

Trunk Muscle Endurance and Low Back Pain in Female Dance Students

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Abstract

Low back pain (LBP) is often cited as a common condition at all levels of dance. Evidence suggests that reduced endurance of the trunk muscles can predispose an individual to LBP. The purpose of this study was to examine differences in trunk muscle endurance in a sample of tertiary level dance students with and without LBP. Seventeen full-time female dance students were divided into two groups: dance students with LBP ($N = 11$), and without LBP ($N = 6$). All participants provided informed consent, and the study was approved by an institutional ethics review board. Participants performed four isometric tests that assess trunk muscle endurance: the right and left side plank, double straight leg raise (DSLRL), and the Sorensen test. A modified version of the Osaka City University test was used to assess the presence of LBP. A significant difference ($p < 0.05$) between groups was observed for the right and left side plank, as well as the DSLRL test, and students with LBP displayed lower levels of endurance compared to those without. No other significant differences were found. This study offers some evidence that reduced trunk muscle endurance is present among dancers with LBP and provides direction for future research into back health among dancers.

Repetitive movements of the spine, including bending, twisting, and extension, are unavoidable components of contemporary dance vocabulary. They have also been identified as movements that may contribute to the development of low back pain (LBP) and injury.¹⁻³ Consequently, LBP is frequently cited as a problem across all levels of dance,⁴ with one study showing 63% of dance students to have a history of LBP.⁵ In another study, the yearly incidence of LBP in a sample of pre-professional ballet dancers was seen to be between 49% and 59%.⁶ Furthermore, persons with LBP may experience a number of ancillary physical deficits,^{7,8} and a history of LBP has been found to predict future injury.⁹ Following a five year investigation into the injury patterns of elite pre-professional ballet students, Gamboa and colleagues¹⁰ revealed that those who experienced injury were 56% more likely to have previously experienced LBP than non-injured dancers.

Various factors can contribute to the development of LBP.^{11,12} One proposed mechanism is reduced endurance and increased fatigability of the trunk muscles,^{13,14} which aid

in stabilizing the spine.¹⁵ To maintain stability, these muscles require only modest levels of activation. Therefore, it is thought that stability is not compromised by insufficient strength, but rather by insufficient endurance,¹⁶ and muscular fatigue may lead to periods of instability.

Several paraspinal muscles also have a proprioceptive function¹⁷ and play an important role in the neuromuscular control of the spine.¹⁸ In the presence of fatigue, spinal proprioception can become impaired,¹⁹ and changes in motor control and spinal biomechanics²⁰ can develop. The resulting dysfunction in the neural control of the spine may create increased muscular tension,¹⁸ leading to further fatigue and failure. Dysfunction may also overload passive structures.¹⁸

A number of studies have shown significantly decreased trunk muscle endurance and increased paraspinal muscle fatigability in non-athletic populations with LBP compared to persons without LBP.²¹⁻²⁴ In addition, there is evidence to suggest continued deconditioning of the trunk muscles in persons with LBP.²⁵ Furthermore, researchers have identified good isometric endurance of the trunk muscles as a protective mechanism against the development of LBP.^{13,14}

Among athletic populations, despite sophisticated and intensive training programs, deconditioning and dysfunction have been docu-

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mented in athletes with LBP.²⁶ In elite young golfers, Evans and colleagues²⁷ found that persons with right side deficit in the side plank test were particularly prone to developing future episodes of LBP. Using electromyography, Roy and coworkers²⁸ found that varsity rowers with LBP displayed increased paraspinal muscle fatigability and slower recovery following a fatigue inducing isometric contraction than rowers without LBP. Rowers with LBP also exhibited asymmetrical muscle function, with less efficient recovery on the left side than on the right.

To the investigator's knowledge, no prior studies have studied the relationship between trunk muscle endurance and LBP in dancers. Therefore, the purpose of this study was to examine differences in trunk muscle endurance among a sample of full-time female dance students with and without LBP. It was hypothesized that dance students with LBP would have significantly ($p < 0.05$) lower levels of trunk muscle endurance compared to dancers without LBP.

Methods

Seventeen female dance students were recruited from a conservatory in London, as well as a university in Sydney. Participants were all over the age of 18 and training at either an undergraduate ($N = 16$) or diploma level ($N = 1$). Additional descriptive data are displayed in Table 1. After all participants had provided written informed consent and ethics approval was obtained from City University, London, they were split into two groups: dance students with LBP ($N = 11$) and dance students without

LBP ($N = 6$).

Procedures

The participants completed three different isometric tests for trunk muscle endurance. Each test chosen has been previously used in studies of LBP and identified as reliable, safe, sensitive to trunk muscle endurance, and to have good predictive value for LBP.^{13,29,30} Performance was measured in seconds, and testing was ended when either the participant chose to stop or could no longer maintain proper technique. There was at least 3 minutes rest between each test.

Side Plank Test

The side plank test (Fig. 1) was performed on both right and left sides and followed protocols outlined by McGill and colleagues.³¹ To perform the test, participants reclined on their side with legs extended and one elbow and two feet on the floor. They then lifted their hips to maintain a straight line over their full body length. The uninvolved arm was held across the chest with the hand placed on the opposite shoulder.

Supine Double Straight Leg Raise

The double straight leg raise (DSLRL) test (Fig. 2) was performed using methods described by Arab and associates.³⁰ Participants reclined in a supine position with legs together and extended and arms held next to the trunk. While maintaining neutral spine, the legs were raised and held 20 inches from the floor.

Sorensen Test

To perform the Sorensen test (Fig. 3), the participant lies on an examination

table in prone position with the upper edge of the iliac crests aligned with the edge of the table and the legs secured. The body is lifted so that the upper torso is horizontal to the floor. The arms are folded across the chest, and a chair is available for support both immediately before and after the test.²⁹⁻³¹

The Osaka City University Test

A modified version of the Osaka City University Test (OCU)^{32,33} was used to assess the presence of LBP. The OCU consists of 10 questions concerning activities of daily living, which the participants grade from zero and two (0 = pain free, 1 = possible with some pain, 2 = impossible) based on the level and effect of pain experienced during the activity in question. Participants who had a total score of one or more were considered to have LBP. The test was only used to categorize participants, not to assess the severity or specific symptoms of LBP.

Statistical Analysis

Statistical analysis was conducted using SPSS 17.0. An independent samples t-test was used to compare performance on the isometric tests for trunk muscle endurance between dance students with and without LBP.

Results

Assessment scores and p values for each group are presented in Table 2 and illustrated in Figure 4. There were significantly different assessments of performance ($p < 0.05$) between groups for the right and left side plank tests, as well as the DSLRL. In general, dance students with LBP produced significantly lower times than students without LBP. Although students without LBP produced higher times than those with LBP for the Sorensen test, this was not statistically significant. There were no significant differences between performance of the right and left side plank tests for either group; both groups had a right-to-left side plank ratio of 1.08.

Discussion

The purpose of this study was to test for differences in trunk muscle

Table 1 Participant Descriptive Data

	LBP ($N = 11$)	NO LBP ($N = 6$)
Age (years)	22.73 (0.65)	22.33 (0.49)
Height (cm)	1.7 (0.02)	1.66 (0.02)
Weight (kg)	60.73 (1.89)	62.17 (3.45)
BMI	21.16 (0.76)	22.54 (0.93)
Years Dancing	15.27 (1.47)	12.5 (3.01)
Weekly Dance Hours	16.18 (1.75)	17.1 (1.77)



Figure 1 The side plank test.



Figure 2 The double straight leg raise test.



Figure 3 The Sorensen test.

endurance between female dance students with and without LBP. The results suggest that students who experience LBP have lower levels of

trunk muscle endurance than dancers who do not. These findings are consistent with previous research, which has shown persons with LBP

to have significantly lower levels of trunk muscle endurance and higher rates of paraspinal muscle fatigability compared to persons without LBP.²¹⁻²⁴ It is thought that lower levels of trunk muscle endurance may compromise an individual's ability to maintain stability of the spine while managing high workloads.³⁴ In addition, fatigue of the trunk muscles has been associated with impaired spinal proprioception¹⁹; therefore, lower endurance may negatively impact neural control of the spine.¹⁸

In this study, significant differences between groups were detected in performance of both the side plank and DSLR tests. The side plank has been shown to optimally challenge m. quadratus lumborum,³⁵ which plays an important role in the maintenance of frontal plane stability, lumbar flexion and extension, as well as the management of compressive loads in upright postures.³⁵ The DSLR test has previously been identified as having good sensitivity, specificity, and predictive value for LBP.³⁰

Previous studies have documented asymmetrical differences in both the size and function of the paraspinal muscles for a number of athletic populations. Evans and coworkers²⁷ found that golfers who had a right side plank deficit relative to their left side were more likely to develop future episodes of LBP. However, in the current study, there was no significant difference between the performance of the right and left side plank for either group. This disparity in findings may be explained by the biomechanical differences between dance and golf. It is also possible that the side plank is not sensitive enough to detect such differences in a dance population.

Although de-conditioning and dysfunction of the trunk muscles has previously been documented in various athletic populations, the precipitating mechanisms are not entirely clear. For the purpose of developing appropriate clinical strategies to combat this trend, it is worth considering why a sample of full-time dance students might demonstrate decreased endurance, despite high training loads.

Table 2 Test Performance Per Group

Test	LBP (N = 11)	NO LBP (N = 6)	P Value
Right Side Plank*	61.18 (6.4)	99.17 (10.04)	0.004
Left Side Plank*	58.69 (6)	91.67 (7.52)	0.004
Right:Left Ratio	1.08 (.06)	1.08 (.09)	0.5
DSLRL*	48.82 (5.12)	83.67 (11.07)	0.005
Sorensen	100.73 (10.71)	131.33 (15.76)	0.12

*Statistically significant inter-group difference.

Some investigators have attributed reduced endurance in persons with LBP to a higher than normal muscle metabolite level, resulting from excessive muscle loading, leading in turn to increased tension and spasm.³⁰ Alternatively, de-loading, resulting from either a reduction in sensory input or alterations in muscular recruitment patterns, may contribute to loss of function, atrophy, and de-conditioning of the paraspinal muscles.³⁶

It is also possible that reduced endurance of the trunk muscles is a consequence of prior episodes of LBP and injury. Hultman and associates²⁵ found evidence to support the continued de-conditioning of the trunk muscles in persons with LBP. In addition, Hides and colleagues⁷ revealed that recovery of the multifidus muscle following acute episodes of LBP is not automatic, and deficits may persist even after pain has subsided and full activity is resumed.

There are a number of limitations in the current study. It can only document association and does not attempt to examine causation. Furthermore, the small sample size limits both the statistical strength and possible interpretation of the findings. In addition, while the causes of LBP are multifactorial, this study was limited to the assessment of trunk muscle endurance; thus, a number of other risk factors that could have influenced the outcomes may have been neglected. The evaluation of LBP here was insensitive to both pain severity and history.

It is important to consider the limitations associated with mechanical assessment methods. While mechanical tests of trunk muscle endurance have been shown to have good reliability, sensitivity, and predictive value,^{29,30} they are unable to isolate specific paraspinal muscles. For example, although the Sorensen test is the most widely used test of trunk muscle endurance, it has been suggested that performance

is influenced by both the trunk extensor muscles and the hip extensor muscles.³⁰ Furthermore, many of the clinical tests shown to be the most sensitive in non-athletic populations³⁰ have not been examined in athletes. It is not entirely clear whether that sensitivity would transfer.

As LBP is a complex problem and the biomechanical and physiological demands of dance are fairly unique, further research into both the mechanisms and management of LBP is required. Future studies should consider the interaction of dance practice with a number of physiological, biomechanical, neuromuscular, and psychosocial variables.

Conclusion

The current study offers some evidence for the correlation of inadequate trunk muscle endurance with LBP in dancers. Female dance students with LBP exhibited lower levels of endurance than students without. This finding is consistent with previous research in non-dancers.

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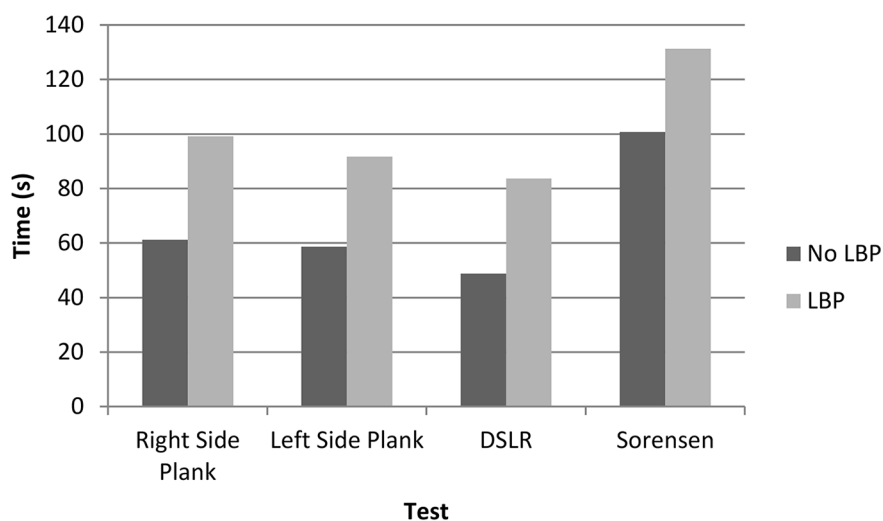


Figure 4 Test performance per group.

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