. The range of movement for hip flexion was limited to approximately 45°\textsuperscript{10}. The participants were instructed to maintain awareness of the hip joint during the hip hinge movement, in which the torso is flexed forward at the hip joint, with the spine kept in neutral position\textsuperscript{10}. During the prone hip extension exercise, bilateral hip/knee extension at 0° was set as the starting posture. Then, unilateral hip joint extension exercises were performed while maintaining knee joint extension at 0°\textsuperscript{17}. All three exercises were performed 30 times a day (three sets of 10 reps), three times a week. In the case of the prone hip extension exercises, three sets of 10 reps were performed on both sides daily.

The NTE group

The participants performed abdominal bracing in the supine, sitting, and standing positions\textsuperscript{10,18}. Abdominal bracing was based on the method of Tayashiki et al.\textsuperscript{18}, which consists of applying force to the abdomen using one’s own fingers and pushing them back for 2-s followed by a 2-s relaxation. Ten sets of five contractions and relaxations were performed in each posture, with a 30-s rest interval between sets. In the supine position, the participants performed the exercise with both knee joints in slight flexion, and both soles placed on the ground. In the seated position, the participants performed the exercise with the hip and knee joints in 90° flexion while maintaining the lumbar region in a neutral position. In the standing position, the participants performed the exercise with both lower extremities spread apart and the lumbar region in neutral position.

5. Primary endpoint

The primary endpoints were the lumbar/hip joint angle during trunk forward bending, intensity of low back pain (evaluated using the Visual Analog Scale [VAS])\textsuperscript{19}, and effect of low back pain on activities of daily living (evaluated using the Oswestry Disability Index [ODI])\textsuperscript{20}. Receiving software (Sensor Controller, ATR-Promotions, Sagara, Japan) and intrinsic motion sensors (TSND 151, ATR-Promotions, Sagara, Japan) were used to measure the lumbar and hip joint angles. The sensors were placed at three locations: the thoracolumbar vertebral transition, the lumbosacral vertebral transition, and the right thigh. At the thoracolumbar transition, the top edge of the sensor was placed at the top edge of the first lumbar vertebra. At the lumbosacral transition, the top edge of the sensor was placed at the top edge of the first sacral vertebra. The thigh sensor was placed on the posterior surface of the thigh at the midpoint of the sciatic tuberosity and popliteal fossa (Fig. 1a). Finally, the sensors at the thoracolumbar and lumbosacral vertebral transitions were positioned at the midline on the frontal plane of the body, and the thigh sensor was positioned at the midline on the frontal plane of the right thigh. The acceleration range, angular velocity range, and sampling interval of the sensors were ±8 G, ±1,000 dps, and 10 ms, respectively. The measurements were taken as follows: after 5 s of starting position, maximum trunk forward bending was performed for 3 seconds, and the final position in trunk forward bending was held for 3 seconds.
Fig. 2. The consolidated standards of reporting trials 2010 flow diagram for this study.

6. Secondary endpoint

The secondary endpoints were unilateral hip flexion/extension, muscle strength, and the range of motion of bilateral passive hip flexion/extension. A hand-held dynamometer (HHD; μ Tas F-1, ANIMA, Chofu, Japan) was used to measure the hip muscle strength. The dominant leg was used for lower extremity measurements, which was defined as the leg that kicked a ball more readily. The hip flexion muscle strength was measured in the seated position, with both lower extremities raised off the floor and the hip and knee joints in 90° flexion, with the HHD placed on the anterior surface of the thigh, 10 cm proximal to the upper edge of the patella. During measurement of hip extension muscle strength, one knee joint was at 90° flexion on one side and the other was at 0° extension on the opposite side in the prone position, with the HHD placed on the posterior surface of the thigh, 10 cm proximal to the center of the popliteal fossa with the knee joint in 90° flexion. For reproducible measurements of muscle strength, a traction belt (Traction belt 270 cm, Erler Zimmer GmbH & Co. KG, Deutschland, Germany) was wrapped around the measurement bed to secure the HHD to the distal thigh of the participant. The examiner instructed the participant to avoid performing compensatory movement, such as trunk extension, during muscle strength measurement. The measurement procedure was as follows: two rounds of maximum isometric muscle contraction performed for 5 s, separated by a 30-second rest period. Passive hip joint range of motion was measured using a goniometer (plastic angle meter,
Table 1. Comparison of the baseline characteristics between the DMCE and NTE groups

| Endpoint variables                                      | Total (n=19) | DMCE group (n=10) | NTE group (n=9) | 95% CI    |
|--------------------------------------------------------|-------------|-------------------|-----------------|-----------|
| Age (years)                                            | 48.2±9.5    | 46.5±9.3          | 50.0±10.0       | -5.8 to 12.8 |
| Male, n (%)                                            | 5 (26.3)    | 3 (30.0)          | 2 (22.2)        |           |
| Female, n (%)                                          | 14 (73.7)   | 7 (70.0)          | 7 (77.8)        |           |
| BMI, (kg/m²)                                           | 23.5±3.6    | 24.7±4.4          | 22.1±1.6        | -5.8 to 0.8 |
| LF angle, (°)                                          |             |                   |                 |           |
| 10°                                                    | 4.1±1.6     | 4.2±1.6           | 3.9±1.7         | -1.9 to 1.3 |
| 30°                                                    | 12.3±4.6    | 12.9±5.4          | 11.7±3.9        | -5.8 to 3.4 |
| 50°                                                    | 21.6±7.6    | 22.4±9.0          | 20.6±6.1        | -9.3 to 5.7 |
| 70°                                                    | 30.9±10.1   | 31.8±11.7         | 29.9±8.6        | -11.9 to 8.1 |
| Max                                                    | 51.1±14.4   | 52.1±18.6         | 49.9±8.9        | -16.6 to 12.1 |
| HF angle, (°)                                          |             |                   |                 |           |
| 10°                                                    | 6.3±2.0     | 5.8±1.5           | 6.8±2.4         | -0.9 to 2.9  |
| 30°                                                    | 20.2±3.9    | 18.7±3.2          | 21.9±4.1        | -0.3 to 6.7  |
| 50°                                                    | 35.5±8.3    | 35.1±8.8          | 35.9±8.2        | -7.5 to 9.0  |
| 70°                                                    | 48.5±11.3   | 48.3±12.3         | 48.8±10.8       | -10.8 to 11.8 |
| Max                                                    | 79.1±20.7   | 79.0±19.7         | 79.3±23.0       | -20.3 to 21.0 |
| LHR                                                    |             |                   |                 |           |
| 10°                                                    | 0.8±0.6     | 0.9±0.7           | 0.7±0.4         | 0.8 to 0.4   |
| 30°                                                    | 0.7±0.4     | 0.8±0.5           | 0.7±0.6         | 0.6 to 0.2   |
| 50°                                                    | 0.7±0.5     | 0.8±0.6           | 0.7±0.4         | 0.6 to 0.4   |
| 70°                                                    | 0.7±0.5     | 0.8±0.6           | 0.7±0.4         | 0.6 to 0.4   |
| Max                                                    | 0.7±0.4     | 0.8±0.5           | 0.7±0.4         | 0.4 to 0.6   |
| ODI, (%)                                               | 17.2±9.1    | 17.3±8.9          | 17.1±9.8        | -9.3 to 8.9  |
| VAS for LBP, (mm)                                      | 25.2±13.6   | 26.3±11.7         | 24.0±16.0       | -15.8 to 11.2 |
| Muscle Strength, (Nm/kg)                               |             |                   |                 |           |
| Hip Flexion                                            | 1.0±0.4     | 1.0±0.4           | 1.0±0.4         | 0.3 to 0.4   |
| Hip Extension                                          | 0.7±0.4     | 0.7±0.4           | 0.7±0.4         | 0.3 to 0.4   |
| ROM, (°)                                               |             |                   |                 |           |
| Hip Flexion, (Rt)                                      | 109.7±7.0   | 110.0±5.6         | 109.5±8.3       | -6.4 to 7.4  |
| Hip Flexion, (Lt)                                      | 109.5±7.2   | 110.0±5.6         | 109.0±8.8       | -6.2 to 8.2  |
| Hip Extension, (Rt)                                    | 16.3±3.7    | 15.5±3.7          | 17.2±3.6        | -1.8 to 5.3  |
| Hip Extension, (Lt)                                    | 16.3±4.0    | 16.0±3.9          | 16.7±4.3        | -3.3 to 4.7  |

Values are expressed as mean±standard deviation.

DMCE: dynamic motor control exercise; NTE: normal trunk exercise; CI: confidence interval; BMI: body mass index; LF: lumbar flexion; HF: hip flexion; LHR: lumbar hip ratio = lumbar flexion angle/hip flexion angle; ODI: Oswestry Disability Index; VAS: Visual Analog Scale; LBP: low back pain; ROM: range of motion

ÖSSUR Japan G.K., Tokyo, Japan). During the measurement of the range of hip flexion, participants were supine on the bed, with the basic axis set as the line parallel to the trunk, and the translation axis as the line connecting the greater trochanter and the lateral epicondyle of the femur. The hip flexion range of motion was defined as the range of motion of the translation axis relative to the basic axis with the knee joint in maximum flexion. For the measurement of the range of hip extension, the participants were prone, with the same basic and translation axes as those considered for hip flexion. The knee joint was fully extended.

7. Data analysis

Flexion angles of the lumbar and hip joints during 10°, 30°, 50°, 70°, and maximum trunk forward bending were calculated. The lumbar flexion angle was defined as the difference between the sensor tilt angles at the thoracolumbar and lumbosacral transitions at each trunk forward bending angle. The hip flexion angle was defined as the difference between the sensor tilt angles at the lumbosacral transition and the thigh at each trunk forward bending angle. For each participant, the average value of the three trials was calculated and used as the representative value. The lumbar hip ratio (LHR; lumbar flexion angle/hip flexion angle) was calculated from the measured lumbar and hip flexion angles. The VAS score was calculated as the intensity of the current low back pain (range, 0-100 mm). For ODI, the total score of each section was divided by 50 and multiplied by 100; this was used as the representative value of the participant. For unanswered sections, the number of sections was multiplied by five, and the resulting value was subtracted from 50. The total score was then divided by this value and multiplied by 100 for use as the representative value for the participant. For hip flexion and extension angles, the VAS score was calculated as the intensity of the current low back pain (range, 0-100 mm). For ODI, the total score of each section was divided by 50 and multiplied by 100; this was used as the representative value of the participant. For unanswered sections, the number of sections was multiplied by five, and the resulting value was subtracted from 50. The total score was then divided by this value and multiplied by 100 for use as the representative value for the participant.
8. Statistical analysis

Statistical analyses were performed using SPSS version 22 (IBM SPSS Statistics, Japan IBM, Tokyo, Japan). Fisher’s exact test and unpaired t-test were used to compare baseline data between the DMCE and NTE groups. The paired t-test was used to compare the primary and secondary endpoints between pre- and post-intervention in each group. The unpaired t-test was used to compare the extent of changes in the primary and secondary endpoints between the two groups. The significance level was set at 0.05, and all values are presented as mean ± standard deviation.

### Table 2. Comparison of the primary and secondary endpoints pre- and post-intervention in each group

| Endpoint variables   | DMCE group (n=10) | NTE group (n=9) | 95% CI | 95% CI |
|----------------------|-------------------|----------------|--------|--------|
|                      | pre               | post           |        |        |
|                      | pre               | post           |        |        |
| LF angle, (°)        | 10°               | 4.2±1.6        | 3.0±1.7 | 0.5 to 2.0 | 3.9±1.7 | 4.2±1.7 | -1.4 to 0.9 |
| 30°                  | 12.8±5.4          | 9.9±5.2*       | 0.7 to 5.4 | 11.7±3.9 | 10.5±4.2 | -1.3 to 3.8 |
| 50°                  | 22.4±9.0          | 18.3±7.9*      | 0.3 to 8.0 | 20.6±6.1 | 17.9±6.3* | 0.1 to 5.3 |
| 70°                  | 31.8±11.7         | 27.5±9.1*      | -0.5 to 9.0 | 29.9±8.6 | 25.4±7.2* | 2.0 to 7.0 |
| Max                  | 52.1±18.5         | 47.3±10.8*     | -3.2 to 12.8 | 49.9±8.9 | 42.5±5.5* | 2.9 to 11.9 |
|                       |                   |                |        |        |
| HF angle, (°)        | 10°               | 5.8±1.5        | 6.7±1.5* | -1.6 to -0.2 | 6.8±2.4 | 6.0±1.6 | -0.3 to 1.9 |
| 30°                  | 18.7±3.2          | 24.0±4.7*      | -7.5 to -3.3 | 21.9±4.1 | 24.2±5.3 | -5.1 to 0.4 |
| 50°                  | 35.1±8.8          | 39.3±7.4*      | -7.9 to -0.5 | 35.9±8.2 | 40.0±7.1* | -7.2 to -1.0 |
| 70°                  | 48.3±12.3         | 52.4±8.9*      | -9.2 to 0.9 | 48.8±10.8 | 55.1±7.8* | -10.0 to -2.6 |
| Max                  | 79.0±19.7         | 81.8±12.0      | -12.8 to 7.2 | 79.3±23.0 | 86.0±15.1* | -15.7 to 2.3 |
| LHR                  | 10°               | 0.9±0.7        | 0.6±0.7* | 0.1 to 0.4 | 0.7±0.4 | 0.8±0.6 | -0.5 to 0.2 |
| 30°                  | 0.8±0.5           | 0.5±0.5*       | 0.1 to 0.5 | 0.6±0.3 | 0.5±0.3 | -0.1 to 0.3 |
| 50°                  | 0.8±0.6           | 0.5±0.4        | -0.1 to 0.5 | 0.6±0.4 | 0.5±0.3 | -0.1 to 0.3 |
| 70°                  | 0.8±0.6           | 0.6±0.4        | -0.1 to 0.4 | 0.7±0.4 | 0.5±0.2* | 0.1 to 0.4 |
| Max                  | 0.8±0.5           | 0.6±0.2        | -0.1 to 0.4 | 0.7±0.4 | 0.5±0.1 | -0.1 to 0.5 |
| ODI, (%)             |                   |                |        |        |
|                      | 17.3±8.9          | 6.6±7.4*       | 7.4 to 15.5 | 17.1±9.8 | 12.7±12.7 | -1.8 to 10.7 |
| VAS for LBP, (mm)    |                   |                |        |        |
|                      | 26.3±11.7         | 4.9±6.2*       | 16.5 to 26.2 | 24.0±16.0 | 18.0±19.5 | -8.3 to 20.3 |
| Muscle Strength, (Nm/kg) | Hip Flexion  | 1.0±0.4        | 1.4±0.5* | -0.6 to -0.2 | 1.0±0.4 | 1.4±0.4* | -0.6 to -0.2 |
|                      | Hip Extension     | 0.7±0.4        | 1.2±0.5* | -0.7 to -0.2 | 0.7±0.4 | 1.2±0.3* | -0.6 to -0.3 |
| ROM, (°)             |                   |                |        |        |
|                      | Hip Flexion, (Rt) | 109.5±8.3      | 114.0±7.3* | -7.6 to -1.4 | 110.5±5.6 | 110.0±4.3 | -1.9 to 1.9 |
|                      | Hip Flexion, (Lt) | 109.0±8.7      | 114.0±7.4* | -7.9 to -2.0 | 110.0±5.6 | 110.0±4.3 | -1.9 to 1.9 |
|                      | Hip Extension, (Rt) | 15.5±3.7      | 20.5±2.8* | -7.4 to -2.6 | 17.2±3.6 | 18.3±2.5 | -2.8 to 0.6 |
|                      | Hip Extension, (Lt) | 16.0±3.9      | 20.5±2.8* | -7.1 to -1.9 | 16.7±4.3 | 17.7±3.6 | -2.8 to 0.6 |

Values are expressed as mean±standard deviation.
DMCE: dynamic motor control exercise; NTE: normal trunk exercise; CI: confidence interval; LF: lumbar flexion; HF: hip flexion; LHR: lumbar hip ratio = lumbar flexion angle/hip flexion angle; ODI: Oswestry Disability Index; VAS: Visual Analog Scale; LBP: low back pain; ROM: range of motion

* Significant difference pre-and post-intervention, p<0.05

### Result

The CONSORT flowchart for this study is shown in Figure 2. In this study, 19 participants (DMCE group = 10, NTE group = 9) were included in the analysis. The baseline characteristics of both groups are shown in Table 1. No significant differences in any characteristics were observed between the two groups. The significance level was set at 0.05, and all values are presented as mean ± standard deviation.
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### Table 3. Comparison of the extent of changes in the primary and secondary endpoints pre- and post-intervention between the two groups

| Endpoint variables | DMCE group (n=10) | NTE group (n=9) | 95% CI |
|--------------------|-------------------|----------------|--------|
| LF angle, (°) | | | |
| 10° | -1.2±1.0* | 0.2±1.5 | 0.2 to 2.7 |
| 30° | -3.0±3.3 | -1.2±3.3 | -1.4 to 5.5 |
| 50° | -4.2±5.4 | -2.7±3.5 | -3.0 to 5.9 |
| 70° | -4.2±6.6 | -4.5±3.2 | -5.4 to 4.9 |
| Max | -4.8±11.2 | -7.4±5.9 | -11.4 to 6.2 |
| HF angle, (°) | | | |
| 10° | 0.9±0.9* | -0.8±1.4 | -2.8 to -0.5 |
| 30° | 5.4±3.0 | 2.3±3.6 | -6.2 to 0.1 |
| 50° | 4.2±5.1 | 4.1±4.0 | -4.6 to 4.5 |
| 70° | 4.1±7.1 | 6.3±4.8 | -3.7 to 8.2 |
| Max | 2.8±14.0 | 6.7±11.7 | -8.6 to 16.5 |
| LHR | | | |
| 10° | -0.3±0.2* | 0.1±0.4 | 0.1 to 0.7 |
| 30° | -0.3±0.3 | -0.1±0.2 | -0.1 to 0.5 |
| 50° | -0.3±0.3 | -0.2±0.2 | -0.2 to 0.4 |
| 70° | -0.2±0.4 | -0.2±0.2 | -0.3 to 0.4 |
| Max | -0.1±0.3 | -0.2±0.3 | -0.4 to 0.2 |
| ODI, (%) | | | |
| | -11.5±5.7* | -4.4±8.1 | 0.3 to 13.7 |
| VAS for LBP, (mm) | | | |
| | -21.4±6.8* | -6.0±18.6 | 2.1 to 28.7 |
| Muscle Strength, (Nm/kg) | | | |
| Hip Flexion | 0.5±0.3 | 0.4±0.3 | -0.3 to 0.2 |
| Hip Extension | 0.5±0.3 | 0.4±0.2 | -0.3 to 0.2 |
| ROM, (°) | | | |
| Hip Flexion, (Rt) | 4.5±4.4* | 0.0±2.5 | -8.0 to -1.0 |
| Hip Flexion, (Lt) | 5.0±4.1* | 0.0±2.5 | -8.3 to -1.7 |
| Hip Extension, (Rt) | 5.0±3.3* | 1.1±2.2 | -6.7 to -1.1 |
| Hip Extension, (Lt) | 4.5±3.7* | 1.1±2.2 | -6.4 to -0.4 |

Values are expressed as mean±standard deviation.

DMCE: dynamic motor control exercise; NTE: normal trunk exercise; CI: confidence interval; LF: lumbar flexion; HF: hip flexion; LHR: lumbar hip ratio = lumbar flexion angle/hip flexion angle, ODI: Oswestry Disability Index; VAS: Visual Analog Scale; LBP: low back pain; ROM: range of motion

* Significant difference between the two groups (p<0.05)

Discussion

The purpose of this study was to clarify the effect of DMCE of the lumbar region on low back pain in SOWs and to evaluate its efficacy as a treatment. Our findings revealed that in the early stage of trunk forward bending, the lumbar flexion angle decreased and the hip flexion angle increased in the DMCE group as opposed to the NTE group. The VAS score and ODI were also decreased in the DMCE group than in the NTE group. Therefore, it is suggested that DMCE of the lumbar region is an effective means of improving low back pain in SOWs.

It has been reported that trunk forward bending in a person with low back pain causes excessive movement of the lumbar region in the early stage of the movement and relatively decreased hip joint movement6. The lumbar ligaments contain a number of free nerve endings that act as pain receptors21. Excessive lumbar region movement in the early stages of lower extremity and trunk movements
causes stress accumulation in the lumbar tissue and promotes tissue degeneration1. In this study, DMCE was used to suppress the movement of the lumbar region and movement of the hip joint. Therefore, unlike in the NTE group, it is possible that in the DMCE group, the stimulation of pain receptors (and consequently, the low back pain) decreased due to a decrease in the lumbar region movement and an increase in the hip joint movement in the early stage of trunk forward bending. The minimal clinically important differences for the VAS score and the ODI are reported to be 15 mm and 10 points, respectively23, and the corresponding values in this study were higher than these values. Therefore, DMCE is suggested as an effective treatment strategy for low back pain in SOWs. It has also been reported that low back pain is associated with decreased hip range of motion and muscle strength23. In this study, DMCE promoted hip joint muscle group activity in the desired direction of the hip joint movement; simultaneously, the extensibility of the antagonist muscle increased due to reciprocal innervation24. This may have improved muscle strength and hip flexion/extension range of motion.

This study has some limitations. First, the number of participants who were able to perform the final analysis was only 19 due to attrition, and it was difficult to verify the intervention effect of DMCE by intention-to-treat analysis. Therefore, it is necessary to increase the number of participants in the future to verify the effect of DMCE intervention on low back pain in SOWs. Moreover, since the number of required participants in this study was calculated by referring to previous studies, it is necessary to calculate the number of required participants using G*Power.

**Conclusion**

This study examined the effect of DMCE of the lumbar region on low back pain in SOWs. Low back pain was reduced with improvements in the motor control ability of the lumbar region. Therefore, intervention by DMCE for the lumbar region is effective in improving motor control in the lumbar region and hip joints and in decreasing low back pain in SOWs and should be further explored as a treatment.

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