The Effects of Preseason Trunk Muscle Training on Low-Back Pain Occurrence in Women Collegiate Gymnasts

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Abstract

Durall, CJ, Udermann, BE, Johansen, DR, Gibson, B, Reineke, DM, and Reuteman, P. The effects of preseason trunk muscle training on low-back pain occurrence in women collegiate gymnasts. *J Strength Cond Res* 23(1): 86–92, 2009–Low-back pain (LBP) in women gymnasts is relatively common. This investigation was performed to evaluate the effects of a preseason training program for the trunk extensor, lateral flexor, and flexor muscles on LBP occurrence during the subsequent competitive season. The training group consisted of 15 collegiate women gymnasts. The control group consisted of 15 nonathlete collegiate women. Pre- and posttesting for all participants consisted of static endurance tests for the trunk extensors, lateral flexors, and flexors. After pretesting, the training group completed 10 weeks of biweekly training consisting of non–foot-supported back extensions and side bridges, in addition to their usual trunk flexor exercises. The control group did not perform any specialized trunk muscle training. Mean improvements in trunk endurance, based on multivariate analysis of variance at the 5% level of significance, were significantly greater in the training group than in the control group. Mean improvements in endurance in the training group were 47 seconds for the lateral trunk flexors, 34 seconds for the trunk extensors, and 80 seconds for the trunk flexors. During the subsequent gymnastics season, none of the gymnasts reported new episodes of LBP. One gymnast with chronic LBP reported a recurrence of LBP during the season. None of the gymnasts reported that the training program adversely affected their gymnastic performance. These data suggest that training the trunk musculature twice per week during a 10-week period with a relatively simple floor exercise protocol was an effective stimulus to improve trunk endurance measures. It is encouraging that none of the gymnasts reported new episodes of LBP during the subsequent competitive gymnastics season.

Key Words gymnastics, low-back injury, trunk, torso endurance

Introduction

Injuries in gymnasts are relatively common, particularly among advanced-skill-level gymnasts (5,9,13,16,19). Reported rates of gymnastic injuries range from 0.5 injuries per 1000 hours of participation (19) to 22.7 injuries per 1000 hours (36). Dixon and Fricker (9), in a 5-year prospective study on injuries in a women's National Collegiate Athletic Association (NCAA) Division I gymnastics team, report that the largest number of injuries were of the repetitive stress syndrome type.

As with athletes from other sports that require repetitive extension, twisting, or bending of the torso, gymnasts tend to have a relatively high incidence of low-back pain (LBP) (7,10–12,14,16,29). In one prospective study, 86% of gymnasts surveyed reported LBP at some point during the study period (16). Low-back pain in gymnasts may result from a variety of disorders including muscle strains and stress fractures (e.g., spondylolysis) (7,13).

Although LBP is often multicausal, different investigators have suggested that trunk musculature performance is associated with the etiology (4,6,17,20,24,30). Reduced trunk extensor muscle endurance has been found to be a risk factor for nonspecific LBP (4). People with poor trunk muscle endurance may have a low muscle fatigue threshold (33), which may lead to increased loading of the passive low-back structures (22,39). Trunk muscle endurance training has been recommended to elevate fatigue threshold (21,35), to increase active pelvic and spinal stability (25), and to reduce the occurrence of LBP (4). Trunk muscle fatigue may also

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lead to a loss of control and precision (3,34), which may adversely affect athletic performance.

Anecdotally, we have observed that many preseason gymnastics training programs involve extensive trunk flexor muscle training but often incorporate little or no targeted training for the trunk extensor or lateral flexor muscles. Given the theoretical relationship between trunk extensor muscle endurance and LBP (4,20), and the importance of the lateral flexor muscles in spinal stabilization (27), we wanted to study the impact of adding trunk extensor and lateral flexor exercises to a preseason gymnastics program. Specifically, we wanted to study the impact of this intervention on the prevalence of LBP during the subsequent competitive season. Because preseason training programs should enhance and not impair athletic performance, we also wanted to study how the training program would affect gymnastic performance, as reported by the gymnasts and coaches. Our hypotheses, based primarily on previously published reports, were that 1) trunk muscle training would be associated with a decreased incidence of reported LBP, and 2) trunk muscle training would not adversely affect the gymnasts' performance.

Methods

Experimental Approach to the Problem

To evaluate the effect of the preseason training program on LBP occurrence, a group of collegiate gymnasts underwent 10 weeks of biweekly trunk muscle training. Fifteen collegiate nonathletes, who did not perform any specialized trunk muscle training, served as the control group. Testing was performed on all subjects before the training program, at the midpoint of the training program, and after the training program had been completed. Changes in test results were compared between the groups. Episodes of LBP in the athletes during the subsequent competitive season were tracked.

Subjects

The training group for this investigation consisted of 15 members of the (NCAA Division III) varsity women's gymnastics team at the University of Wisconsin-La Crosse (Table 1). These subjects were already enrolled in a gymnastics "conditioning" course during the fall 2005 semester. The control group for this investigation consisted of 15 collegiate women who were not involved in a varsity sport. All subjects were asked to inform the investigators of any past or present lumbar injuries and/or pain, and their participation in the study was then determined on an individual basis. Three subjects were excluded from participation because of previous or current injuries not related to the investigation. All subjects volunteered to participate in this investigation and gave written informed consent in accordance with the ethical guidelines of the institutional review board of the University of Wisconsin-La Crosse.

Table 1. Age, height, and weight by group (mean ± *SE*).

Group	*n*	Age (y)	Height (cm)	Weight (kg)
Training	15	19.5 ± 0.3	159.6 ± 1.4	58.1 ± 1.9
Control	15	19.7 ± 0.4	165.8 ± 2.1	63.0 ± 2.3

Procedures

Testing. The pre- and posttesting protocol was modified from a similar protocol described by McGill et al. (26,28). Each participant performed 4 static hold tests: the Biering-Sorensen trunk extensor test, a trunk flexor test, and right and left lateral side bridge tests. Each of these tests is described below. Reliability coefficients with these tests have been reported ranging between 0.97 and 0.99 (18, 26–28,38). All of these testing positions were held as long as possible. Testing order was randomly determined for each participant. Hold times were determined with stopwatches. To reduce testing bias, subjects were not informed of the results of their tests.

The Biering-Sorenson trunk extensor test (Figure 1) was performed with each individual in a prone position, with her anterior-superior iliac spine aligned with the edge of the testing plinth (4,18,32). Immediately before and after the test, subjects supported their upper bodies with their hands on a chair. With the examiner holding the participant's lower extremities, the participant lifted her upper body until the upper torso was horizontal to the floor. Each participant's arms were folded across her chest, and her hands were held on her opposite shoulders. The timer was started when a participant assumed a horizontal position and was stopped when she placed her hands back on the stool. As in previous studies of this nature, assessment of the horizontal position of the upper body was based on visual evaluation (1,4,23). Subjects were verbally cued to assume a more horizontal position if the examiner observed the subject's torso lowering toward the floor.

The flexor endurance test (Figure 2) was performed by having subjects sit on the floor with both knees and hips flexed 90°. One examiner held the participant's feet down while another helped the participant recline her torso to a 60°angle using a padded wedge against the participant's upper back. Joint angles were measured using a standard goniometer. The arms were folded across the chest with the hands placed on the opposite shoulder, and toes were placed under toe straps. Subjects were instructed to maintain the body position while the supporting wedge was pulled back 10 cm to begin the test. The test was ended, and the time was recorded, when the upper body fell below the 60° angle.

The lateral side bridge static hold test (Figure 3) was conducted with subjects lying on their sides with their legs extended on a foam-padded exercise mat (thickness, 2.5 cm).

Figure 1. Biering-Sorenson trunk extensor endurance test position.

The top foot was placed in front of the lower foot on the mat to increase the base of support width. While supporting the upper body on one elbow, subjects were instructed to lift their hips off the mat and to maintain a straight line from the upper body to the feet (i.e., no trunk or hip flexion or extension). The uninvolved arm was placed on the opposite shoulder to assist in stabilizing the weight-bearing upper extremity. The test ended when a participant's pelvis lowered toward the exercise mat. This test was performed on each participant's right and left sides.

Training. After pretesting, the training group performed trunk muscle training twice per week for 10 weeks (20 total training sessions). Each training session lasted approximately 15 minutes. To be consistent with the gymnasts' previous training program, and to reduce total training time, the trunk muscle exercises were performed without a warm-up. The order of exercises was alternated during each training session. Trunk extensor training occurred with subjects prone on the floor with their hands cupped over their ears. Each subject raised her chest/upper torso off the floor as far as possible and held each repetition for 6 seconds. If the participant could hold 10 × 6-second repetitions, manual resistance was applied by a partner to the posterior upper torso for up to another 10 repetitions. To train the lateral flexor muscles, subjects performed 10 side bridges (technique identical to testing protocol), holding each repetition for 6 seconds. If the participant could hold 10 × 6-second repetitions, manual resistance (toward the floor) was applied by a partner to the lateral pelvis for up to another 10 repetitions. Consistent with a previous study of this nature (8), the training group performed one set of each exercise. A variety of abdominal exercises (e.g., crunches) were performed as part of the team's usual preseason strength and conditioning program; therefore, no additional exercises for the trunk flexors were included in the training protocol. To minimize the confounding influence of exercise beyond the study protocol, subjects were asked to continue with their usual exercise habits and not to introduce new exercises or modes of training during the study period.

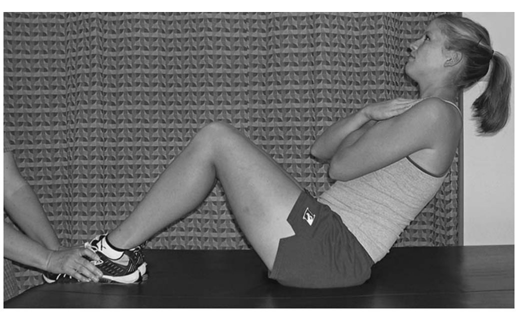

Figure 2. Trunk flexor endurance test position.

Statistical Analyses

Means, and changes in means, for the 4 trunk endurance measures before training (pre) and after 5 and 10 weeks (mid and final) of training were compared between the training and control groups using repeated-measures multivariate analysis of variance at the 5% level of significance. Further post hoc analysis was conducted on each of the 4 endurance measures separately using repeated-measures analysis of variance to compare pre vs. mid (5 weeks) and pre vs. final (10 weeks) changes in endurance measures. Post hoc analysis of covariance, with the pretraining measures as covariates, was performed to compare the mean improvements that occurred from mid to final (5–10 weeks) for the training and control groups. The test-retest reliability for each of the 4 tests was measured by computing the intraclass correlation coefficient (ICC) with the control group sample data.

Results

There were no significant differences in age, height, or weight between the training and control groups ($p > 0.05$) (Table 1). The training group showed significant improvements ($p < 0.0005$) in all 4 trunk endurance tests after 10 weeks of training (Table 2). The control group showed improvements in trunk flexor endurance, but the improvements were not statistically significant ($p = 0.153$). Improvements in extensor ($p = 0.307$), right lateral flexor ($p = 0.053$), or left lateral flexor ($p = 0.050$) endurance were not observed in the control group. Overall, there were significant differences in the mean improvement over time (pre, mid, and final) between the training and control groups among the 4 trunk endurance measures ($p < 0.0005$) (Figures 4–7). Endurance improvements from pre to final were significantly higher for subjects

Table 2. Means and standard errors for endurance (seconds).

Endurance measure	Group	Pre	Mid	Final
Side bridge right	Training	84.7 ± 6.1	107.8 ± 3.5	133.1 ± 7.4
	Control	64.8 ± 6.6	57.8 ± 5.1	64.0 ± 6.2
Side bridge left	Training	85.9 ± 6.4	112.3 ± 7.5	130.1 ± 7.4
	Control	65.7 ± 7.1	58.2 ± 5.6	65.3 ± 6.1
Trunk extension	Training	102.9 ± 10.8	113.2 ± 7.9	136.1 ± 6.9
	Control	118.2 ± 10.0	109.5 ± 9.5	110.1 ± 11.1
Trunk flexion	Training	108.6 ± 12.7	153.9 ± 12.2	188.8 ± 13.3
	Control	105.0 ± 15.6	113.0 ± 18.0	123.7 ± 17.0

in the training group in all 4 measures ($p < 0.0005$ for each). Improvements from pre to mid were also significantly higher in the training group for side bridge right ($p < 0.0005$), side bridge left ($p < 0.0005$), trunk extension ($p = 0.024$), and trunk flexion ($p = 0.001$). Moreover, significant differences existed between mean endurance improvements from mid to final, using pretraining measures as covariates, for the training and control groups for side bridge right ($p = 0.024$), trunk extension ($p = 0.002$), and trunk flexion ($p = 0.047$). Mean improvement in side bridge left endurance from mid to final did not differ significantly between the control and training groups ($p = 0.101$) (Figure 7). According to the control group sample data, the ICC was 0.89 for the Biering-Sorensen trunk extensor test, 0.92 for the trunk flexor test, 0.89 for the right lateral side bridge test, and 0.91 for the left lateral side bridge test.

No new episodes of LBP were reported during the 2005 gymnastics season by the gymnasts, coaches, or athletic trainers. Only one member of the training group, a gymnast with chronic LBP, reported LBP during the subsequent competitive season that resulted in time lost from practice or competition. None of the gymnasts or coaches reported that the training program adversely affected performance.

Figure 3. Trunk side bridge endurance test position.

Discussion

The purpose of this study was to investigate the impact of preseason trunk muscle training on occurrence of LBP during the subsequent competitive gymnastics season. We chose to supplement the gymnastics team's current preseason conditioning program with exercises intended to reduce imbalances in muscle performance between the trunk flexors, extensors, and lateral flexors. Consistent with our hypothesis, the coaches, athletes, and athletic trainers reported a marked reduction in new reports of LBP during the subsequent gymnastics season. The athletic training staff reported that 3–4 gymnasts (in the gymnastics program studied) are typically treated each season for LBP. Also consistent with our hypotheses, none of the gymnasts in this study reported that the trunk muscle training program adversely affected their gymnastics performance. On the contrary, some subjects in the training group reported (during an informal debriefing session) that they seemed to have greater overall stamina during longer gymnastics routines, which they attributed to the training program.

We measured a 10% mean improvement in trunk extensor endurance after 5 weeks of training and a roughly 32% mean improvement in trunk extensor endurance after 10 weeks. In contrast, Moffroid et al. (31) have reported a 22% improvement in trunk extensor muscle endurance after 6 weeks of training in a group of healthy women. We chose a 10-week training program because we believed that this would be adequate for inducing a significant change in endurance. In future investigations, we intend to experiment with different training protocols–for example, exercise repetitions performed to concentric failure vs. sets of 10 repetitions.

Regarding the testing protocol, we found that the trunk flexor endurance test was the most difficult test to standardize. Subjects were instructed to maintain a static torso angle during the test. We observed, though, that many subjects attempted to prolong the test by subtly flexing the thoracic or cervical spine. This is a sensible strategy because flexing the upper back and/or neck would shorten the external moment arm and reduce the flexor torque required to maintain

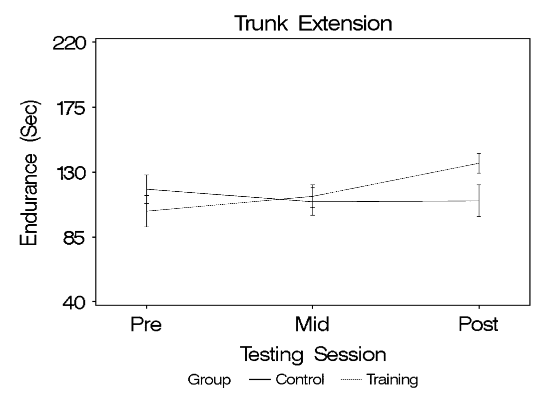

Figure 4. Trunk extension endurance mean and *SE* values from 3 testing sessions.

Figure 6. Right side bridge endurance mean and *SE* values from 3 testing sessions.

a static 60° reclined position. Frequent verbal cueing was required to discourage subjects from flexing their necks and upper backs. Despite our concerns, the test-retest reliability for the trunk flexor endurance test was satisfactory (ICC = 0.92).

We observed that the lateral trunk flexor test was subject to variability based on how much deviation from the start position was permitted before the tester terminated the test. Some subjects dropped slightly toward the support surface, presumably when fatigue started, but were able to return to the start position after verbal cueing. Consistent with a report by McGill and colleagues (26), we found the side bridge test to have reasonably good test/retest reliability. We are currently conducting a study to identify alternative tests for the flexors and lateral flexors with less testing variability. The Biering-Sorenson trunk extensor endurance test we used has been shown to have satisfactory reproducibility (ICC > 0.75) in healthy individuals and in patients with LBP (18,26,28,38). Likewise, we measured satisfactory test-retest reliability with this procedure.

A limitation of our study was the lack of a control group of gymnasts. Given the small number of gymnasts on the team, we decided to involve all of them in the training program. However, the lack of a control group of gymnasts makes it difficult to ascertain whether the absence of significant new episodes of LBP during the 2005 competitive season was attributable to the trunk endurance training program. It is plausible that other factors contributed to the low LBP rate, including chance. Although we cannot confidently conclude that the training program reduced the incidence of LBP, our preliminary observations are encouraging. Our intent is to replicate this study over several consecutive seasons to see whether the trend of less LBP continues.

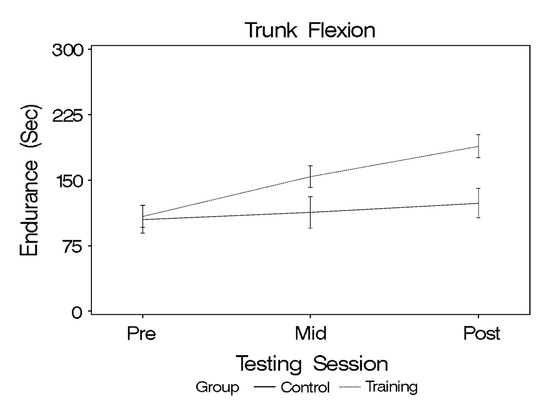

Figure 5. Trunk flexion endurance mean and *SE* values from 3 testing sessions.

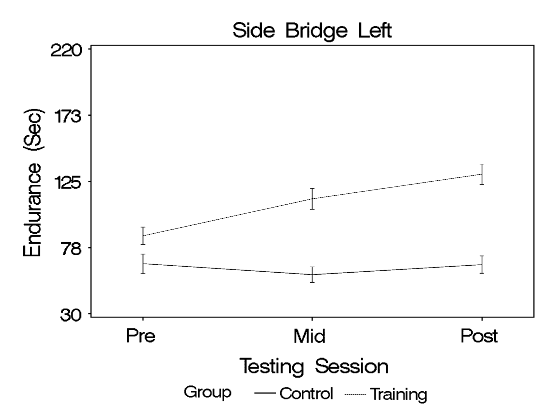

Figure 7. Left side bridge endurance mean and *SE* values from 3 testing sessions.

Another limitation of our study, as with most training studies, was the lack of control over additional exercises that the subjects may have performed during the study period. To minimize the contribution of exercise beyond the study protocol, subjects were asked to continue with their typical exercise habits during the study period. Still, it is possible that additional exercise/training performed by the subjects may have had a synergistic effect on the outcomes.

Our results on the incidence of LBP and the effect of the training program on performance were based on reports by the gymnasts and coaches. It is possible that reporting omissions were made, which would affect the veracity of our findings. This is a limitation of any study that relies on participant reporting.

Practical Applications

In the current study, 10 weeks of trunk muscle training resulted in significant improvements in isometric hold times in their trunk extensors, flexors, and lateral flexors. After the training, there were no reported new episodes of LBP during the gymnastics season that followed the training period, which is in contrast to previous seasons. Although we cannot conclude that the training program reduced the incidence of LBP, our preliminary observations are encouraging. Our observations of improved trunk endurance and reduced episodes of LBP in the training group suggest that an association between these variables may exist. Further trials are needed to study the strength and direction of this association. At the least, we can conclude that the training program did not seem to harm the gymnasts. On the contrary, anecdotal reports suggest that the training program may have improved performance in some of the gymnasts.

To feasibly conduct large-scale training programs, such as the one used in this study, the time and equipment required should be kept to a minimum. The training program in this study required roughly 15 minutes per session and did not require specialized equipment. Likewise, the testing protocol did not require specialized equipment or a significant time commitment from subjects or investigators. Trunk muscle endurance was assessed with relatively simple floor tests instead of isokinetic dynamometers, which are expensive and can require more testing time (15,37). Although the variability of the floor tests may be greater, the ability to administer the tests to multiple subjects simultaneously is advantageous.

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