Evaluation of Static and Dynamic Balance Tests in Single and Dual Task Conditions in Participants With Nonspecific Chronic Low Back Pain

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ABSTRACT

Objective: The purpose of this study was to investigate static and dynamic balance tests in single, dual cognitive, and dual manual task conditions in participants with and without nonspecific chronic low back pain.

Methods: In this case control study, 40 patients (age range 18-50 years) with nonspecific chronic low back pain for at least 3 months and 40 healthy participants matched for age, weight, height, and sex participated in this study. Balance performance was evaluated using static (One Leg Stance) and dynamic (Modified Star Excursion Balance Test, 10-m walk test, and Timed Up and Go) balance tests. All tests were performed in three conditions: single task (balance only), dual cognitive task (balance and counting numbers backward), and dual manual task (balance and carrying a cup of water).

Results: The results indicated that different balance tests were impaired in dual task conditions compared with single task in each group. Cognitive and balance performances were not significantly different between nonspecific chronic low back pain and healthy participants in all clinical balance tests.

Conclusion: It seems that the static and dynamic balance performance under dual task conditions (excluding the Modified Star Excursion Balance Test) was impaired in each group. Dual tasking did not differ between nonspecific chronic low back pain participants with low level of pain and disability compared with healthy participants. (J Chiropr Med 2017;16:189-194)

Key Indexing Terms: *Low Back Pain; Posture; Attention*

INTRODUCTION

Low back pain (LBP) is one of the serious problems that leads to loss of working days in industrial societies.¹ It has been estimated that low back pain has been the main cause of years of living with disability in 86 of 188 countries between 1990 and 2013 based on the Global Burden of Disease Study 2013.² Prevalence of low back pain is 65% to 80% during a human lifetime and billions of dollars are spent annually for treatment of low back pain in the United States.¹ It is estimated that approximately 70% to 85% of people have experienced low back pain with recurrent symptoms at least once during their life, and 4% to 33% of patients suffer consistently from chronic pain.^{3,4}

Postural control is the control of body position in space to maintain balance and orientation.⁵ Although maintenance of postural control is essential in static and dynamic conditions, dynamic postural control plays a more critical role because individuals are participant to different threats during their daily activities and dynamic states. A review of the literature indicates that improvement of postural control using rehabilitation training could alleviate pain in musculoskeletal disorders.^{6,7} For example, Kent et al⁸ reported that posture and movement retraining using motion-sensor biofeedback can lead to improvement of pain and functional disability in patients with chronic low back pain. Therefore, these studies indicated that the improvement in postural control may result in improvement of pain and disability symptoms.⁶⁻⁸ Previous researchers have reported impaired postural control in chronic LBP.⁹⁻¹¹ It has been proposed that balance impairment in LBP patients may correlate with deficits in the musculoskeletal and neural systems, such as compromised lumbar proprioception and delayed muscle response, which finally decrease lumbar stabilization.^{9,12}

The traditional view states that postural control is automatic and demands minimal attention.¹³⁻¹⁵ Recently, however, researchers have suggested that it is attentionally demanding.¹³⁻¹⁵ It is assumed that the interaction between postural and cognitive tasks depends on many factors, such

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as postural and cognitive task complexity, aging, integrity of sensorimotor system, and balance abilities.¹⁶ Therefore, sensory motor deficit in these patients could be compensated by higher cognitive systems. When cognitive load enhances through the addition of a dual task, it would be expected to intensify impaired postural control in patients with low back pain.¹⁷

The dual task paradigm is a new method to investigate the attentional demand of postural control.^{16,18,19} With regard to limited capacity theory, simultaneous performance of 2 tasks will compromise the performance of one or both tasks because of competition for attentional resources.²⁰ Salavati et al¹⁵ studied the effect of dual tasking on static postural control in participants with nonspecific low back pain. They reported that there was no significant difference while performing a cognitive task (Backward Digit Span Task) between patients with low back pain and healthy participants using force plates.¹⁵ On the contrary, Sherafat et al²¹ reported that postural sway decreased with an increase in the level of cognitive difficulty in nonspecific LBP patients during dynamic postural control. In fact, postural control deficit in LBP is related not only to sensorimotor impairment but also to cognitive dysfunctions in terms of slow psychomotor speed and impaired short-term memory.^{11,22} Therefore, the current data highlighted the importance of the role of attentional resources as the third element of postural control in LBP patients.

Considering all of these documents, it has been reported that posture maintenance plays an important role in static and dynamic situations during daily activities. On the other hand, several studies have reported that evaluation of balance under dual tasking has a priority compared with single task conditions as a result of the multitasking nature of the modern society.²³⁻²⁶ In addition, Salavati et al¹⁵ suggested that evaluation of static postural control under dual tasking might not be sensitive enough to identify attentional demand of postural control in chronic LBP patients. Thus, assessment of dynamic balance under dual tasking can better reveal subtle balance deficiency than assessment of static balance while performing dual tasks. So it is expected that we observe more attentional interference in dynamic balance task compared with static balance task.

Additionally, the assessment of postural control has been performed using both the laboratory and clinical tests. It seems that the clinical tests are more affordable and cost-effective methods to evaluate postural control in clinical environments. The most important point is that improvement of the laboratory results does not essentially lead to improved postural control while the clinical findings of improving the postural control may be a better indicator of posture performance. If the performance of balance tests is affected by dual task conditions, it can be used as a prognostic factor for individuals with chronic LBP. When balance performance is disturbed, the risk of injuries increases because it can affect the lumbar spine stability as a result of changes in postural recovery strategies.⁹

Thus, the aim of this study was to evaluate and compare the clinical balance tests in single and dual task conditions in nonspecific chronic low back pain patients. In the present study, 2 main questions were addressed:

1. Are laboratory results consistent with clinical balance tests of static and dynamic balance in chronic LBP participants under dual task conditions?
2. Did the response to dual tasking differ between participants with and without chronic LBP?

METHODS

Participants

This experiment was a case control study. Forty patients with nonspecific chronic low back pain (age range 18-50 years) and 40 healthy participants (age range 18-50 years) matched for age, weight, height, and sex took part in this study. The participants were recruited by flyers through a convenience sampling method from students and staff of Shiraz University of Medical Sciences.

They were included if they had chronic LBP for at least 3 months with a pain score of 3 to 5 out of 10 on numerical rating scale (NRS; 0 = no pain, 10 = severe pain)²¹ and a pain score lower than 3 at the time of testing.¹⁵ To evaluate the nature of postural control changes under dual tasking in chronic LBP patients, we controlled the pain intensity before testing because of the effect of pain on motor and postural control dysfunction.¹⁵ Also, they were asked to respond to Hospital Anxiety and Depression Scale (HADS) before testing. If participants had an anxiety score lower than 8, they were included in this study. Because the level of anxiety affects postural control, we included only patients with low levels of anxiety to control the confounding factors.^{27,28}

Participants were excluded if they had a history of spinal surgery for at least the previous 3 months, uncorrected vision impairment, vestibular dysfunction, auditory deficits, the presence of nerve root compression resulting in neurologic symptoms, trunk or spinal deformity, spinal pathologic conditions, and use of any tranquilizer that might influence their balance and pregnancy. All participants signed an informed consent form approved by the Ethics Committee at Shiraz University of Medical Science (#11686).

Procedure

We used clinically different balance tests in different conditions: One Leg Stance (OLS), Modified Star Excursion Balance Test (SEBT), Timed Up and Go test (TUG), and 10-m walk test.

Static balance was assessed by OLS. Also, the TUG,²⁹ 10-m walking test,³⁰ and Modified SEBT³¹ were used as measures of dynamic balance.

To evaluate OLS, the participants were instructed to stand on one leg with eyes open. OLS duration and cognitive performance were measured on the dominant leg.

Modified SEBT was used for assessment of dynamic balance. In this test, the participants were asked to perform maximal reaches with their nondominant limb in 3 directions (anterior, posteromedial, and posterolateral) while the dominant limb was at the center of a modified SEBT test. Recorded distance (cm) of the most distal portion of the reach foot in each direction was normalized by the lower limb length.

In the TUG test, the participants were instructed to rise from a chair without handles, walk 5 m as quickly as possible, turn around an obstacle, walk back, and sit down on the chair.

To perform the 10-m walk test, we asked them to walk 10 m at a comfortable speed from a static start. The time to complete both tests was recorded by a stopwatch.

All tests were carried out in 3 conditions: single task (performance of the test alone), dual cognitive task (performance of the test while counting backward in increments of 3 from a random number between 200 and 300), and dual manual task (performance of the test while carrying a cup of water with the surface of water 3 cm from the edge).

In addition, accuracy (total number of correct answers/total number of answers) and speed of response (total number of answers/response time) were calculated as cognitive task performance. Each test was performed 3 times and the average of the 3 times was used for final analysis.

Data Analysis

Most variables had normal distribution with respect to the Kolmogorov-Smirnov test ($P > .05$). Balance performance for each test was analyzed by 2-way mixed-design analysis of variance with 1 between-participant factor (Group: LBP, Healthy) and 1 within-participant factor (conditions: single task, dual cognitive task, dual manual task). Also, an independent-sample t test was used for cognitive performance. A post hoc analysis with Bonferroni was done if there was a significant effect. The significance level was considered at $P < .05$. Statistical analysis was performed using SPSS 17 for Windows XP (SPSS Inc., Chicago, Illinois).

RESULTS

Table 1 shows the demographic characteristics of all participants. There were no significant differences in sex, age, weight, and height between the 2 groups ($P > .05$).

Balance Performance

Mixed-design 2-way analysis of variance illustrated that the main effect of a task was significant for each balance test with the exception of modified SEBT (Tables 2 and 3). As shown in Figure 1, pairwise comparisons of the tasks

Table 1. Demographic Characteristics of LBP and Healthy Groups

Variables	LBP Group (Mean $\pm$ SD)	Healthy Group (Mean $\pm$ SD)
Age (y)	24.20 $\pm$ 6.09	23.52 $\pm$ 4.84
Weight (kg)	70.68 $\pm$ 11.04	71.87 $\pm$ 12.53
Height (cm)	171.80 $\pm$ 9.35	172 $\pm$ 6.00
Duration of back pain (y)	2.30 $\pm$ 1.15	N/A
RMQS (scale 0-24)	3.70 $\pm$ 2.26	N/A

LBP, low back pain; N/A, not applicable; RMQS, Roland Morris Questionnaire Scale; SD, standard deviation.

revealed that there were significant differences in single task–dual cognitive task, single task–dual manual task, and dual cognitive task–dual manual task pairs in OLS and TUG, whereas balance performance differed significantly only in single task–dual cognitive task and dual cognitive task–dual manual task pairs. The time taken to complete these balance tests increased in dual task conditions (cognitive and manual) compared with single task with the exception of dual manual task in OLS.

Cognitive Performance

The independent-sample t tests indicated that the cognitive performance was not significant for accuracy and speed of response between the 2 groups in all clinical balance tests (Table 4).

DISCUSSION

Previous studies indicated the importance of evaluation of postural control under dual task conditions because of the multitasking nature of daily activities.²³⁻²⁶ Laboratory tests of posture maintenance under dual task conditions indicated that postural control was impaired in LBP patients.^{17,21} Additionally, it seems that the clinical balance tests may be a more affordable and cost-effective method to assess static and dynamic postural control in clinics. Moreover, the clinical balance tests under dual task conditions were assessed in patients with chronic LBP.

The results indicated that the time to stand on the dominant limb in participants with nonspecific chronic LBP was not different from that of healthy participants under

Table 2. Summary of Analysis of Variance for 3 Clinical Balance Tests

Independent Variables	OLS		TUG		10-m Walk	
	F Ratio	P	F Ratio	P	F Ratio	P
Task	15.69	<.001 ^a	69.26	<.001 ^a	35.55	<.001 ^a
Group	1.27	.26	2.35	.12	2.20	.14
Task $\times$ group	1.36	.25	2.07	.12	3.67	.05

OLS, One Leg Stance; TUG, Timed Up and Go.

^a Significant differences ($P < .05$).

Table 3. Results of 2-Way Mixed Analysis of Variance Comparing Anterior, Posteromedial, and Posterolateral Directions

Independent Variables	Modified SEBT					
	Anterior		Posteromedial		Posterolateral	
	F Ratio	P	F Ratio	P	F Ratio	P
Task	2.22	.12	7.18	.06	2.30	.11
Group	1.75	.26	2.92	.09	2.34	.12
Task × group	0.60	.26	2.30	.11	3.01	.06

SEBT, Star Excursion Balance Test.

dual task conditions. These results are consistent with those of Salavati et al.¹⁵ They did not report any difference during an attention-demanding task in patients with chronic LBP compared with the healthy group using force platform. Therefore, it seems that laboratory findings in evaluation of static balance under dual tasking in patients with nonspecific low back pain are in line with clinical findings. This finding suggests that, in general, maintenance of static

Table 4. Mean ± SD of Cognitive Performance for Both LBP and Healthy Groups

Variables	Accuracy			Speed of Responses		
	LBP	Healthy	P	LBP	Healthy	P
OLS	0.79 ± 0.29	0.75 ± 0.26	.15	0.48 ± 0.15	0.46 ± 0.17	.78
Modified SEBT	0.87 ± 0.19	0.86 ± 0.15	.78	0.51 ± 0.12	0.47 ± 0.12	.10
TUG	0.88 ± 0.16	0.91 ± 0.11	.33	0.58 ± 0.11	0.59 ± 0.13	.70
10-m walk	0.88 ± 0.16	0.89 ± 0.15	.86	0.53 ± 0.13	0.56 ± 0.14	.31

LBP, low back pain; OLS, One Leg Stance; TUG, Timed Up and Go; SEBT, Star Excursion Balance Test; SD, standard deviation.

balance may be automatic and requires little attention in patients with chronic LBP.

Additionally, we noted that both groups revealed the same behaviors of changes in time to stand with the difficulty levels of a secondary task. Vance et al²⁵ reported that dual motor tasks required less attentional resources than dual cognitive tasks. Therefore, it is supposed that

Fig 1. Main effects of task for One Leg Stance (A), 10-m walk test (B), and Timed Up and Go test (C). *Significant results ($P < .05$).

improved balance abilities with increased level of secondary task difficulty may be due to posture-first strategy or external focus of attention.

Also, we did not find any differences in modified SEBT performance (dynamic balance) in all reach directions in the LBP group compared with the control group. This result is inconsistent with laboratory findings using the Biodex Balance System²¹ and the 3-dimensional motion analysis system.¹⁷ These inconsistent results between clinical and laboratory findings could be related to the different age of the participants¹⁷ and type of cognitive task.²¹ Sherafat et al²¹ reported that increased postural sway with cognitive task (auditory Stroop test) in patients with LBP compared with healthy participants is in the moderate level of postural task difficulty. This difference in the results could be due to complexity of the secondary task. Recently, studies have indicated that the Stroop test activates extensive brain areas such as the anterior cingulate cortex, supplementary motor area, insula, and middle frontal gyrus compared with other cognitive tasks.³² Therefore, more attentional resources are required compared with a counting-backward task.

In functional balance tests (TUG and 10-m walk), dual tasking did not affect LBP patients and healthy participants differently. These results are contrary to those of Lamoth et al³³ in 2008, who suggested that the results of clinical tests were not consistent with laboratory results. The findings of Lamoth et al³³ revealed that trunk coordination and variability of gait parameters diminished while performing a cognitive task by the 3-camera Simi Reality Motion System.³³

There are 2 possible reasons. First, the secondary cognitive task in our study was counting backward, whereas Lamoth et al³³ reported that the Stroop task reduced gait variability in LBP patients compared with healthy participants, suggesting more attentional demand from the Stroop task.³³ Second, the mean age of the participants in the present study was 24 years, whereas Lamoth et al³³ evaluated participants with a mean age of 45 years. With aging, sensory, motor, and cognitive processing abilities decrease.¹⁶ Thus, according to limited capacity theory, control of the gait and posture requires more attentional resources for older adults.

Finally, we did not find any differences between groups in all clinical balance tests. This finding may be due to the mild symptoms in patients with low back pain. In fact, this level of pain and disability did not significantly affect cognitive functions of the patients to determine different patterns under dual task condition between both groups.

Limitations

This study was only done on patients with nonspecific low back pain. Therefore, the obtained results cannot be generalized to other groups of patients with low back pain. This was one of the limitations of the present study that should be taken into account in future studies.

CONCLUSIONS

It seems that the static and dynamic balance performance under dual task conditions (excluding the SEBT) was impaired in each group. Also, this study indicated that dual tasking did not differ in chronic LBP participants with low level of pain and disability compared with healthy participants in different balance tests. Future studies should investigate LBP with more levels of pain and disability and other more attentionally demanding tasks to clarify the differences between groups in clinical balance testing.

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Practical Applications

- Static and dynamic balance performance was attenuated by adding dual tasks.
- This appears to be an affordable method to reveal changes in postural performance after an intervention in clinics.
- To detect changes in balance performance under dual tasking between groups of participants with low back pain and healthy participants, low back pain symptoms could be considered.

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