Effects of muscle extension strength exercise on trunk muscle strength and stability of patients with lumbar herniated nucleus pulposus

Kyoungkyu Jeon, PhD1), Taeyoung Kim, PhD2), Sang-Ho Lee, PhD2)*

1) Sport Science Institute, Incheon National University, Republic of Korea
2) Department of Physical Education, College of Education, Hankuk University of Foreign Studies: 107 Imun-ro, Dongdaemun-gu, Seoul 02450, Republic of Korea

Abstract. [Purpose] The purpose of this study was to provide the data for constructing an integrated exercise program to help restore muscle strength and stability through extension strength exercise in adult females with lumbar disc herniation. [Subjects and Methods] An 8-week exercise program for lumbar muscle extension strength and stabilization was performed by 26 females older than 20 with lumbar disc herniation findings. [Results] Significant differences were found in lumbar extension muscle strength at every angle of lumbar flexion after participation in the 8-week stabilization exercise program; but there was no significant difference in the weight distribution index. [Conclusion] An integrated exercise program aiming to strengthen lumbar spine muscles, reduce pain and stabilize the trunk can help to maintain muscle strength and balance. In addition, improvement in extension strength is expected to be helpful in daily life by securing the range of joint motion and improving the strength and stability.

Key words: Herniated Nucleus Pulposus (HNP), Extension strength, Stability

INTRODUCTION

Lumbar spine instability has been reported to be the leading cause of chronic back pain11. An abnormal vertebral joint creates mechanical lesions and pains in the lumbar spine, decreasing stability and increasing the range of motion, resulting in functional degeneration11. These negative patterns have a variety of forms such as aging, medical history, and exercise deficiency and present serious problems in the age group of 20–40, due to developments of modern society and recent changes in various working forms of work3, 4.

Herniated Nucleus Pulposus (HNP) is a representative disease of the functional vertebral unit that occurs when the pulposus nucleus is exposed by rupture of the annulus fibrosus and it is a disease that causes chronic back pains5, 6). Chronic back pain patients not only have weak deep muscles of the lumbar region and muscle imbalance compared to normal subjects, but also show reduction in the re-positioning ability which leads to problem with the stability of the spine, due to the reduction in proprioceptive sense, which causes lumbar pain and recurrence7, 8).

Stabilization exercises help with functional return to daily life. They include exercises for increasing muscle strength, improving functions, and maintaining posture as well as preventing excessive movements of the lumbar spine9). Exercise rehabilitation approaches for strength and stability are important even after surgical treatments, due to degeneration and restricted activities10, 11) and conservative methods of treatment by exercise have been recommended for the purpose of preventing recurrence of pain and improving functions12–16). Thus, exercise therapis based on the stabilization exercises are considered to be necessary for preventing chronic pain and reductions in functional capabilities by the reduction of functional instability in various of type and the improvement of motor functional capabilities of the lumbar joints.
Therefore, this study aims to help adult women with lumbar disc herniation recover muscle strength and stability through 8-week lumbar extension strength exercise programs, and to provide data for constructing an integrated exercise program.

**SUBJECTS AND METHODS**

In this study, an 8-week exercise program for lumbar muscle extension strength and stabilization was performed by 26 females older than 20 with lumbar disc herniation. This study was approved by the Hankuk University of Foreign Studies and the institution where it was performed, and it complied with the ethical principles of the Declaration of Helsinki. The purposes and process of the study were fully explained to the subjects and their consent was obtained before participation. Persons with neurological diseases such as dyskinesia were excluded from the study. The subjects’ mean ± SD was 27.2 ± 4.4 years old; their mean ± SD height was 162.3 ± 5.1 cm and their mean ± SD weight was 55.4 ± 7.1 kg.

The programs were conducted for a total of 8 weeks, 60 minutes a session, twice a week, to improve strength and stabilize lumbar extension. The exercise program was divided into warm-up exercises, main exercises and cool-down exercises. The warm-up exercises and cool-down exercises were conducted focusing on the range of joint motion (ROM) without pain, utilizing cycles and steppers for 10 minutes, alternately. For the purpose of improving the lumbar stability and resistance muscles, the main exercises were designed to be individually conducted in the form of a circuit training in which the number of repetitions increased gradually, utilizing sling and weight exercise equipment.

A lumbar Extension Strength Machine (MedX, MedX Inc., Ocala, FL, USA) was utilized for the evaluation of lumbar extensor strength. The maximum static muscular strength of lumbar extension was measured at 7 different angles of lumbar flexion: 0, 12, 24, 36, 48, 60, and 72 degrees. Passive tests were conducted to determine whether to limit the range of motion before measurement. The tests were conducted 12 times at 45 lbs in accordance with the MedX exercise measurement guidelines. The measurement was performed after fixing the pelvis and thigh of the subjects on the support. Then, the motion of the lumbar spine was limited during measurement by adjusting the footrest. The subjects were asked to increasingly extend the lumbar spine by sufficiently considering the limited angular range of motion of the joints. The measurements were performed in the same manner at every angle by maintaining maximum muscle contraction for about 2 seconds.

Stability was measured using a Tetrax (Sunlight Ltd., Israel). For the physical stability measurements, the total weight distribution index (WDI) was calculated by assessing the degree of interaction and coordination of the lower body through body away while maintaining a standing posture.

For data processing, the statistical program SPSS (SPSS Inc., IBM, USA) Ver. 23.0 was used. The mean and standard deviation of the measurements was calculated for all metrics. To compare the difference between the pre-exercise and post-exercise state of the 8-week exercise program, the paired t-test was used and statistical significance was accepted for values of p <0.05.

**RESULTS**

Significant differences were observed in lumbar extension strength (LES) between pre-exercise and post-exercise at every angle of lumbar flexion, but no significant difference was found in WDI (%) (Table 1). The post-exercise LES were found to be very significantly (p<0.01) higher than pre-exercise at 0 degree and 12 degree, and extremity significantly (p<0.001) higher than pre-exercise at 24, 36, 48, and 72 degrees of lumbar flexion. The exercise resulted in significant changes in all angles.

### Table 1. Changes of the LES and WDI

| Variable | Angle | Pre-exercise (ft-lbs) | Post-exercise (ft-lbs) |
|----------|-------|-----------------------|------------------------|
| LES      | 0     | 61.8 ± 33.8           | 80.1 ± 31.6**          |
|          | 12    | 78.7 ± 33.8           | 98.8 ± 33.6**          |
|          | 24    | 87.6 ± 36.5           | 116.5 ± 32.7***        |
|          | 36    | 98.6 ± 35.9           | 129.7 ± 32.3***        |
|          | 48    | 104.7 ± 35.0          | 137.6 ± 30.2****       |
|          | 60    | 113.1 ± 36.9          | 146.5 ± 30.5***        |
|          | 72    | 122.3 ± 40.1          | 158.7 ± 34.7****       |
| WDI (%)  | 0     | 5.9 ± 3.3             | 5.0 ± 2.8              |

Values are mean ± SD, LES: lumbar extension strength, WDI: weight distribution index. **p<0.01, ***p<0.001
DISCUSSION

This study attempted to identify the positive impacts that were exerted on extension muscle strength and stability by an 8-week extension strength exercise program which was performed by 26 females with lumbar disc herniation.

HNP is caused by the annulus fibrosus that is squeezed into the spinal canal when the pulposus nucleus is torn due to a degenerative intervertebral disc. It has been reported that approximately 29% of the projected and escaped intervertebral discs are associated with the pulposus nucleus\(^7\). Chronic back pains resulting from HNP aggravate the instability of the lumbar spine, causing degenerative changes, atrophy of muscle strength, and reduce flexibility and joint range of motion due to trunk damage and instability\(^{18, 19}\). Lumbar herniated nucleus pulposus does not occur due to lumbar pain or disability, but more frequently occurs due to deterioration of the related muscles or functions interacting with them adjunctively\(^8\). In addition, it is said that the joint range of motion is limited due to the loss of muscle strength and flexibility caused by occupational factors, mode of action, specific changes in posture, or degenerative disease\(^{18}\).

These musculoskeletal diseases can be generally improved by utilizing conservative treatments such as exercise\(^9, 18\). Rehabilitation exercise therapies for muscular strength and stability are important even after surgery\(^{10, 16}\). Various types of composite exercises and core exercises in addition to exercises for muscular strength and stability are currently being utilized\(^8, 12\). Lumbar and trunk muscle extension exercise therapies were utilized. These exercise therapies help to stabilize the lumbar spine through lumbar and trunk dynamic stabilization and exercise modulation, and increase of muscle strength\(^{20}\).

Similar to the present study, a study analyzing the impacts of an 8-week functional exercise program for lumbar muscle strength, that was performed by 26 females with degenerative disc findings, found that there were significant differences between pre-exercise and post-exercise\(^{15}\) in lumbar muscle extension strength at all 7 angles of lumbar flexion, proving that exercise participation develops stability of the muscles around the lumbar spine. In addition, a study analyzing the effects of decompression therapy by 4-week joint mobilization that was performed for patients with lumbar herniated nucleus pulposus, reported improvements in joint range of motion in flexion and extension\(^{21}\), proving its effectiveness. Similarly, a study of\(^{13}\) lumbar traction for patients with lumbar herniated nucleus pulposus, and a study\(^{11}\) of lumbar disectomy and stabilization exercises for patients with lumbar herniated nucleus pulposus, both reported improvements in flexion and extension. The improvements in functions pursuant to improved muscle strength and stability were statistically significant, as were the results of the studies cited above. Therefore, prevention of excessive movement of the lumbar spine and trunk, in the patients with chronic back pains or lumbar herniated nucleus pulposus can be helpful in their daily life because they secure the joint range of motion, thereby improving strength and stability\(^9\).

Thus, the development of muscular strength for stabilization and integrated exercise for pain reduction and rehabilitation help to maintain the range of joint motion, muscle strength, and balance\(^{21-23}\). For the improvement and rehabilitation of impaired capacity in daily life due to back pain-associated injuries experienced by about 80% of the population a higher occurrence rate\(^{6, 10}\) when recurrence is included muscle weakness, and loss\(^{15}\) of balance the development of an integrated exercise program is required.

The above results indicate that improving muscle extension strength to enhance and improve the functions the patients with chronic back pain or lumbar herniated nucleus pulposus can help improve muscle functions and increase the range of joint motion thereby exerting a positive impact on physical stability.

ACKNOWLEDGEMENT

This work was supported by Hankuk University of Foreign Studies Research Fund of 2016.

REFERENCES

1) Gill K, Krag MH, Johnson GB, et al.: Repeatability of four clinical methods for assessment of lumbar spinal motion. Spine, 1988, 13: 50–53. [Medline] [Cross-Ref]
2) Hamaoui A, Do MC, Bouisset S: Postural sway increase in low back pain subjects is not related to reduced spine range of motion. Neurosci Lett, 2004, 357: 135–138. [Medline] [CrossRef]
3) Chiarotto A, Deyo RA, Terwee CB, et al.: Core outcome domains for clinical trials in non-specific low back pain. Eur Spine J, 2015, 24: 1127–1142. [Medline] [CrossRef]
4) Paolakka K, Ylinen J, Neva MH, et al.: Risk factors for back-pain-related loss of working time after surgery for lumbar disc herniation: a 5-year follow-up study. Eur Spine J, 2008, 17: 386–392. [Medline] [CrossRef]
5) Deyo RA, Rainville J, Kent DL: What can the history and physical examination tell us about low back pain? JAMA, 1992, 268: 760–765. [Medline] [CrossRef]
6) Kim HT: Management of chronic low back pain and prevention of low back pain. J Korean Soc Spine Surg, 2004, 11: 181–193. [CrossRef]
7) Lurie JD, Gerber PD, Sox HC: Clinical problem-solving. A pain in the back. N Engl J Med, 2000, 343: 723–726. [Medline] [CrossRef]
8) O’Sullivan PB, Burnett A, Floyd AN, et al.: Lumbar repositioning deficit in a specific low back pain population. Spine, 2003, 28: 1074–1079. [Medline] [Cross-Ref]
9) Taylor NF, Dodd KJ, Shields N, et al.: Therapeutic exercise in physiotherapy practice is beneficial: a summary of systematic reviews 2002-2005. Aust J Physiother, 2007, 53: 7–16. [Medline] [CrossRef]

10) Weinstein JN, Lurie JD, Tosteson TD, et al.: Surgical vs nonoperative treatment for lumbar disk herniation: the Spine Patient Outcomes Research Trial (SPORT) observational cohort. JAMA, 2006, 296: 2451–2459. [Medline] [CrossRef]

11) Ishida K, Tsushima E, Umeno Y, et al.: Factors associated with the Oswestry disability index score one month after lumbar discectomy. J Phys Ther Sci, 2012, 24: 415–421. [CrossRef]

12) Datta S, Lee M, Falco FJ, et al.: Systematic assessment of diagnostic accuracy and therapeutic utility of lumbar facet joint interventions. Pain Physician, 2009, 12: 437–460. [Medline]

13) Yang HS, Yoo WG: The effects of stretching with lumbar traction on VAS and Oswestry scales of patients with lumbar 4–5 herniated intervertebral disc. J Phys Ther Sci, 2012, 24: 415–421. [CrossRef]

14) Datta S, Lee M, Falco FJ, et al.: Systematic assessment of diagnostic accuracy and therapeutic utility of lumbar facet joint interventions. Pain Physician, 2009, 12: 437–460. [Medline] [CrossRef]

15) Shin CH, Jeon KK: The effects of functional exercise program on lumbar extension strength and stability in middle-aged women of degenerative disc patients. Korean J Growth Development, 19: 291–296.

16) Yang HS, Yoo WG: The effects of stretching with lumbar traction on VAS and Oswestry scales of patients with lumbar 4–5 herniated intervertebral disc. J Phys Ther Sci, 2012, 24: 415–421. [CrossRef]

17) Yang HS, Yoo WG: The effects of stretching with lumbar traction on VAS and Oswestry scales of patients with lumbar 4–5 herniated intervertebral disc. J Phys Ther Sci, 2012, 24: 415–421. [CrossRef]

18) Mayer J, Mooney V, Dagenais S: Evidence-informed management of chronic low back pain with lumbar extensor strengthening exercises. Spine J, 2008, 8: 96–113. [Medline] [CrossRef]

19) Shin CH, Jeon KK: The effects of functional exercise program on lumbar extension strength and stability in middle-aged women of degenerative disc patients. Korean J Growth Development, 19: 291–296.

20) Park SY, Noh SY, Jeon KK: The effect of lumbar stabilization exercise on extension strength and visual analogue scale in patients with chronic low back pain. J Phys Ther Sci, 2013, 25: 953–956. [Medline] [CrossRef]

21) Park SY, Noh SY, Jeon KK: The effect of lumbar stabilization exercise on extension strength and visual analogue scale in patients with chronic low back pain. J Phys Ther Sci, 2013, 25: 953–956. [Medline] [CrossRef]

22) Park SY, Noh SY, Jeon KK: The effect of lumbar stabilization exercise on extension strength and visual analogue scale in patients with chronic low back pain. J Phys Ther Sci, 2013, 25: 953–956. [Medline] [CrossRef]

23) Yang J, Seo D: The effects of whole body vibration on static balance, spinal curvature, pain, and disability of patients with low back pain. J Phys Ther Sci, 2015, 27: 805–808. [Medline] [CrossRef]