Effects of Practice on the Ability to Perform Lumbar Stabilization Exercises

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Study Design: Randomized pretest-posttest control group design.

Objectives: To determine the intratester and intertester reliability of a modified isometric stability test and to use this test to evaluate the effects of practice following a 4-week stabilization exercise program with weekly reinstruction.

Background: Although “stabilization” exercise programs are commonplace in the clinic, the reliability of a tool capable of measuring changes in the ability to perform increasingly difficult stabilization exercises has not, to our knowledge, been reported. In addition, it is not clear if practice improves the ability to perform stabilization exercises.

Methods and Measures: A convenience sample of 44 asymptomatic subjects was pretested using a pressure transducer placed beneath the lumbar spine to detect motion (≤4 mm Hg). A series of 7 exercises was attempted, which required increasing levels of muscular control of the lumbar spine for stability. Subjects received a pass or fail for each exercise level based on the pressure gauge readings and the absence of movement compensations. Subjects were assigned randomly to exercise and nonexercise groups, and posttest measurements were taken after 4 weeks. The control group did not receive additional instruction.

Results: The weighted κ coefficient of 0.61 for intratester and 0.62 for intertester represents good agreement. The median level of exercise attainment increased for the exercise group but not for the nonexercise group.

Conclusion: These results suggest that the modified isometric stability test was reliable and that a 4-week lumbar stabilization exercise program, with weekly intervals of reinstruction and testing, improves the ability to perform progressively difficult lumbar stabilization exercises. J Orthop Sports Phys Ther 1999;29:546–555.

Key Words: exercises, lumbar stability, reliability

Inability has been suggested as a common cause of recurrent and chronic low back pain (LBP). There is a lack of consensus regarding the precise biomechanical definition of instability, and there is no current method, including X-ray examinations, that can reliably demonstrate the presence of this condition. Despite the lack of agreement on a definition, lumbar instability is a commonly used diagnostic category that frequently is intended to guide physical therapy treatment.

For many years, physical therapists have focused on the muscular system as the most accessible and mutable of the contributors to lumbar stability and have treated lumbar instability with stabilization exercise programs designed to increase muscular control of the lumbar spine. The underlying concept of these exercise programs is the ability of the muscular system to help maintain a neutral position of the spine to prevent excessive lumbar segment motion, which, if not attenuated, can lead to high levels of repetitive stress and tissue damage.

Many exercise programs for instability initially attempt to train
muscular control of the lumbar spine by requiring gross isometric contractions of the lumbar muscles while imposing progressively demanding loads through various extremity motions.\textsuperscript{20,31,32} Patients are commonly informed that their “stability” has improved because they are able to successfully perform more difficult exercises without the occurrence of motion in the lumbar spine. Precisely how clinicians are making judgments regarding the effects of stabilization exercise programs is not clear. The authors are unaware of any well-defined, reliable measurement tools that can be used to determine the effects of an exercise program for increased muscular control of lumbar spinal motion.

Wohlfahrt et al\textsuperscript{36} outlined a specific progression of exercises and reported an objective method for determining gross motion within the lumbar spine. This tool has been called an isometric stability test (IST). The IST requires the patient to be in a supine position while a pressure transducer is placed under the low back. The transducer detects motion of the lumbar spine by indicating changes in the pressure reading. The IST assigns an ordinal level measure (1–5) based on “the subject’s proficiency in isometrically contracting the abdominal muscles in order to hold the pelvis and lower trunk stable, while load [is] progressively added by movements of the lower limb.” To our knowledge, the reliability of the IST has not been reported.

In attempting to use the IST in pilot studies, we determined that several features of the test needed modification or development before the measure could be reliably applied. The following features were addressed in the modified IST: movement compensations that signal failure to achieve the appropriate muscular control; quantity and type of training involved for the subject before testing; and type and quantity of both verbal and instrumented feedback. During our pilot studies, it was found that many subjects could not attain the lowest score of the IST, so a new set of progressively difficult exercises that represented less muscular control was developed.

It is presumed that the ability to maintain the spine in a static position during increasing lower extremity loading is indicative of increased lumbar stability. It is important, therefore, to determine if subjects can learn increasingly difficult lumbar stabilization exercises with training. The purposes of this study were to determine the intratester and intertester reliability of the modified IST and to use the modified IST to determine the effects of practice during a 4-week stabilization exercise program with weekly intervals of reinstruction and testing.

**METHODS**

**Subjects**

A total of 44 nonimpaired volunteers participated in this study, representing a sample of convenience.

The characteristics of the subjects are shown in Table 1. Subjects were screened to exclude those with a history of LBP within 3 months of participation in the study or those having had abdominal or back surgery within the previous year. The inability to flex the hip sufficiently would prevent us from obtaining a valid measurement using the IST. Subjects, therefore, were screened for the ability to perform 100° of active hip flexion on the right. No one was excluded based on these criteria. Informed consent was obtained from each subject in accordance with the guidelines of the Institutional Review Board of Long Island University, Brooklyn, NY.

**Instrumentation**

Pressure gauge readings were collected using an inflatable trisectional rectangular cushion (23 × 14 cm) connected to a pressure gauge (Stabilizer, Chattanooga Pacific Pty. Ltd., Brisbane, Australia) (Figure 1).\textsuperscript{36} The sections of the cushion communicate with one another and are made from nonelastic material. External force applied to the cushion is reflected as changes in air pressure (accuracy, ±3 mm Hg). The pressure gauge is marked in increments of 2 mm Hg. Known weights of 1800, 1500, 1200, 900, 600, and 300 g applied to the surface of the cushion during a preset inflation pressure of 50 mm Hg (identical to the modified IST protocol) for 3 trials consistently created pressure increases of approximately 6, 5, 4, 3, 2, and 1 mm Hg, respectively.

The device was placed between the lumbar spine and a hard surface (Figure 2) to detect motion in the lumbar spine as progressively more difficult exercises of the lower extremities were performed.

It is possible, although improbable, that a force applied to one section of the cushion could be offset by a lessening of force on another section of the cushion such that the pressure reading remained constant. For this to occur, the transfer of force would have to be equal and opposite in direction and occur at the same time.

**Procedure**

The 44 subjects were assigned randomly into an exercise and a nonexercise control group of 22 each. Examiners were blinded to group assignment during

**TABLE 1. Demographics of experimental and control group.**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Experimental group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Age range (y)</td>
<td>20–40</td>
<td>21–42</td>
</tr>
<tr>
<td>Mean age (y)</td>
<td>27.00 (±5.0)</td>
<td>27.05 (±6.3)</td>
</tr>
<tr>
<td>Median age (y)</td>
<td>26</td>
<td>25</td>
</tr>
<tr>
<td>Male subjects</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>Female subjects</td>
<td>17</td>
<td>9</td>
</tr>
</tbody>
</table>

J Orthop Sports Phys Ther • Volume 29 • Number 9 • September 1999
FIGURE 1. Pressure transducer.

FIGURE 2. Position of subject and placement of pressure transducer for test of level 1.
the pretest but not the posttest. All subjects were tested initially and 4 weeks later. In addition, the exercise group received 3 additional instruction and testing sessions at 1-week intervals before the final testing session. All subjects were measured 2 times during the pretest to determine intratester and intertester reliability. Half of the exercise and nonexercise subjects were retested by the same tester and half were retested by a different examiner.

The new set of exercise progressions was derived from the basic guidelines suggested by Wohlfahrt et al. The new set of exercises was created to address the following goals: to focus training on particular muscles that the literature suggests are important for increased stability, to represent the full range of potential levels of difficulty, and to provide clear increases in difficulty based on increased moment to the muscles stabilizing the lumbar spine.

Recent literature suggests that exercises for stabilization should focus on the transversus abdominis (TA) and multifidus, because these muscles are the primary stabilizers of the spine and do not function properly in patients with LBP. Studies have suggested that in nonimpaired subjects the TA fires before muscles of the arms or legs while the extremities perform reaching tasks. This has been interpreted as a feed-forward mechanism, providing increased spinal stiffness before loading. In patients with chronic LBP, the TA fails to contract normally. It has also been shown that patients with LBP cannot achieve a voluntary "hollowing" action of the abdomen attributed to the TA compared with patients without LBP.

Increasing difficulty of the exercise is based on the biomechanical construct that the quantity of torque the lumbar muscles are resisting is defined by the mass of the legs and the moment arm from the center of mass of the legs to the axis of rotation. Torque is increased, and consequently the load on the lumbar muscles is increased, when 2 legs are lifted instead of 1, when an extended leg is used rather than a flexed one, and when a leg that is fully unsupported is used rather than one partially supported by sliding on the mat. The specific quantity of increase in torque between exercise levels is unknown, but the exercises are thought to create a progressive increase in the magnitude of torque at each level (Appendix and Figure 3).

All subjects began testing with exercise level 1. The subject was required to perform the exercise without moving the pressure gauge dial. The subject was specifically instructed not to allow any of the following compensations to occur: elevation of the shoulders from the table, flexion or extension of the neck, posterior rotation of the pelvis, protrusion of the rectus abdominis, or extension of the lumbar spine.

The examiner monitored the pressure gauge dial for movement and the subject's body for compensations to determine if the subject completed the exercise level successfully. The highest level successfully completed was the subject's test score for that testing session. For example, a score of 2 on the modified IST indicates the subject successfully completed the second level of exercise but failed to successfully complete the third level of exercises. If a subject failed to pass exercise level 1, he or she was given a grade of 0. The 7 exercises used in testing were used in the stabilization program performed by the experimental group.

Training Session Before Pretest

Pilot work showed that most subjects could not begin testing until they had an opportunity to practice the appropriate muscular coordination strategy. Richardson and Jull have described in extensive detail an approach to teaching isometric co-contraction of the TA and multifidus with a static neutral spine. Richardson and Jull suggest that training should involve isometric, low-level, tonic contractions of spinal muscles. The vertical rectus abdominis should not protrude during efforts, and the entire anterior abdominal wall should move slightly posterior. Methods...
of teaching require visualization of the “corsetlike structure” of the TA, specific cues such as “draw your lower abdomen up and in or pull your navel to your spine,” and manual pressure on the TA or multifidus.

Pretest

The subjects were pretested 1–3 days after the training session. The subject assumed a hook-lying position (supine with knees flexed approximately 90° and the feet flat on the table) and raised the pelvis so that the examiner could place the pressure transducer under the low back, aligning the midpoint of the transducer with the side-to-side midpoint between the most superior aspects of the iliac crests. The subject returned to the hook-lying position and performed alternating anterior and posterior pelvic tilts to settle the spine into a relaxed position, attempting to adopt the neutral position of the spine for that subject, typically producing a small quantity of lumbar lordosis.

The examiner pumped up the transducer to 40 mm Hg and handed the pressure gauge to the subject, who held the gauge so that it was visible to both the subject and the examiner. The subject was given verbal instruction and manual pressure on the abdomen for exercise level 1 (Appendix) followed by an attempt to complete that exercise. The subject successfully performed the exercise if he or she was able to perform abdominal hollowing and increase and maintain the pressure at 50 mm Hg (±4 mm Hg) for 3 breathing cycles without 1 of the compensations occurring. Subjects occasionally coughed or sneezed during the test without losing the appropriate muscle firing strategy as demonstrated by a consistently flattened abdominal wall. This particular type of motion created a single virtually instantaneous movement of the pressure gauge needle outside the boundaries with an immediate return. This was termed a spike and was not considered a failure. The subjects were given practice attempts before the measurement at each level. They were allowed to ask questions after each practice attempt concerning any characteristic of the testing they desired. If the subject passed exercise level 1, he or she was instructed in exercise level 2 (Appendix) and continued in this manner until failure. For exercise levels 2–7, the subject was first instructed in the necessary leg movement, and then his or her leg(s) was passively moved through the motions required.

The second pretest occurred on the same day, at least 1 hour after the first pretest. At the completion of the second pretest, the experimental subjects were provided with instructions on their home exercise program (HEP). Subjects were assigned a HEP based on the exercise level attained in the 2 pretest sessions. If these 2 levels differed, the lower of the 2 pretest values was used. The HEP was a 15-minute routine that consisted of 5 minutes of exercise at 1 level below their pretest level, 5 minutes at their pretest level, and 5 minutes 1 step above their pretest level. The subject was given a handout of his or her level of HEP that included written descriptions of the 3 specific exercises and directions on how to perform the exercises 3 times per week at a comfortable pace (Appendix). Subjects were instructed to perform each exercise continuously for 5 minutes. For exercise levels 0 and 1, it was necessary to use one or both of the 2 training session activities as part of the HEP (Figure 3A and B). The exercise subjects were asked to fill out and return a compliance form that indicated the dates on which they performed their exercises. They were also given an appointment approximately 1 week later during which they were to receive the first of their 3 reinstruction and testing sessions. The control group was explicitly instructed not to change their normal exercise activities and to return on a scheduled date approximately 4 weeks later.

Interim Testing and Reinstruction Sessions for the Exercise Group

Exercise subjects returned one time during each of the next 3 weeks to be retested and to progress in the HEP. During the session, the subject demonstrated and reviewed his or her 3 assigned home exercises by performing each exercise 3 times using the pressure transducer for biofeedback to help ensure correct performance. Any questions from the subject were answered at that time. If the subject demonstrated correct performance of his or her previously assigned exercise level in accordance with the gauge readings and lack of compensations for at least 2 of 3 attempts, he or she was assigned a new HEP that included the next level of exercise. The examiner instructed the subject on the proper execution of the new exercise and provided him or her with a handout that included the new exercise prescription. If the subject did not successfully perform the previous-
TABLE 2. Test-retest repeatability of exercise level attainment assessed by a single rater. $N = 22$ subjects.

<table>
<thead>
<tr>
<th>Test</th>
<th>Level 0</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
<th>Level 6</th>
<th>Row totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Level 1</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Level 2</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Level 3</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Level 4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Level 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Level 6</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>22</td>
</tr>
</tbody>
</table>

Subjects were tested twice by a single rater prior to practicing stabilization exercises.

Intratester and Intertester Reliability

Intratester and intertester reliability is reported in Tables 2 and 3, respectively. Values along the diagonal in both tables represent those cases in which the rater assigned the same value during both pretests. These values represent perfect agreement between raters (Table 3) or within the same rater (Table 2). Values near the diagonal represent near agreement. The weighted $\kappa$ coefficient of 0.61 for intratester (Table 2) and 0.62 for intertester (Table 3) represents good agreement.21

Between-Group Comparison

The median exercise level that study subjects were able to perform successfully was the same between those randomly assigned to the exercise and nonexercise groups at the beginning of the study ($P = .74$) (Table 4). However, at the end of the study, there was a tendency (although not statistically significant) for individuals in the exercise group to perform more complex exercises successfully than those in the nonexercise group ($P = .06$) (Table 4). The median exercise level successfully performed by the exercise group was 2.5, whereas the median exercise

TABLE 3. Test-retest repeatability of exercise level attainment assessed by 2 different raters. $N = 22$ subjects.

<table>
<thead>
<tr>
<th>Rater 1</th>
<th>Level 0</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
<th>Level 6</th>
<th>Row totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rater 2</td>
<td>9</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>Level 0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Level 1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Level 2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Level 3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Level 4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Level 5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Level 6</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Column totals</td>
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<td>2</td>
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<td>1</td>
<td>22</td>
</tr>
</tbody>
</table>

Subjects were tested by each rater prior to practicing stabilization exercises.

RESULTS

Distribution of scores on the modified IST for exercise and nonexercise groups at pretest and posttest is shown in Figure 4.
level successfully performed by the nonexercise
group was 1.0 (Table 4).

Within-Group Comparison

Table 5 shows results of the within-group analysis
at pretest and posttest. There was no statistically sig-
nificant change in the median level of exercise at-
tainment in the nonexercise group from pretest to
posttest. The median level of exercise attainment for
the exercise group, however, increased significantly
from pretest to posttest ($P = .01$) (Table 5).

DISCUSSION

Exercise programs for lumbar stabilization are
commonplace in the clinic, but, to our knowledge,
the literature has not described a reliable tool capa-
ble of measuring changes in the ability to perform
progressively difficult stabilization exercises. The in-
tratester and intertester reliabilities found in this
study for the modified IST are considered good.\textsuperscript{21}

We found that intertester and intratester reliability
was good, but it may have been lessened by forcing
testers to accomplish 2 visual tasks simultaneously.
Testers reported that it was difficult to monitor the
subject's body for compensations and to pay strict at-
tention to the pressure needle gauge.

One way that testers thought to increase reliability
is to add breathing pattern to the compensation er-
ror list. Many subjects were able to successfully
achieve a level only by breathing rapidly or shallowly.

This should have been reported as a failure because
breathing at a regular pace should be possible dur-
ing lumbar stability. Additionally, the screening
process should have included 100° of hip flexion bilat-
early, performed in a supine position with a stabilized
pelvis, since this more accurately resembles the mo-
tions required of the test.

Although some studies have associated lumbar sta-
bilization exercises with the relief of symptoms,\textsuperscript{12,26}
the authors are unaware of any studies that have
measured improvements in the ability of subjects to
perform stabilization exercises with practice. Studies
have shown that initial changes in muscle training
programs are primarily due to neurologic effects
rather than muscle hypertrophy.\textsuperscript{8,17,50,54} The authors
believe that significant differences in the ability to
perform exercises found in this study are primarily
attributable to adaptations that occur within the ner-
vous system. Although often perceived as strength
training, the early stages of stabilization training
might more appropriately be called awareness train-
ing. Learning how to coactivate the appropriate mus-
culature while inhibiting activation of the rectus ab-
dominis has been suggested as the primary goal of
lumbar stabilization training.\textsuperscript{31} It can be argued that
the motor learning involved in the practice of these
exercises is, in fact, the primary intention of the sta-
bilization exercise program.

The frequency and duration of both the home ex-
ercise program and the once-per-week reinstruction
and testing sessions were chosen to approximate the
realities of clinical practice. There was no attempt in
this study to separate effects due to guided practice
with testing versus effects due to practice performed
alone. Consequently, any changes occurring in the
exercise group should be viewed as a result of both
the reinstruction and testing sessions and the
HEP.

Pressure gauge errors, or concurrent pressure
gauge and compensation errors, accounted for most
of the failed tests. There were only 4 occasions dur-
ing testing when compensation errors alone created
a failed test. The most common compensation errors
were rectus abdominis protrusion and pelvic tilt,
both of which stem from overactivation of the rectus
abdominis. The rectus abdominis is a “global” mus-

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### TABLE 4. Between-group comparisons: exercise levels attained at pretest and posttest for the exercise and nonexercise groups.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Exercise</th>
<th>Control</th>
<th>$P$ value</th>
<th>Exercise</th>
<th>Control</th>
<th>$P$ value</th>
</tr>
</thead>
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<tr>
<td>$N$</td>
<td>22</td>
<td>22</td>
<td></td>
<td>22</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
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<td>0</td>
<td></td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Lower quartile</td>
<td>1</td>
<td>1</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>1.0</td>
<td>1.0</td>
<td>0.74*</td>
<td>2.5</td>
<td>1.0</td>
<td>0.06*</td>
</tr>
<tr>
<td>Mean ($\pm SD$)</td>
<td>1.32 ($\pm 1.55$)</td>
<td>0.95 ($\pm 1.05$)</td>
<td></td>
<td>2.59 ($\pm 2.13$)</td>
<td>1.41 ($\pm 1.47$)</td>
<td></td>
</tr>
<tr>
<td>Upper quartile</td>
<td>2</td>
<td>2</td>
<td></td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>6</td>
<td>3</td>
<td></td>
<td>7</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

* $P$ value for median test.

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### TABLE 5. Within-group comparison: change of exercise level attainment over the course of the study.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control</th>
<th>Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>$N$</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Minimum</td>
<td>-3</td>
<td>-1</td>
</tr>
<tr>
<td>Lower quartile</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Median*</td>
<td>0.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Mean ($\pm SD$)</td>
<td>0.45 ($\pm 1.33$)</td>
<td>1.27 ($\pm 1.72$)</td>
</tr>
<tr>
<td>Upper Quartile</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Maximum</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

* For the median test for the control group, the $P$ value for the Friedman $F$ test was .10; for the exercise group, the $P$ value for the Friedman $F$ test was .01.
rather than a "local" muscle, and as such it operates primarily to approximate the ribcage to the pelvis. Stabilization training aims to target the "local" intersegmental muscles, which are thought to "stiffen" the spine. Disengaging the rectus abdominis and locating voluntary control of the TA appears to be the most difficult task in stabilization exercises.

Signatures and dates on the HEP handouts reported a compliance of 100%. The authors recognize the significant possibility that the reported compliance did not accurately reflect true compliance. However, this situation does represent actual clinical practice that depends on patient report, and it is assumed that increases in true compliance would have only increased the significance of changes between groups.

The participants in this study were nonimpaired physical therapy students who volunteered for participation and, as such, limit the generalizability of the results. Although the examiners were blinded to group assignment during the pretest, the same examiners provided the reinstruction and testing for the exercise group. Therefore, it is possible that the examiner's awareness of group assignment may have influenced posttest measurements.

We recognize the possibility that reliability within a symptomatic population may be different than that of an asymptomatic population. Future research should use the modified IST with a symptomatic population. This might provide some measure of predictive and/or prescriptive validity for the modified IST.

CONCLUSION

We measured improvements in the ability to perform exercises that are presumed to be related to static lumbar stability. The results demonstrate that the modified IST is a reliable tool for evaluating the ability of subjects to perform increasingly difficult lumbar stabilization exercises. Our research demonstrated that 4 weeks of a HEP, with weekly reinstruction and testing sessions, significantly improved the ability of a group of asymptomatic subjects to perform stabilization exercises.

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REFERENCES

15. Hodges PW, Richardson CA. Feedforward contraction of the transversus abdominis is not influenced by the direction of arm movement. Exp Brain Res. 1997;114:362-370.
26. Panjabi M. The stabilizing system of the spine, part I:
33. Sahrmann S. Diagnosis and Treatment of Muscle Imbalances Associated with Regional Pain Syndromes. St Louis, Mo: Physical Therapy Department, School of Medicine, Washington University; 1990.

APPENDIX

Home Exercise Program Instructions

This is your home exercise program, which you will perform at home 3 times a week until the next
reinstruction session, during which you will be given further instructions. This exercise program consists of 3 exercises that should each be done for 5 minutes for a total of 15 minutes per session. For all the exercises, speed is not an issue. Perform the exercises at a comfortable rate that will allow you to maintain the required contraction.

Training Session Exercise A—Abdominal Breathing

You will need either a heavy book or a 2-lb weight to use for resistance on your belly. Lay down on your back with your knees bent and feet flat on the floor. Place the weight or book just below your navel. Place one hand on your chest and the other hand on your abdomen. As you inhale, keep your chest still while letting your abdomen expand. As you exhale, let your abdomen drop toward your spine. Continue this breathing pattern for 5 minutes. Now breathe in,

Training Session Exercise B—Quadruped Abdominal Hollowing

Assume a quadruped position on the floor with approximately 90° of flexion at the hips and shoulders. While in this position, your spine should remain in a neutral position. As you inhale, allow your belly to drop. As you exhale, pull your belly button to your spine, but do not move your spine. Continue to do this breathing pattern for 5 minutes.

Exercise 1—Abdominal Hollowing

Assume a supine position with knees bent and feet flat on the floor. Place your hands on your lower abdomen below your navel, and feel the muscles tightening. Imagine the same feeling you created in your abdomen while exhaling in quadruped and during coughing during exhalation. As you exhale, bring your belly button to your spine. Try to maintain the contraction while maintaining normal breathing. Do this for 5 minutes.

Exercise 2—Unilateral Abduction

Assume a supine position on the floor with knees bent and feet flat. Recreate the abdominal hollowing by contracting your lower abdominal muscles. Continue to breathe in a normal fashion. While maintaining this contraction, abduct your right leg to approximately 45° in relation to the floor while keeping the contralateral knee motionless. Return the leg to the starting position. Remember to continue a normal breathing pattern. Do this exercise for 5 minutes.

Exercise 3—Unilateral Knee Raise

Assume a supine position with your knees bent and feet flat on the floor. Recreate the abdominal hollowing by contracting your lower abdominal muscles. Continue to breathe in a normal fashion. While maintaining this contraction, raise your right leg toward your chest until it just passes approximately 90° of hip flexion while allowing the knee to flex naturally. While performing the lift, make sure you do not press down with the left foot. Keep breathing. Don’t move your head, neck, or shoulders. Return to the start position. Do this exercise for 5 minutes.

Exercise 4—Bilateral Knee Raise

Assume a supine position with your knees bent and feet flat on the floor. Recreate the abdominal hollowing by contracting your lower abdominal mus-
cles. Continue to breathe in a normal fashion. While maintaining this contraction, raise your right leg toward your chest until it just passes approximately 90° of hip flexion while allowing the knee to flex naturally. Hold your right leg in this position and then raise the left leg in the same manner so that both legs are elevated. Return your right leg to the start position and then your left. Continue to breathe normally throughout the exercise. Do this for 5 minutes.

Exercise 5—Unilateral Heel Slide

Assume a supine position with your knees bent and feet flat on the floor. Recreate the abdominal hollowing by contracting your lower abdominal muscles. Continue to breathe in a normal fashion. While maintaining this contraction, raise your right leg toward your chest until it just passes approximately 90° of hip flexion while allowing the knee to flex naturally. Hold your right leg in this position and then raise the left leg in the same manner so that both legs are elevated. Return your right leg to the start position and then your left. Continue to breathe normally throughout the exercise. Do this for 5 minutes.

Exercise 6—Bilateral Heel Slide

Assume a supine position with your knees bent and feet flat on the floor. Recreate the abdominal hollowing by contracting your lower abdominal muscles. Continue to breathe in a normal fashion. While maintaining this contraction, raise your right leg toward your chest until it just passes approximately 90° of hip flexion while allowing the knee to flex naturally. Hold your right leg in this position and then raise the left leg in the same manner so that both legs are elevated. From this position, lower and straighten both heels to the floor. Slide both heels along the floor until your knees are straight. Then slide your heels back, and with your knees bent, lift your legs to the start position. Remember to breathe in a normal fashion. Continue to do this exercise for 5 minutes from this position. When you are finished, lower your legs back down to the floor.

Exercise 7—Bilateral Heel Hover

Assume a supine position with your knees bent and feet flat on the floor. Recreate the abdominal hollowing by contracting your lower abdominal muscles. Continue to breathe in a normal fashion. While maintaining this contraction, raise your right leg toward your chest until it just passes approximately 90° of hip flexion while allowing the knee to flex naturally. Hold your right leg in this position and then raise the left leg in the same manner so that both legs are elevated. From this position, lower both feet toward the floor so both heels are approximately 3 in from the ground. Do not touch the floor with your feet. Remember to breathe normally. Slowly straighten both legs until your knees are straight while keeping them approximately 3 in above the ground. Slowly return your knees toward your chest. Continue to do this exercise for 5 minutes from this position. When you are finished, lower your legs back down to the floor.