ORIGINAL RESEARCH

The Effectiveness of Hollowing and Bracing Strategies With Lumbar Stabilization Exercise in Older Adult Women With Nonspecific Low Back Pain: A Quasi-Experimental Study on a Community-based Rehabilitation

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ABSTRACT

Objective: The purpose of this study was to explore the therapeutic effectiveness of hollowing lumbar stabilization exercise (HLSE) and bracing lumbar stabilization exercise (BLSE) for older adult women with nonspecific low back pain (NSLBP) in community welfare centers.
Method: A total of 38 older adult women with NSLBP were allocated to either the HLSE group (n = 17, 70.4 ± 1.7 years) or the BLSE group (n = 21, 66.8 ± 4.4 years). Both groups performed intervention for 12 consecutive weeks, 3 times per week. Each group performed 5 lumbar stabilization exercises, including side plank exercise, bridge exercise, 4-kneeling exercise, prone plank exercise, and prone back extension exercise with hollowing and bracing strategy, respectively. The baseline and post-test values of trunk strength, low back disability (Korean Oswestry Disability Index [K-ODI] and Korean Roland Morris Disability Questionnaire [K-RMDQ]), and static balance (1-leg standing test) were compared by using per-protocol analysis.
Results: In trunk strength, the trunk flexor had significant difference (F = 11.10, P = .001) between groups and within groups of BLSE (t = –5.56, P = .001) and HLSE (t = –2.50, P = .024). Trunk back extensor of HLSE (t = –6.00, P = .001) and BLSE (t = –9.19, P = .001) only had significant within-group difference. However, in trunk side flexor, HLSE and BLSE had only significant difference between groups. In low back disability, K-ODI for HLSE (t = 4.50, P = .001) and BLSE (t = 4.60, P = .001) had significant within-group difference but no significant difference between groups (F = 0.28, P = .202). In K-RMDQ, HLSE only had significant within-group difference (t = 3.97, P = .001). In trunk muscle strength, the effect size of HLSE and BLSE groups for trunk flexor was HLSE –0.53 (medium) and BLSE –1.21 (large); trunk side flexor: HLSE 0.27 (small) and BLSE –0.24 (small); and trunk back extensor: HLSE 1.1 (large) and BLSE 2.00 (large), respectively. In low back disability, the effect size of both groups for K-ODI was HLSE 0.88 (large) and BLSE 1.05 (large), and K-RMDQ, HLSE 0.19 (small) and BLSE 0.40 (small), respectively.
Conclusion: Our findings suggest that HLSE and BLSE could be recommended for community settings to improve trunk strength and low back disability in older adult women with NSLBP. Especially, HLSE and BLSE could be recommended for elderly women with NSLBP who have lower back disability and weak trunk muscle strength, respectively. (J Manipulative Physiol Ther 2018;41:1-9)
Key Indexing Terms: *Low Back Pain; Exercise Therapy; Adult, Aged; Rehabilitation*

INTRODUCTION

The incidence of low back pain, a condition that can potentially affect 70% to 80% of the population,[1] has increased in persons aged 60 years and older.[2] Chronic nonspecific low back pain (NSLBP) is a pain not associated with any specific disease; it accounts for approximately 80% to 90% of all cases of low back pain.[2] Nonspecific low back pain patients tend to have muscle weakness, excessive muscle activation to compensate for the unstable posture in abdominal muscles,[3-5] and decreased static balance.[6,7]

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Paper submitted October 17, 2016; in revised form June 20, 2017; accepted June 20, 2017.
0161-4754

https://doi.org/10.1016/j.jmpt.2017.06.012

Lumbar stabilization exercises have become increasingly popular as a treatment for low back pain.[8] The exercise protocols to improve lumbar stabilization vary from training of multifidus and transversus abdominis (TrA) with isometric contraction to using weight machines designed to strengthen the prime movers of the spine.[9,10] Some notable lumbar stabilization exercises include the side plank, bridge, 4-kneeling, prone plank, and prone back extension exercises. Lumbar stabilization exercises are commonly used to improve lumbar stability and increase trunk muscle strength.[11,12] Although previous studies have revealed the therapeutic effectiveness of lumbar stabilization exercises, these exercises focus on contraction of rectus abdominis (RA), external oblique (EO), and erector spinae (ES) muscles[13] but considered less preferential contraction of the TrA or co-contraction of anterolateral muscles, which are effective to relieve pain and low back disability.[14]

Hollowing strategy preferentially contracts the TrA while minimizing global muscles, including the RA muscle.[15,16] Bracing strategy simultaneously contracts anterolateral abdominal muscles, including TrA, internal oblique (IO), EO, and RA.[13,15] The hollowing strategy has been reported to relieve pain and improve low back disability in persons with NSLBP.[17,18] Hollowing strategy is effective for muscle activation mainly focused on RA, EO, IO, and TrA, which contribute to the partial stability of the spine.[11,12] The bracing strategy is also beneficial in inducing higher activation in deep abdominal muscles.[13] However, because the therapeutic effects of hollowing and bracing strategies in previous reports were based on experimental studies, it is difficult to apply the therapeutic effects to the community setting.

Hollowing and bracing strategies with lumbar stabilization exercises could be expected to provide the preferred neutral lumbar spine position with contraction of the IO, EO, and TrA muscles, which all contribute to spinal stability.[17,19] Therefore, the purpose of the present study was to explore the therapeutic effectiveness of HLSE and BLSE for older adult women with NSLBP to be applied in a community setting. We hypothesized that HLSE and BLSE are effective in enhancing trunk strength and static balance and improving low back disability in older adult women with NSLBP in community welfare centers. To test our hypothesis, we measured trunk strength (trunk flexor, trunk side flexor, and trunk back extensor), static balance (1-leg standing), and low back disability (Korean Oswestry disability index [K-ODI] and Korean Roland Morris disability questionnaire [K-RMDQ]) of older adult women with NSLBP, at baseline and then after 12 weeks of the intervention, in community welfare centers.

Methods

Design

We used a quasi-experimental design on community-based rehabilitation to identify the therapeutic effectiveness of HLSE and BLSE for older adult women with NSLBP in community welfare centers. All participants signed an informed consent form. This study was approved by the Medical Research Ethics Committee of Korea University (IRB NO. 1040548-KU-IRB-14-19-A-1).

Participants

From February 2014 to April 2014, 67 participants were recruited from 2 local community welfare centers, located in Seongbuk-gu, Seoul, South Korea, through announcements on notice boards 1 month before the intervention. To assign groups, we set up the 1 community welfare center as the HLSE group and another community welfare center as the BLSE group. The HLSE and BLSE groups performed the intervention at different community welfare centers 20 minutes' walking distance apart, which minimized the economic differences of participants between the 2 community welfare centers. The participation eligibility criteria were as follows: elderly women aged 60 or older, those diagnosed with chronic NSLBP by a doctor, those who could participate in intervention 3 times a week or more, and those living in Seongbuk-gu. Participants younger than 60 years with previous spinal surgery or spinal pathologic conditions such as lumbar herniated intervertebral disk, spondylolysis, spondylolisthesis, or nerve root pain signs were excluded. Thirty-eight participants completed the 12-week intervention. As shown in Figure 1, 19 of 67 were excluded. Before the commencement of intervention, 12 participants were dropped from the hollowing group and 7 from the bracing group. Each group performed 5 lumbar stabilization exercises, including side plank, bridge, 4-kneeling, prone plank, and prone back extension exercises, with hollowing or bracing strategy, respectively.

Preintervention Stage for Instruction

Ultrasonography (Sonoplus 992; Enraf Nonius, Delft, Netherlands) was used by 1 physical therapist with more than 3 years' clinical experience to instruct the participants on performing the hollowing and bracing strategies. The movements of the EO, IO, and TrA on the right side of the abdominal wall were monitored by using ultrasonography, and visual feedback from the connected monitor was used to identify the correct abdominal contraction by 1 physical therapist. The physical therapist could identify TrA and IO+EO contractions during hollowing and bracing strategies, respectively. Ultrasonography was performed about 3 to 5 times until the participants proficiently performed the hollowing and bracing strategies. Another physical therapist who was the assistant guided the participants and checked for the correctness of the performance of the strategies by palpating and observing the abdominal muscles nearby. After instruction of ultrasonography, 1

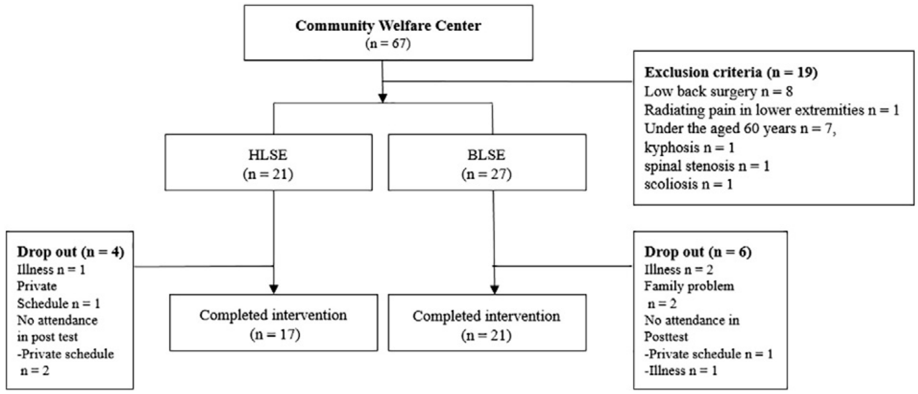

Fig 1. *Flow diagram of participant enrollment.*

physical therapist explained the HLSE and BLSE, which combine hollowing and bracing strategies and 5 lumbar stabilization exercises. Both groups were given verbal commands to pull their navel toward their spine and to perform co-activation of the anterolateral abdominal muscles, respectively.

Measurement

Low Back Disability. Two physical therapists individually explained the contents of K-ODI and K-RMDQ and provided tips. One physical therapist predominantly explained the method of how to complete questionnaires and provided tips. Another physical therapist played an auxiliary role to help draw up the questionnaires.

Trunk Muscle Strength. After the participants completed the questionnaires, 2 therapists performed muscle strength tests. One physical therapist measured the muscle strength using a dynamometer (MicroFET 2, Hoggan Scientific, Salt Lake City, Utah), and the other physical therapist fixed the measurement posture to minimize compensation. All muscle strength tests were performed with 3 consecutive trials with a resting time of at least 60 seconds between each trial, and the mean of the 3 trials was used in the analysis. First, the participants laid on the mat in a supine–hook lying position.[20] To measure trunk side flexor, the physical therapist placed the dynamometer on the coracoid process, which was covered by a thin towel on the scapula, on the contralateral side of the participants while they maintained their upper body at 30° in the supine position.[21,22] The participants then flexed their trunk with maximal force. Second, for the measurement of the strength of the lateral flexor muscles, the participants laid on the mat in a side-lying position. The physical therapist placed the dynamometer on the acromion of the scapula of the participants who were maintaining their upper body at 10°.[20,22] The participants then exerted their side by bending the trunk with maximal force. Third, the participants lay on the mat in the prone position. The physical therapist placed the dynamometer on the upper medial border of the scapula of the participants who were maintaining their upper body at 20°, to measure the back extensor. Next, the participants extended their trunk to the back with maximal force.[21] Simultaneously, another physical therapist anchored the ankles of participants to prevent the compensation of other muscles.

Static Balance. The participants were assessed by using a 1-leg standing test; static balance was measured in each of 2 trials with their eyes closed.[23] The participants stood on the flat ground with bare feet and their upper extremities abducted and closed their eyes. After the “start” verbal command, the participants flexed their nondominant hip joint, maintaining 90°. The physical therapist started the timer when the participants raised their nondominant lower extremity. The evaluation was ended when participants opened their eyes or touched their foot to the ground. The measurement unit was seconds.

Statistical Analysis. The trunk strength, low back disability, and 1-leg standing test findings were represented as mean and standard deviation values averaged over 3 measurements. The normality of distribution for all data collected was analyzed with the Shapiro-Wilk test. Analysis was per-protocol analysis. Characteristics were 21 and 27 in the HLSE and BLSE groups, respectively. Trunk strength, low back disability, and static balance were calculated as 21 and 27 in the HLSE and BLSE groups at the baseline and 17 and 21 in the post-test, respectively. In the physical characteristics of both groups, an independent *t* test was used. For each outcome variable, analysis of covariance with the baseline score as the covariate was used to compare the adjusted post-test score between the 2 groups. The therapeutic effect for each group was determined by using the effect size, called Cohen’s *d*, in which values > .2, .5, and .8 were defined as small, medium, and large effects, respectively.[24] All statistical analyses were performed by using the Statistical Package for the Social Science (Version 21.0; SPSS, Chicago, Illinois). The level of significance was set at .05.

Intervention

In each group, 1 hour of exercise was performed 3 times per week for 12 weeks with a total of 38 participants. The intervention program consisted of a 10-minute warm-up session, a 40-minute exercise session, and a 10-minute cooldown session. We demonstrated HLSE and BLSE to both groups. One physical therapist demonstrated the intervention methods in front of the participants to guide the intervention from start to finish. During HLSE, 1 physical therapist palpated the left anterolateral abdominal wall, which is approximately 2.5 cm medial to the anterior superior iliac spine, while another physical therapist helped participants to correctly perform the HLSE and BLSE by palpating the abdominal muscles of the participants to check the tension in the TrA and IO muscles and using verbal commands during the intervention. Conversely, the physical therapist could identify the tension of anterolateral abdominal muscles during BLSE.[11] To ensure that the participants could adjust to the intervention, the intervention intensity was increased from 1 to 3 weeks and 4 to 9 weeks to 10 to 12 weeks with the holding times 3, 5, and 8 seconds, and we freely provided break time when they felt fatigue and discomfort.

Hollowing and Bracing with Lumbar Stabilization Exercise

The HLSE and BLSE groups performed the intervention at different community welfare centers. First, for the side plank exercise, the participants of each group laid on their sides with their knees extended. They lifted their hips off the mat, keeping only their feet and flexed elbows on the ground. They extended the other upper extremity laterally alongside their bodies. Then HLSE and BLSE groups maintained this position while performing the hollowing or bracing strategies, respectively. Second, participants of each group lay in the supine position with their knees flexed and their feet on the mat for the bridge exercise. They extended both upper extremities, lay on the ground, and lifted their trunks off the mat, keeping the trunk and pelvis in a neutral position alignment while performing the hollowing or bracing strategies. Third, the participants bent down and knelt with their feet in a comfortable, neutral position to perform the 4-kneeling exercise. The participants of each group maintained a small arch in the lower back while performing the hollowing or bracing strategies. Fourth, the participants of each group lay on the mat in prone position. They placed their hands by their shoulders, with their palms down and their necks kept in alignment with the spine. Then, they contracted their trunk back extensor to lift the trunk while performing the hollowing or bracing strategies to perform the prone back extension. Fifth, for the prone plank bridge exercise, the participants of each group lay on the mat face down, with their feet shoulder-width apart and their spine and pelvis in a neutral position. With their elbows spaced shoulder-width apart directly below the glenohumeral joint, participants of each group lifted their trunk with their forearms and toes while performing the hollowing or bracing strategies and keeping their trunk straight (Fig 2).

Results

Characteristics of the Participants

There were 67 initial participants, but 19 participants were excluded before the groups were assigned for the following reasons: low back surgery (n = 8), radiating pain in the lower extremities (n = 1), age < 60 years (n = 7), kyphosis (n = 1), spinal stenosis (n = 1), and scoliosis (n = 1). The HLSE group that initiated the intervention included 21 participants; the BLSE group included 27. However, 4 participants dropped out of the HLSE group for the following reasons: illness (n = 1), private scheduling conflicts (n = 1), and failure to attend the post-test (n = 2). Six participants dropped out of the BLSE group because of illness (n = 2), family problems (n = 2), and absence from the post-test (n = 2).

Finally, 17 and 21 participants in HLSE and BLSE groups, respectively, completed the intervention. Table 1 shows that there were no significant differences of the baseline age, height, and weight between the HLSE group and the BLSE group. The mean ages of the participants were 70.6 (standard deviation [SD] = 1.7) years and 66.8 (SD = 4.4) years in the HLSE group and the BLSE group, respectively (Table 1).

Exercise Attendance Rate. The total number of interventions was 36, and the participation ratio was 89.76% and 77.81% for the HLSE and BLSE groups, respectively.

Trunk Muscles Strength

Our results indicated that BLSE (F = 18.20, P = .002) was more effective than HLSE for trunk flexor strength. The BLSE group (t = –2.50, P = .024) also was more effective than HLSE (t = –5.56, P = .001) in within-group difference. Cohen's d value, which compared and quantified the effect size of the intervention, was twice as high in the BLSE group (–1.21) than in the HLSE group (–0.53) (Table 2).

For trunk back extensor, BLSE (F = 4.38, P = .363) appeared to be more effective to increase trunk back extensor strength than HLSE according to the between-group difference. BLSE (t = –9.19, P = .001) also was more effective than HLSE (t = –6.00, P = .001) in within-group difference. The effect size of the BLSE group (–2.00) was extremely high compared with that of the HLSE group (–1.10) (Table 2).

In trunk side flexor, although there was significant difference (F = 11.10, P = .001) between HLSE and BLSE groups, HLSE (P = .23) and BLSE (P = .94) were insufficient to increase trunk side flexor strength in within-group difference and effect size, which were 0.27 and –0.24 for the HLSE and BLSE groups, respectively.

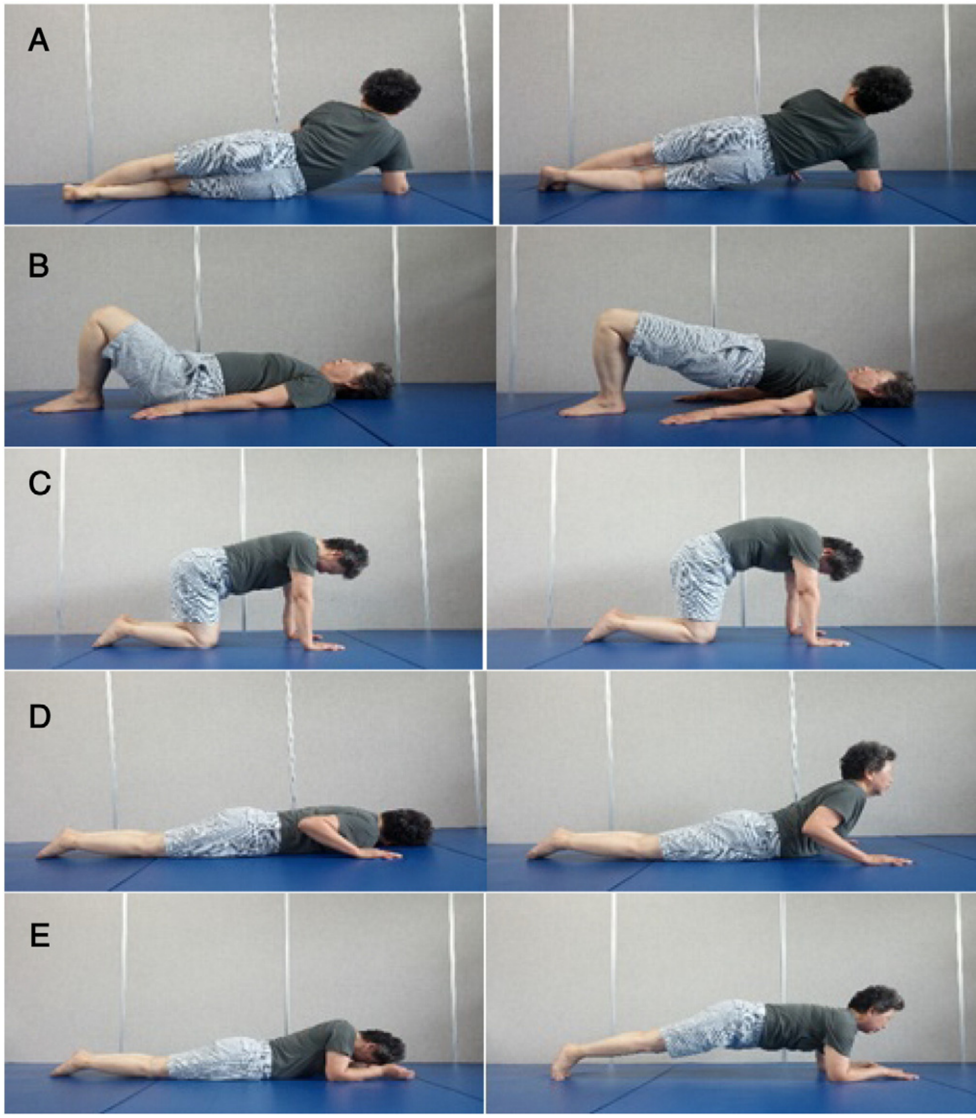

Fig 2. *Exercises. (A) Side plank exercise. Start and finish, left side (3), right side (3) × 5 set, total (15). (B) Bridge exercise. Start and finish, 5 × 5 set, total (25). (C) Bridge exercise. Start and finish, 5 × 5 set, total (25). (D) Four kneeling exercise. Start and finish, 5 × 5 set, total (25). (E) Prone back extension. Start and finish, 5 × 5 set, total (25).*

Table 1. *Baseline Demographics, Mean (SD)*

	HLSE Group (n = 21)	BLSE Group (n = 27)	*P*
Age, y	70.6 (1.7)	66.8 (4.4)	.17
Height, cm	154.76 (0.97)	156.95 (4.36)	.89
Body weight, kg	57.47 (5.60)	56.57 (1.42)	.19
Body mass index, kg/m^2	24.00	22.96	—

BLSE, bracing lumbar strategy exercise; *HLSE,* hollowing lumbar strategy exercise; *SD,* standard deviation.

Low Back Disability

Although there was a significant difference between HLSE and BLSE groups, HLSE and BLSE were useful to improve low back disability in within-group difference. The difference in K-ODI between both groups was not significant (F = 0.28, P = .20) after 12 weeks, but within-group differences were significant for HLSE (t = 4.45, P = .001) and BLSE (t = 4.60, P = .001), respectively. The effect size for the HLSE group was 0.88 and that for the BLSE group was 0.81.

Table 2. *Cohen's d of Both Groups*

		HLSE	BLSE
Trunk muscle strength	Trunk flexor	–0.53	–1.21
	Trunk side flexor	0.27	–0.24
Static balance	Trunk back extensor	–1.10	–2.00
	One leg standing	0.19	0.21
Low back disability	K-ODI	0.88	1.05
	K-RMDQ	0.19	0.40

Values are expressed as effect size of Cohen's *d*.
BLSE, bracing lumbar stabilization exercise; *HLSE,* hollowing lumbar stabilization exercise; *K-ODI,* Korean Oswestry Disability Index; *K-RMDQ,* Korean Roland Morris Disability Questionnaire.

The difference in K-RMDQ between groups was not significant ($F = 1.122$, $P = .283$) after 12 weeks (Table 3), but HLSEs ($t = 3.97$, $P = .001$) were only significant in within-group difference. The effect size of the HLSE group (0.80) was more than double that of the BLSE group (0.34) (Table 2).

Static Balance

HLSEs and BLSEs were not helpful to improve static balance. After 12 weeks, neither the group difference was significantly different in the 1-leg standing test (F = 1.10, $P = .54$), nor the within-group difference of HLSE ($t = –1.01$, $P = .33$) and BLSE ($t = 0.97$, $P = .34$) (Table 2). The effect size was 0.19 for the HLSE group and 0.21 for the BLSE group.

Discussion

Trunk Muscle Strength

Although both groups improved, BLSE was more effective for trunk flexor improvement of older adult women with NSLBP than HLSE. This suggested that the EO and RA were activated as the agonists of trunk flexion and that muscle hypertrophy occurred enough to increase the strength of the trunk flexor when activated by the EO and RA. More activation of EO has been reported in bracing strategy than hollowing strategy. One study reported that bracing strategy is more effective to activate abdominal deep muscles.[25] EO was activated to approximately 32% of maximum voluntary isometric contractions by bracing and 12% by hollowing. The percent electromyography maximum value in RA was 18% in the bracing strategy, whereas the RA value was approximately 6% in the hollowing strategy.[13] Thus, we suggest that BLSE would be effective for improvement of trunk flexor strength more than HLSE.

Although there were no significant differences between groups, HLSE and BLSE could improve the muscle strength of the trunk back extensor considering the increase in the mean value and effect size (Tables 2 and 3). Activation of ES has been reported to be greater in bracing strategy than hollowing strategy. For the trunk back extensor, the percent electromyography max value of the ES was 20% in the bracing group and 10% in the hollowing group, and the ES was activated about 63% more in trunk extension performed without the hollowing and bracing strategies.[13] Reduced activation of the ES is due to dual task interference or antagonist co-contraction, such as the hollowing and bracing strategies, which can influence reciprocal inhibition; it is also assumed to be involved as a factor that limits the maximal activation of antagonistic muscles.[26] Trunk back extension except for the hollowing and bracing strategies can be effective in improving the muscle strength of the back extensor in older adult women with NSLBP, with the focus on muscle strengthening. Conversely, HLSE and BLSE would be effective for simultaneously improving lumbar stability and strengthening muscles in older adult women with NSLBP in community setting.

HLSE and BLSE may be less effective in increasing the muscle strength of the trunk side flexor. The strength of the trunk side flexor can be confirmed by the increase in the activation of the EO, IO, and latissimus dorsi (LD) muscles.[27,28] We suggested that the muscle strength of the EO and LD is important for identifying significant differences in trunk side bending. Thus, the reason why there were no significant differences in the strength of trunk side flexor is because the lower activation of the LD was caused by static posture. The bracing strategy is more effective in increasing the strength of EO than the hollowing strategy,[25] whereas the hollowing strategy with the 4-point kneeling position activated IO about 2 times more than the EO. Although the EO and IO activated, the data suggest that strength of the EO and IO would neither cause significant differences in the trunk side flexor nor be enough to induce muscle hypertrophy in both groups. Thus, we have identified that HLSE and BLSE may be less effective in muscle strengthening of the trunk side flexor.

Low Back Disability

HLSE and BLSE appeared to be effective for low back disability of older adult women with NSLBP. Although there were no significant differences between the groups in K-ODI and K-RMDQ, both groups had significant improvement of low back pain in within-group difference of K-ODI and K-RMDQ but not K-RMDQ in the BLSE group. The small differences between the HLSE and BLSE groups concerning K-ODI and K-RMDQ seem to be insufficient to have statistical meaning. However, in terms of the minimally clinically important difference (MCID) and effect size, HLSE may be more effective in improving low back disability than BLSE. In K-ODI, the effect size of HLSE (0.80) and BLSE (0.34) had similarity in MCID (10.23 [HLSE] vs 6.76 [BLSE]). The MCID of K-RMDQ was 2.88 and 2.24 for the HLSE and BLSE groups, respectively.[28,29] Our results suggest that, in the clinical viewpoint, HLSE and BLSE can be used to improve low back disability in older adult women with NSLBP.

Table 3. *Physical Function of Both Groups, Mean (SD)*

Variables		Hollowing Lumbar Stabilization Exercise	Bracing Lumbar Stabilization Exercise	Between-Group Difference, *F (P)*
Trunk strength	Trunk flexor, lb			18.20 (.002)[a]
	Pre	30.97 (4.62)	37.00 (8.32)	
	Post	35.73 (8.63)	48.46 (11.38)	
	Within-group difference	–04.79 (9.05)[a]	–14.73 (12.13)[a]	
	Trunk side flexor, lb			11.10 (.001)[a]
	Pre	45.70 (9.44)	54.10 (11.31)	
	Post	43.22 (9.41)	56.46 (11.31)	
	Within-group difference	2.48 (9.15)	–3.95 (16.21)	
	Trunk back extensor, lb			4.38 (.363)
	Pre	48.08 (10.79)	54.14 (10.80)	
	Post	68.77 (19.90)	79.27 (22.84)	
	Within-group difference	–20.69 (18.78)[a]	–32.32 (16.11)[a]	
Low back disability	K-ODI score			0.28 (.202)
	Pre	22.67 (11.10)	20.32 (17.95)	
	Post	14.38 (13.60)	15.28 (16.60)	
	Within-group difference	8.29 (9.43)[a]	6.63 (6.29)[a]	
	K-RMDQ score			1.12 (.283)
	Pre	5.14 (4.11)	4.26 (4.79)	
	Post	2.81 (3.39)	3.11 (3.84)	
	Within-group difference	2.33 (2.91)[a]	1.48 (3.74)	
Static balance	One leg standing, s			1.10 (.54)
	Pre	5.87 (5.32)	10.21 (13.18)	
	Post	7.37 (5.42)	8.95 (9.41)	
	Within-group difference	1.26 (6.76)	1.62 (7.67)	

K-ODI, Korean Oswestry Disability Index; *K-RMDQ,* Korean Roland Morris Disability Questionnaire; *SD,* standard deviation.
[a] Significant difference ($P < .05$).

Static Balance

HLSE and BLSE appear to be not enough to improve static balance of older adult women with NSLBP. There were neither significant between-group differences nor within-group differences of static balance. Cohen's *d* also indicated a small effect of about 0.2 in both groups.[24] As a result of reduced proprioception, deficiencies in reaction time, defects in postural control and stability,[30] and lumbar instability have been noted in patients with NSLBP.[28] This study appeared to predict the improvement of low back disability and trunk muscle strength through HLSE and BLSE. However, static balance may not have been increased, although low back disability was improved, because static balance depends on proprioception, altering muscle activation patterns, visual feedback, and the vestibular system. If an intervention for visual feedback and vestibular system was provided, the improvement of static balance could have been anticipated. However, intervention for the improvement of visual feedback and the vestibular system was not provided in the present study to focus on static and stable postures for correct HLSE and BLSE. Thus, because HLSE and BLSE mainly enhanced the proprioceptive sensory system and trunk muscle strength without improving the visual and vestibular systems, our results suggest that HLSE and BLSE were not enough to improve static balance for older adult women with NSLBP.

Limitations

This study is a community-based research that used a quasi-experimental design. However, it has some limitations, including the fact that the adequate number of participants was not calculated. Another limitation of this study is the absence of a control group. Moreover, although no sex restriction was used in the recruitment process, all the included participants were women. Potential threats to the internal validity of the healthy participants, spouse's health, and private schedule have to be considered. Nonetheless, the present study is relevant because it is the first quasi-experimental study on community-based rehabilitation to explore the effectiveness of HLSE and BLSE in the community setting. However, further large-scale clinical studies are necessary to confirm the generalizability and applicability of the hollowing and bracing strategies.

Conclusion

Our findings suggest that HLSE and BLSE could be recommended for use in community settings to improve trunk strength and low back disability in older adult women with NSLBP. HLSEs and BLSEs could be especially recommendable for elderly women with NSLBP who have lower back disability and weak trunk muscle strength, respectively.

Funding Sources and Conflicts of Interest

No funding sources or conflicts of interest were reported for this study.

Contributorship Information

Concept development (provided idea for the research): M.S.K.
Design (planned the methods to generate the results): M.S.K.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): M.H.K., S.J.O.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): M.S.K.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): M.S.K.
Literature search (performed the literature search): M.S.K.
Writing (responsible for writing a substantive part of the manuscript): M.S.K.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): M.H.K., S.J.O.

Practical Applications

- The present study aimed to explore the effectiveness of HLSEs and BLSEs for older adult women with chronic NSLBP to apply to community settings.
- Our findings suggest that HLSEs and BLSEs could be recommended for use in community settings to improve trunk strength and low back disability in older adult women with NSLBP.
- HLSEs and BLSEs could be especially recommendable for elderly women with NSLBP who have lower back disability and weak trunk muscle strength, respectively.

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