Effects of Different Frequencies of Whole Body Vibration on Repositioning Error in Patients With Chronic Low Back Pain in Different Angles of Lumbar Flexion

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Abstract

Objective: This study aimed to evaluate the effect of high and low frequency of whole body vibration (WBV) on repositioning error in 3 different angles of lumbar flexion in patients with chronic low back pain.

Methods: Twenty-four participants with chronic low back pain, aged between 20 and 35 years, were included in this randomized crossover trial study. Participants were randomly assigned into 2 groups as follows: (1) low frequency/high frequency, and (2) high frequency/low frequency. Participants received high-frequency (50 Hz) and low-frequency (30 Hz) WBV in a semi-squat position for 5 minutes in 2 sessions, with 2 weeks of rest. Before and after the WBV, lumbar repositioning error in 30% and 60% of lumbar full flexion and neutral position with eyes closed when standing was evaluated using an electrogoniometer.

Results: The repositioning error was decreased in neutral, 30%, and 60% of lumbar flexion after the low-frequency and high-frequency WBV. Post hoc testing revealed that the effect of angle was not significant in repositioning error changes between high-frequency and low-frequency WBV ($P > .05$). However, the effect of low-frequency WBV on the repositioning error was significantly higher compared with high-frequency WBV ($P < .05$).

Conclusion: Low-frequency WBV might induce more improvement in the accuracy of lumbopelvic repositioning compared with high-frequency WBV with the method of WBV used in this study. (J Manipulative Physiol Ther 2019;42:227-236)

Key Indexing Terms: *Proprioception; Spine; Low Back Pain*

Introduction

Chronic low back pain (CLBP) is one of the most prevalent problems worldwide, with up to 84%[1,2] of employees being restricted from their work for at least 23 days in a year.[3-6] Chronic low back pain is a condition with a variety of associated symptoms, such as segmental instability and proprioception deficiency.[7] Findings generally encountered in patients with CLBP include reduced lumbar flexibility, reduced flexion–relaxation observed in healthy participants, reduced proprioception, and reduced static balance.[8-11] Proprioception as part of the somatosensory system provides some necessary information for controlling the spine via the afferent input such as joint, ligamentous, skin, and the muscles to the central nervous system.[12,13] A common assessment of proprioception is the measurement of active or passive repositioning error (RE) (ie, the difference between a target position and the reached position of the patient) using kinematic tools.[12-14] Some data revealed that decreased proprioceptive sense is a manifestation of neuromuscular deficiency and unbalanced muscular activation pattern in agonist and antagonist in CLBP.[7,15,16] Therefore, normal proprioception is thought to be essential for this muscular coordination, which is an essential component in the rehabilitation of the spine to restore normal motor control.[17]

Several therapeutic approaches, such as bracing, neurodynamic taping, manual maneuver, and weight-bearing exercise on balance board, have been used to improve proprioception.[13] Introduced recently, whole body vibration (WBV) is known as mechanical oscillatory movements

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Paper submitted November 18, 2017; in revised form July 16, 2018; accepted November 2, 2018.

0161-4754

https://doi.org/10.1016/j.jmpt.2018.11.006

on a platform that is used in physiotherapy, sport medicine, and rehabilitation.[9,18] The intensity of the device can be set up via frequency range between 15 and 60 Hz and an amplitude of between about 1 and 10 mm.[18] Vibration training has been used in acute and long-term settings.[18-21] In a clinical view, it may be useful as a neuromuscular warm-up to prepare the athlete for competition.[18] It also improves force, power, hormonal profile, strength, flexibility, balance, bone marrow density, and proprioception.[18-20,22] Whole body vibration has shown success in improving aspects of proprioception, such as RE in anterior cruciate ligament reconstruction and knee osteoarthritis.[23,24] However, some studies reported that the position sense accuracy and RE of the knee and shoulder joints were not improved after the application of several sessions of WBV in healthy participants.[25,26] In CLBP, there is some evidence that the WBV can improve pain, disability, balance ability, trunk muscle activity, and trunk kinematics.[27-29] There are no data about the acute effect of WBV on RE of the lumbar region in CLBP. However, Fontana et al demonstrated that WBV improved the accuracy of lumbosacral repositioning to about 39% in normal healthy participants.[21]

Flexion of the spine is an activity that is repeated frequently throughout the day. High repetition of this movement associated with reduced lumbar extensor torque can cause tissue failure and pain in the lumbar spine.[8,9] Moreover, it is possible that the unbalanced lumbar muscle activation pattern, impaired motor control, and altered lumbar spine kinematic in CLBP is a manifestation of the commonly associated lumbar proprioception deficit.[17,30,31] Whole body vibration training is one of the new clinically useful adjuncts to improve some aspects of proprioception in peripheral joints such as knee joint RE.[23,24] To the best of our knowledge, the effect of WBV during lumbar spine flexion has not been evaluated in CLBP. Considering that the effect of WBV on proprioception can be frequency dependent, the aim of this study was to evaluate the acute effect of different frequencies of WBV on RE during lumbar spine flexion in 3 different angles in CLBP.

Methods

Study Design

This study was conducted between September 2016 and April 2017 (≈32 weeks) in Tehran, Iran. This was a crossover trial comprising 2 separate sessions of WBV (low and high frequency) 2 weeks apart to reduce the impact of possible carryover effects. The order of receiving the WBV was counterbalanced by dividing the participants into 2 groups (low/high and high/low frequency) randomly. Randomization was conducted using a random sequence generator program (available at http://www.random.org). In the first session, half of the participants received low-frequency WBV and the other half received high-frequency WBV. The order was reversed in the second session.

Ethics

Approval for the study was obtained from the ethics committee at Iran University of Medical Sciences (REC Reference: IR.IUMS.REC 1392/d/206/320). All participants received a verbal and written description of the study. A written informed consent was obtained from all volunteers, and all procedures were performed according to the Declaration of Helsinki. The participants were assured that their personal information was kept confidential (confidentiality principle). None of the volunteers received monetary rewards or compensation for their time and participation in this study.

Recruitment

Participants were included in the study via the convenience sampling method using verbal requests and posters that were displayed in the most visited area of the university and the surrounding locality. This study was conducted in the biomechanical laboratory of Iran University of Medical Science.

Study Population

Sample size was determined according to the previous similar study and was calculated according to the formula

$$\left(\mathrm{N} = \frac{\left(\left(Z_{1-\frac{\alpha}{2}} + Z_{\beta}\right)^2 \times \left(S_1{}^2 + S_2{}^2\right)\right)}{\left(X_1 - X_2\right)^2} \right).$$

Moezy et al[23] obtained the mean (± standard deviation) of the lumbosacral angle joint during repositioning test equal to 1.4 ± 0.64 and 1 ± 0 before and after WBV, respectively. To obtain a 95% CI and 80% power, 20 participants were needed. The significance level was set at 0.05 as the critical value. To allow for 20% attrition, the sample size was increased to 24 participants. Therefore, 24 participants with CLBP were included based on eligibility criteria.

A convenience sample of 24 participants (12 male and 12 female) who were diagnosed with CLBP by a physician was included in this study. The inclusion and exclusion criteria were selected according to studies by Boucher et al[30] and Moezy et al[23] (Fig 1).

Apparatus

This study was conducted in 2 separate sessions with a 2-week washout period to avoid any possible carryover effect.[32] The participants were intervened via the WBV with high and low frequency during standing on both feet. The

Inclusion Criteria

- CLBP (LBP persisting for more than 3 months in the absence of an underlying pathology)
- Aged between 20 and 35 years
- Ability to perform forward flexion movement without an aid or pain and discomfort
- Pain lower than 60mm as measured by visual analog scale.

Exclusion Criteria

- Obvious deformity of the spine, pelvis, and lower extremities
- Pregnancy
- Rheumatological or neurological diseases
- Presence of infection, tumors or radicular symptoms
- Spinal fractures
- Back surgery
- Any recent trauma to the musculoskeletal system such as bony, muscular, ligamentous, and soft tissue structures in the lower extremities and trunk that might interfere with forward flexion movement
- Epilepsy and osteoporosis and any condition that the exercise on the WBV machine is contraindicated.[30]

Fig 1. *Inclusion and exclusion criteria.* CLBP, *chronic low back pain;* LBP, *low back pain;* WBV, *whole body vibration.*

position sense was recorded before and after the intervention using an electrogoniometer (Biometrics Ltd, England) with sampling rate of 50 Hz. Previous studies demonstrated a high correlation coefficient equal to 0.97 and a high intraclass correlation coefficient equal to 0.98 for this device to evaluate the sagittal motions of the T_8 vertebrae through S_1.[33]

Position Sense Assessment

To measure the absolute repositioning error, participants were asked to stand barefoot and the sensors were attached to the bony landmark as follows: superior margin and inferior margin of the sensor were fixed along with the lumbar spinous processes to the L1 and S1, respectively[31,34] (see Fig 2). First, by using palpation, the L1 and S1 spinous processes were detected according to *Gray's Anatomy for Students*[35] and double-checked by counting the spinous processes cranially; the spinous processes were marked and the sensors were positioned by double-sided adhesive tape.[36] To avoid using visual feedback, participants were asked to close their eyes and were blindfolded. To decrease the participation of hip and other joints of the lower limb during flexion, participants were positioned just in front of the frame while the pelvis was fixed through the strap below the anterior inferior iliac spine (see Fig 2).

To evaluate RE, participants were assessed in 2 steps.[31] First, the maximum lumbar flexion without contribution of the pelvis was recorded as follows: the participants stood next to the frame and started to bend forward, and the examiner followed the movement of the lumbar spine just a moment before the posterior superior iliac spine of the pelvis moved anteriorly. To decrease measurement error by the examiner, this phase was repeated 3 times with 2 minutes' rest between, and the maximum range of flexion was obtained from the mean of 3 ranges.[31] Accordingly, the full range of lumbar flexion obtained in the first step was used to calculate 30% and 60% of the lumbar flexion for the repositioning accuracy test.

Second, the participants were asked to stand in the starting position and with the command "start" they bent forward. The participants were requested to stop when the range of lumbar flexion reached 30% of the maximum range of lumbar flexion and maintained this position for about 5 seconds. After a 15-second rest interval, the participants were asked to repeat the trunk flexion to reach the previous range of lumbar flexion (30% of the maximum flexion) with the eyes closed. With 15-second rest intervals between tests, this test was repeated 3 times and the mean of these tests was calculated for the accuracy of the repositioning phase.[31]

To obtain the absolute RE for the neutral position and 60% of the maximum range of lumbar flexion, this test was repeated after 2 minutes' rest. The order for performing RE in the neutral 30% and 60% was randomly assigned. Finally, all data were recorded using the DataLink software.

WBV

The participants were asked to stand on the WBV device (Power Plate Inc, Irvine, California), and supported themselves by grasping the handles while flexing the hips and the knees in about 15° (semi-squat position) and the lumbar positioned in slight flexion.[30] The participants were asked to maintain their tragus aligned with their lateral malleolus of the foot while standing on the board. The WBV protocol consisted of 5 1-minute vibration sets with 1-minute rest between sets.[30] The participants were asked to report any unpleasant sense and pain while the WBV was established. The frequency was set to 50 Hz and 2.5 mm for the high frequency and 30 Hz and 2.5 mm for the low frequency, as described by previous studies.[18,32]

Procedure

The procedures were described in detail to the participants. The participant's barefoot weight and height were recorded. The L1 and S1 spinous processes were marked, and the sensor was fixed to these landmarks. The participants were asked to stand next to the frame and the examiner fixed their pelvis with a strap as mentioned earier.

Fig 2. *Participants' positioning for the repositioning error evaluation.*

Then, the maximum flexion range of motion of the lumbar spine was evaluated. The participants were asked to close their eyes and the RE was recorded 3 times in the neutral, 30%, and 60% of its maximum available range.[31] After applying the first assigned WBV according to the randomization scheme, the RE was recorded as described earlier, 5 minutes after WBV. The participants were asked to revisit the lab after 2 weeks and all the procedures were repeated for the second assigned WBV frequency. To avoid the negative effect of fatigue on the position sense, participants were advised to get sufficient rest the night before the experiments.[31] Repositioning of the lumbar spine was performed 5 minutes after the application of WBV protocol. Previous studies have demonstrated that WBV might induce a fatigue effect on the muscles;[32,37] therefore, to avoid the effect of fatigue on the results, all measurements were performed after this rest interval.

Statistical Analysis

Descriptive analysis was used to summarize the participant's demographic characteristics. For each position, RE was calculated through the absolute difference between the actual target position and the mean of the 3 replicated positions. The analysis was done with a repeated-measure (frequency [2] × angle [3] ×time [2]) analysis of variance (ANOVA) method. Post hoc testing was completed using a Bonferroni index to compare the mean differences of the RE between groups. A 2-sided P value < .05 was noted as significant. All analysis was conducted using SPSS version 17 (IBM Inc, Chicago, Illinois).

Results

Participants included 24 people with CLBP who were evaluated in 2 separate sessions, 2 weeks apart. Demographic characteristics are presented in Table 1. A Kolmogorov-Smirnov Z test demonstrated that all parameters obtained in this study were distributed normally. All participants successfully completed the WBV protocol and did not report any pain or discomfort during the WBV and testing condition.

First, the effect of frequency (low and high), angle (0°, 30°, and 60°), and time (pre and post) is evaluated separately. Then the interaction of these dependent variables on the RE as independent variable is reported. Pain was analyzed using a repeated-measure ANOVA from pre-WBV to post-WBV.

The Effect of Frequency, Angle, and Time on RE

There was no sequence effect on the absolute RE (P = .7). The effect of frequency (low and high) on the RE was demonstrated as being significant with higher RE values for the high-frequency WBV ($F[1.00, 1.573] = 9.252$, $P < .007$) (Table 1). A repeated-measures ANOVA with a Greenhouse-Geisser correction determined that the mean differed in a statistically significant fashion between points (pre and post) ($F[1.00, 36.512] = 28.333$, $P < .001$). However, the effect of angle on RE was not significant in the 3 angle conditions (Table 2).

The statistic model with a Greenhouse-Geisser correction revealed a significant effect of interaction between the "frequency × angle," "frequency × time," and

Table 1. *Demographic Characteristics*

Variable	Mean	SD
Sex (n) [a]	12 M, 12 F	-
Age (y) [a]	25.2	2.6
Height (cm) [a]	165	4.31
Weight (kg) [a]	62.1	6.8
Mean VAS 24 h (mm) [a]	45.8	10.2
Duration of LBP [a]	50.55	35.24
ODI (pts) [a]	12.46	8.51
Lumbar flexion [a]	48.5	3.3
Working status (n)		
Working full-time	9 (39%)	-
Working part-time	12 (52%)	-
Not working	3 (9%)	-
Education (n)		
Lower than diploma, diploma, and advanced diploma	4 (17%)	-
Bachelor's degree	16 (65%)	-
Higher than bachelor's degree	4 (17%)	-

F, female; *LBP*, low back pain; *M*, male; *ODI*, Oswestry Disability Index; *SD*, standard deviation; *VAS*, visual analog scale.
[a] Values are presented as mean ± SD.

"frequency × angle × time" in the RE. However, the interaction between the "angle × time" on the repositioning error was not significant (F[1.520, 1.322] = 1.589, *P* = .223) (Table 3). Therefore, we can conclude that a WBV program elicits a statistically significant reduction in absolute RE, but this improvement obtained through the WBV did not differ in the 3 angles evaluated in this study (Table 3). Table 4 shows the mean and standard error of mean of the absolute RE in pre- and post-treatment after low-frequency and high-frequency WBV obtained from repositioning accuracy in the 3 different angles of flexion.

Repeated-measure ANOVA revealed that the pain decreased significantly between pre-WBV (mean of pain 45.8 ± 10.2) and post-WBV (mean of pain after the low frequency: 36.6 ± 7.8, and high frequency: 34.7 ± 8.7) with low frequency (mean difference: 9.22, *P* = .000) and high frequency (mean difference: 11.05, *P* = .000). However, no difference was demonstrated between post-WBV with high frequency and post-WBV with low frequency.

The statistic model with a Greenhouse-Geisser correction revealed a significant effect of low-frequency WBV on the target angle on the post-treatment versus pretreatment when the participants repositioned the lumbar in 30% and 60% and neutral joint positions. However, the effect of high-frequency WBV on the target angle was significant at the neutral joint angle. The effect of frequency was significant on the joint angle when the participants repositioned the joint to the neutral position (see Table 5).

Discussion

This study aimed to evaluate the effect of 2 protocols of low-frequency and high-frequency WBV on the absolute RE of the lumbar flexion in 3 angles, including neutral (0°), 30%, and 60% of its maximum range. Our results demonstrated that the WBV is effective in decreasing the RE and improving the position sense accuracy in CLBP. Our study may have practical future implications for possible application of WBV to reduce pain and improve proprioception in CLBP.

Our results demonstrated that the amount of error measured in different angles is dependent closely on the frequency of WBV. The absolute RE measured in this study after the low-frequency WBV protocol was lower than the high-frequency WBV. However, the effect of different angles on the RE was not significant. Instead, the interaction among the frequency, angle, and time was significant in decreasing the RE. Another finding of this study was that the pain decreased after the WBV was received. No difference was observed between high-frequency and low-frequency WBV in pain reduction. Moreover, the effect of low-frequency WBV on the angle when the participants repositioned the joint to the neutral and 30% and 60% of maximum range was significant.

Our results demonstrated that 1 session of high-frequency and low-frequency WBV improved repositioning accuracy in 3 different angles during lumbar flexion. This improvement might be considered a consequence of increased joint and muscle receptor stimulation after WBV.[7,16,37,38] Spinal joints have maximum congruency in the neutral position where the receptors have optimal activity in this zone,[31,38] whereas the muscle receptors including the Ia afferent fibers could be easily stimulated in the middle range of the muscle length and therefore contribute to increase of the position sense accuracy where they are in a slight stretching position.[9,39] Previous studies considered the muscle receptors as the most important factors for the position sense and proprioception in the lumbar spine.[16,40,41] Although RE was improved in 30% of maximum lumbar flexion range, this improvement was obtained in the neutral position and 60% of maximum lumbar flexion, showing that the proprioception might be developed throughout the lumbar spine flexion range when the measurements were performed immediately after WBV. This may be due to activation of

Table 2. *The Effect of Frequency, Angle, and Time Associated With Mean Difference ± Standard Error and Significance Levels on Repositioning Error*

Variable	Condition 1	Condition 2	Mean Difference	Standard Error	Sig.	F	95% CI for Difference Lower Bound	95% CI for Difference Upper Bound
Frequency	Low	High	-0.162	0.053	0.007	9.2	-.273	-.051
Angle								
	0	30	0.501	0.224	0.112		-.087	1.089
	0	60	0.213	0.209	0.968	3.033	-.337	.762
	30	60	-0.288	0.176	0.355		-.751	.174
Time	1	2	0.780	0.147	0.000	28.333	0.473	1.087

CI, confidence interval; *F*, F-statistic; *Sig.*, level of significancy.

Table 3. *Interaction With a Greenhouse-Geisser Correction for the Frequency, Angle, and Time in Pre- and Post-WBV Training*

Interaction With a Greenhouse-Geisser Correction	Type III Sum of Squares	*df*	Mean Square	F	Sig.
Frequency × angle	1.446	1.871	.773	3.606	.04
Frequency × time	1.573	1.000	1.573	9.252	.007
Angle × time	2.009	1.520	1.322	1.589	.223
Frequency × angle × time	1.446	1.871	.773	3.606	.04

df, degrees of freedom; *F*, F-statistic; *Sig.*, level of significancy; *WBV*, whole body vibration.

the Ia afferent fibers and α-motor neurons by repetitive stimulation of the back muscles during WBV,[30,42] causing the muscle receptor activity to remain high for a short time after receiving WBV. However, recently Ahmadi et al evaluated the acute effect of WBV on the H-reflex recruitment curve and revealed that the H-reflex recruitment curve parameters were inhibited after low-frequency WBV.[32] Apple et al reported similar results; however, they revealed that this inhibition returned to the baseline within 5 minutes after the receipt of WBV.[37] Ritzmann et al evaluated the effect of WBV on the motor neuron excitability using H-reflex and stretch reflex during receiving WBV and immediately, 5 minutes, and 10 minutes after the WBV in healthy patients.[43] They revealed that the suppression of H-reflex and stretch reflex obtained during the WBV training lasted for 5 minutes and returned to the initial state after 10 minutes. However, they demonstrated that suppression effect of the WBV on the H-reflex and stretch reflex was only seen when the measurement was performed during rest conditions, and no distinct suppression in the active task performance such as hopping was observed. However, it might be because all of these studies evaluated healthy participants, and we evaluated a group of participants with CLBP. Therefore, reduced RE obtained in the current study might be as a consequence of other mechanisms such as gaiting mechanism."

Whole body vibration is a method that exposes the entire body to mechanical vibration. It is possible that exposure to WBV induces a vast input of sensory feedback from the muscles and joint receptors to the central nervous system.[18,30] Previous studies have demonstrated that pain might be considered a possible explanation of gaiting mechanism for decreased proprioception and joint position sense.[44] Gaiting is a form of competition in sensory information such as proprioceptors and chronic pain in the higher centers for perception.[44] As pain decreased in our study after WBV, decreased RE in lumbar flexion after a period of WBV could be due to the sea of sensory flow arising from the joints and muscles to the central nervous system.[18] It is possible that this sensory flow competes with pain for attention in the brain.[44] Our results are in line with some studies that demonstrated a decrease in RE after WBV;[21,23,31,45] however, Li et al obtained different results.[46] They found that the RE increased after applying WBV in the seated and standing positions for 20 minutes compared with the control participants. However, the difference in the results might be due to the healthy participants exhibiting different neuromuscular responses after the WBV program.[21,25,26] In addition, they used a different approach to analyze the spinal motion (a 3-dimensional motion analyzer), and the WBV was applied for 20 minutes with different frequency (5 Hz).[47] These are possible reasons for the obtained results.

Table 4. *Mean ± Standard Error and CI 95% for the Mean Obtained From Pre- to Post-WBV*

Frequency	Angle	Time	Mean	Standard Error	95% CI Lower Bound	95% CI Upper Bound
Low						
	0	Pre	2.912	.195	2.505	3.320
		Post	1.569	.155	1.244	1.894
	30	Pre	2.309	.210	1.870	2.748
		Post	1.550	.140	1.258	1.843
	60	Pre	2.476	.237	1.981	2.971
		Post	1.752	.219	1.294	2.210
High						
	0	Pre	2.90	.195	2.5	3.30
		Post	2.260	.222	1.795	2.726
	30	Pre	2.3	.210	1.90	2.75
		Post	1.483	.182	1.101	1.864
	60	Pre	2.50	.237	1.99	2.98
		Post	2.100	.262	1.552	2.648

CI, confidence interval; *WBV*, whole body vibration.

Table 5. *Interaction With a Greenhouse-Geisser Correction for the Frequency and Time in Pre- and Post-WBV Training for the Joint Angle*

Angle	Frequency	Pre Mean ± (SD)	Post Mean ± (SD)	Pre Versus Post Mean Difference	Pre Versus Post *P* Value	Low Versus High Mean Difference	Low Versus High *P* Value
30	Low	13.6 (1.97)	14.6 (1.47)	-0.9	.05 [a]	0.7	.6
	High	13.53 (1.67)	14.2 (1.54)	-0.5	.1		
60	Low	29.7 (3.97)	28.48 (2.78)	0.73	.004 [a]	0.67	.06
	High	29.2 (3.17)	28.63 (3.17)	0.57	.2		
0	Low	-2.91 (.57)	-1.47 (.88)	1.4	< .001 [a]	1.04	.000
	High	-2.51 (.87)	-2.26 (.99)	-0.65	< .001 [a]		

SD, standard deviation; *WBV*, whole body vibration.
[a] Significant at $P \leq .05$.

Another interesting finding of this study was that participants consistently undershot the target positions when they were asked to reposition the lumbar spine in the neutral and 60% of maximum range. However, they overshot the target position when they were asked to reposition the lumbar spine in the 30% of maximum range position. Overshooting and undershooting the target has been reported in other vibration studies. A previous vibration study revealed that when repositioning to posterior direction and neutral position, undershooting occurred during low-frequency WBV[21] and also during vibration at the tendon.[47] However, the effect of vibration is very complex, and it is beyond the scope of this study to determine the reason for undershooting and overshooting occurring when repositioning the lumbar to the neutral, 60%, and 30% positions, respectively.

The results also revealed a significant difference between high-frequency and low-frequency WBV in improving the repositioning error, in favor of low frequency. In addition, the low-frequency WBV has more effect on the neutral position error. It is presumably due to the different roles of slow- and fast-adapting receptors in response to the high-frequency and low-frequency WBV.[27,32] Consequently, the low-frequency WBV induces a tonic response and enhances the position sense, while high-frequency WBV induces a phasic response.[32] Previous studies demonstrated that the high-frequency WBV disturbs the accuracy of information to be processed in the brain or the spinal level.[19,20] Low-frequency WBV affects the deep joint and muscle receptors, whereas the high-frequency WBV affects skin receptors.[19] Fontana et al demonstrated that low-frequency WBV can improve repositioning accuracy;[21] however, they did not compare the effect of low-frequency WBV with high frequency WBV. Moezy et al[23] and Trans et al[32] evaluated the effect of several sessions of WBV on knee joint proprioception with low-frequency WBV (30 Hz). The results obtained demonstrated the improvement of position sense accuracy after this program.[23,24] Recently, Ko et al evaluated the effect of 6 sessions, twice a week, on joint position sense in cerebral palsy. They concluded that joint position sense and gait variables were improved after this program.[40] The present study had different WBV protocol in low back pain, but the joint position sense improved significantly. In contrast, Hong et al[25] and Pollock et al[26] evaluated the effect of short-term low-frequency WBV on the position sense in healthy participants. They did not reveal any significant difference in altering the RE after this program. Ahmadi et al evaluated the acute effect of low-frequency WBV (30 Hz) on motor neuron excitability in healthy participants. They concluded that the inhibition of the H-reflex is due to the decrease in the Ia drive to the motor neuron pool after WBV.[32] Recently, Sitjà-Rabert et al reported that the effect of 6 weeks of low-frequency WBV associated with exercise including balance and strength training has no superiority to an exercise program only on balance and performance.[48]

The immediate effect of WBV on RE in healthy patients differs from that in patients with musculoskeletal injury.[21,25,26] It is assumed that chronic pain could interrupt the proprioception inputs to perception in the brain. Accordingly, long-lasting pain can disturb the proprioception and impair the motor control of the spine.[17,44] Our results demonstrated that WBV could be a useful modality for improving such an aspect of proprioception including lumbar spine absolute RE using the method of this study. Two main clinical implications of this study are as follows: (1) the use in the acute setting of WBV training with the method described in this paper for pain reduction and proprioception improvement, and (2) low-frequency WBV has a superior effect on proprioception compared to high-frequency WBV.

Limitations and Strengths

This study assessed only a small number of participants in 1 region; therefore, the findings may be limited. We also did not include a control group to compare the effect of the WBV protocol used in this study with the healthy participants. In addition, we evaluated the immediate effect of 1 session of WBV to alter the RE in different angles of lumbar flexion. Further studies would be beneficial to evaluate the effect of several sessions associated with follow-up to alter the lumbar motions in the 3 planes (ie, sagittal, frontal, and transverse planes). The main strength of our study is its randomized crossover design, which is known to be a statistically efficient approach with reduced inter-individual and experimental variability.[49]

Conclusion

We believe that our study was the first work to compare the immediate effect of low-frequency and high-frequency WBV to alter RE in different angles of lumbar flexion in CLBP. According to the obtained results, the variation of the lumbar flexion RE was dependent on the frequency and not the angle of flexion. Higher improvement of RE was obtained at the low-frequency WBV using the protocol proposed in this study.

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

Practical Applications

- This study has a practical implication for the use of WBV training in an acute setting to improve position sense accuracy in CLBP.
- In this study, low frequency was superior to higher frequency.

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