Diagnosis and Treatment of 2 Adolescent Female Athletes With Transient Abdominal Pain During Running

Theresa M. Spitznagle and Shirley Sahrmann

Context: Transient abdominal pain commonly occurs during running. There is limited information to guide the physical examination and treatment of individuals with this transient pain with running (TAPR). The purposes of this report are to describe the movement-system examination, diagnosis, and treatment of 2 female adolescent athletes with TAPR and highlight the differences in their treatment based on specific movement impairments. Study Design: Case series. Diagnosis: The movement diagnosis determined for both patients was thoracic flexion with rotation. The key signs and symptoms that supported this diagnosis included (1) alignment impairments of thoracic flexion and posterior sway and ribcage asymmetry; (2) movement impairments during testing and running of asymmetrical range of motion for trunk rotation, side bending, and flexion of the thoracic spine; and (3) reproduction of TAPR. Discussion: Musculoskeletal impairments related to the trunk muscles combined with the mechanical stresses of running could contribute to TAPR. Treatment in each of the patients was focused on patient education regarding correction of alignment, muscle, and movement impairments of the extremities, thoracic spine, and ribcage. A strategy was determined for correcting motion during running to reduce or abolish the TAPR. Outcomes were positive in both patients. Differences in specific impairments in each patient demonstrate the need for specificity of treatment. These 2 patients illustrate how developing a movement diagnosis and identifying the contributing factors based on a systematic examination can be used in individuals with TAPR.

Keywords: movement, thoracic spine, alignment

Transient abdominal pain commonly occurs during running, resolving shortly after running stops. In a retrospective interview of athletes, 69% reported past experience of transient abdominal pain during running (TAPR) while participating in their sporting activities. The incidence of exercise-related transient abdominal pain is commonly associated with sporting activities that require running. Currently, there is no reported influence of gender, body-mass index, or training status on the prevalence of TAPR; however, the intensity of the symptoms has been reported to...
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decrease significantly with increasing age. Proposed theories related to the etiology of TAPR are based on musculoskeletal and visceral pathology. Symptoms that are common when visceral pathology is suspected include belching, vomiting, flatulence, bowel urgency, diarrhea, blood in the stool, and nausea. Most individuals who present with visceral pathology are marathon or ultramarathon runners. Musculoskeletal sources have been proposed as the most likely cause of TAPR in the absence of visceral symptomology.

For many regions of the body the location of pain provides some guidance as to whether the source of the symptoms is visceral or mechanical. Individuals who experience TAPR have reported symptoms in all regions of the abdomen. However, the most common site of TAPR is at the mid- to upper-lateral aspect of the abdomen along the subcostal margin. The subcostal margin is the most flexible region of the ribcage. The lower ribs that compose the subcostal margin are the site of attachment for all of the abdominal muscles, as well as the diaphragm. In addition, the peripheral nerves that provide both sensory and motor innervation to the subcostal region exit the vertebral canal from the thoracic spine. The alignment of the thoracic spine can be affected by the action of the abdominal muscles. Because running imposes a demand for both increased ventilation and increased trunk stabilization and the upper lateral aspects of the abdomen are the most common sites of TAPR, a reasonable hypothesis is that the anatomical structures associated with the thoracic spine, the ribcage, the diaphragm, and the abdominal muscles are likely sources of TAPR.

Mechanical sources of TAPR have not been clearly defined, so there is limited information to guide the physical examination and subsequent treatment of individuals with TAPR. Passive testing of the thoracic spine and ribcage has been reported to reproduce abdominal pain experienced by some individuals with TAPR. In individuals who experience TAPR on a treadmill, contraction of the abdominal muscles or application of abdominal support has been found to reduce the pain. Finally, individuals who have abdominal pain that increases with activity report symptom changes during repeated movements and functional activities including walking, running, bending, moving heavy objects, twisting, supine positions, and sitting. The repeated movements of the trunk and extremities that occur during running suggest that the examination should include a systematic assessment of movements and functional activities of individuals with TAPR.

Examination of movement impairments related to musculoskeletal pain syndromes has been suggested by several authors. The Movement System examination was developed by Sahrmann et al to provide a method of diagnosing movement impairments to guide treatment of individuals with musculoskeletal pain conditions. The systematic examination of movement aids in the identification of mechanical pain conditions by grouping signs and symptoms associated with the movement causing the pain. The use of active exercise and modification of functional activities, postures, and positions as guided by specific movement impairments has been reported to be successful in treating individuals with impairments of the cervical and lumbar spine. However, the use of a movement examination to classify and direct treatment of individuals with transient abdominal pain during a sporting activity has not been reported. Thus, the purpose of this report is threefold: to describe the Movement System examination, describe the diagnosis and treatment of 2 female adolescent athletes with transient abdominal pain with
running and playing soccer, and highlight the differences in treatment based on specific movement impairments even though both patients have the same Movement System diagnosis. The commonality of diagnosis indicates that the principle cause of the pain is the same but the contributing factors differ.

**Case Descriptions**

Both patients were White adolescent female athletes. Detailed descriptions of each are given in Table 1. They were referred to physical therapy for examination and treatment of transient abdominal pain that occurred both during running and playing soccer. Both patients were participating in highly competitive soccer at the time of the initial exam. Running was a necessary element of their sporting activity, and both patients noted pain onset with running more than 15 to 30 minutes during both practice and competition. Patient 1 most commonly played 1 of the 2 forward positions because of her speed and skill in goal scoring. Patient 2 most commonly played a midfield position, assisting in both defensive and offensive plays for her team. Patient 2 reported symptoms during cutting or repeated change of direction. In each patient the abdominal discomfort was absent at rest. The severity of their symptoms required running slower or cessation of the activity. Patient 1 reported that the symptoms had been occurring for 8 months and noticed the abdominal pain

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Patient Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patient 1</strong></td>
<td><strong>Patient 2</strong></td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>11 y</td>
</tr>
<tr>
<td><strong>Height</strong></td>
<td>5 ft</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>98 lb</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>8 mo</td>
</tr>
<tr>
<td><strong>Onset</strong></td>
<td>After performing multiple sit-ups</td>
</tr>
<tr>
<td><strong>Activities</strong></td>
<td>Participates in soccer year-round, recreational volleyball and basketball</td>
</tr>
<tr>
<td><strong>Symptom characteristics</strong></td>
<td>Left-sided sharp abdominal pain, just below subcostal margin.</td>
</tr>
<tr>
<td><strong>Pain onset</strong></td>
<td>Pain starts after 30 min of running while playing soccer. Slows pace of running or stops because of pain intensity.</td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
<td>Resolution of symptoms occurs within 5–10 min if running is stopped.</td>
</tr>
</tbody>
</table>
for the first time during soccer practice on a day when she had also been practicing bent-knee sit-ups for a fitness test at her grade school. Patient 2 reported having had the symptoms for 2 years and did not recall any specific incident that precipitated the pain. Initial body-pain diagrams for each of the patients can be found in Figure 1. Informed consent was obtained for each of the patients.

**Examination**

For each patient, a systems review was performed to screen for visceral causes of abdominal pain (see Appendix A). To determine whether there was a relationship between dietary intake and the TAPR, each patient was questioned regarding pre-event (practice or game) eating habits and any symptoms of nausea, belching, or diarrhea that may have occurred just before, during, or after playing soccer. Initial scores indicated a 16% and 12% functional disability for the patients. In addition, neither patient reported any symptoms related to timing or type of food intake. The modified Oswestry Disability Index (mODI) was used to document patient-perceived functional changes. Initial responses in Table 1. Because of the reported presence of abdominal pain in individuals with slipping rib syndrome, both patients were questioned regarding presence of popping or a slipping sensation. A hooking maneuver was performed to rule out neural compression at the rib cage as a source of the TAPR. The hooking maneuver is a test in which the examiner’s curled fingers are hooked under the ribs at the costal margin and the ribs are gently pulled forward to test for the presence of motion, a pop or click, and reproduction of pain. In both cases there were no symptoms of rib motion, a pop or click, or pain, so the hooking sign was considered negative (Tables 2 and 3).

![Figure 1](image-url) — Location of symptoms.
Table 2  Examination Results for Patient 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Initial visit</th>
<th>Final visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standing alignment</td>
<td>Depressed chest, with low thoracic kyphosis, flat lumbar spine, left rotation, and side bending of ribcage. Shoulder: Scapula downward rotation with bilateral abduction.</td>
<td>Flat thoracic and lumbar spine.</td>
</tr>
<tr>
<td>Forward bending</td>
<td>Observed spine motion greater than hip motion, apex of flexion at midthoracic spine.</td>
<td>Hip greater than spine motion.</td>
</tr>
<tr>
<td>Side bending</td>
<td>Observed asymmetrical side bending.</td>
<td>Symmetrical side bending.</td>
</tr>
<tr>
<td>Single-leg stance</td>
<td>Observed trunk side bend and rotation to left with stance on left.</td>
<td>Decreased trunk motion noted with single-leg stance, side bending still present.</td>
</tr>
<tr>
<td>Ventilation</td>
<td>Circumferential diameter change of the ribcage: 1.0 cm above breast at axilla, 2.0 cm below breast. Narrow subcostal margin, &lt;90°. No change in subcostal angle with shoulder flexion or inhalation.</td>
<td>Circumferential diameter change of the ribcage: 3.0 cm above breast at axilla, 3.0 cm below breast. Narrow subcostal margin, &lt;90°. Widening of subcostal angle with shoulder flexion or inhalation.</td>
</tr>
<tr>
<td>Shoulder flexion standing</td>
<td>Unilateral shoulder flexion: Decreased scapular upward rotation and elevation.</td>
<td>Unilateral shoulder flexion: Increased scapular upward rotation and elevation compared with initial visit.</td>
</tr>
<tr>
<td></td>
<td>Bilateral shoulder flexion: Observed trunk sway.</td>
<td>Bilateral shoulder flexion: No observable trunk sway.</td>
</tr>
<tr>
<td>Quadruped</td>
<td>Initial position observed thoracic flexion, with increased hip flexion. Rocking: Observed side bending with rocking back</td>
<td>No side bending noted with rocking backward.</td>
</tr>
<tr>
<td></td>
<td>Single-arm raise: Right ribcage rotation noted during motion.</td>
<td>No motion with single-arm raises.</td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>Variable</th>
<th>Initial visit</th>
<th>Final visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting</td>
<td>Terminal knee extension: Trunk flexion with rotation noted bilaterally.</td>
<td>Able to control trunk rotation with lower extremity motion.</td>
</tr>
<tr>
<td>Length tests</td>
<td>Pectoralis minor short bilaterally.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shoulder medial rotation: 30° right–left.</td>
<td>Shoulder medial rotation: 45° right–left.</td>
</tr>
<tr>
<td></td>
<td>Latissimus dorsi: 130°, observed lumbar extension with shoulder flexion.</td>
<td>Latissimus dorsi: 150°, no lumbar motion noted.</td>
</tr>
<tr>
<td>Manual muscle testing</td>
<td>Serratus anterior: 3–/5 bilaterally.</td>
<td>No change noted.</td>
</tr>
<tr>
<td></td>
<td>Trunk curl: 5/5.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lower abdominal muscles: 3/5. Ribcage rotation with lower extremity flexion.</td>
<td></td>
</tr>
<tr>
<td>Running</td>
<td>Asymmetrical thoracic rotation left &gt; right. Pain onset: 5 min on treadmill, at 5 miles/h. Pain relief with cue to adduct scapulae.</td>
<td>Symmetrical thoracic rotation during running, no transient abdominal pain during running.</td>
</tr>
<tr>
<td>Special tests</td>
<td>Beighton score = 17.</td>
<td>Oswestry Disability Index = 0.</td>
</tr>
<tr>
<td></td>
<td>Hooking sign = negative.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oswestry Disability Index = 16.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Posterior-to-anterior spring testing of thoracic and lumbar spine negative.</td>
<td></td>
</tr>
<tr>
<td>Variable</td>
<td>Initial visit</td>
<td>Final visit</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Standing alignment</td>
<td>Thoracic kyphosis with posterior sway, right ribcage side bend</td>
<td>Slight sway of thoracic spine with flat lumbar spine.</td>
</tr>
<tr>
<td></td>
<td>with rotation, lumbar lordosis, anterior pelvic tilt, bilateral knee</td>
<td></td>
</tr>
<tr>
<td></td>
<td>hyperextension.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bilateral scapula tipped and abducted from the midline.</td>
<td></td>
</tr>
<tr>
<td>Forward bending</td>
<td>Increased lower thoracic flexion with slight right rotation.</td>
<td>Slight tipping of scapula bilaterally.</td>
</tr>
<tr>
<td>Rotation</td>
<td>Off-axis rotation to left (side glide with rotation).</td>
<td>Hips greater then spine motion with decreased</td>
</tr>
<tr>
<td>Side bending</td>
<td>Asymmetrical side bending with movement primarily at lumbar region (left &gt;</td>
<td>thoracic-spine flexion.</td>
</tr>
<tr>
<td></td>
<td>right motion), pain at left side of abdominal region</td>
<td></td>
</tr>
<tr>
<td></td>
<td>produced with side bending right.</td>
<td></td>
</tr>
<tr>
<td>Ventilation</td>
<td>Subcostal margin: 60°.</td>
<td>Subcostal margin: 70°.</td>
</tr>
<tr>
<td></td>
<td>Increased kyphosis with sway during exhalation, 9th rib depression on right,</td>
<td>No spine motion with inhalation. Equal rib motion</td>
</tr>
<tr>
<td></td>
<td>noted for all tests.</td>
<td>throughout ventilation.</td>
</tr>
<tr>
<td></td>
<td>Circumferential diameter change of the ribcage: 2.5 cm above breast at</td>
<td>Circumferential diameter change of the ribcage: 3.5</td>
</tr>
<tr>
<td></td>
<td>axilla, 4.0 cm below breast.</td>
<td>cm above breast at axilla, 6 cm below breast</td>
</tr>
<tr>
<td>Shoulder flexion</td>
<td>Unilateral shoulder flexion: Observed bilateral decreased</td>
<td>Unilateral shoulder flexion: Observed bilateral scapular</td>
</tr>
<tr>
<td>standing</td>
<td>scapular upward rotation and elevation with winging on return.</td>
<td>upward rotation to midaxillary line. No trunk</td>
</tr>
<tr>
<td></td>
<td>Observed trunk rotation with left shoulder flexion.</td>
<td>rotation noted.</td>
</tr>
<tr>
<td></td>
<td>Bilateral shoulder flexion: Observed trunk sway.</td>
<td>Bilateral shoulder flexion: No trunk sway noted.</td>
</tr>
<tr>
<td>Supine hip flexion</td>
<td>Lumbar rotation with extension.</td>
<td>Able to control trunk motion with lower extremity</td>
</tr>
<tr>
<td>Supine cervical flexion</td>
<td>Demonstrated thoracic flexion with ribcage depression before cervical</td>
<td>Cervical motion complete before ribcage motion.</td>
</tr>
<tr>
<td></td>
<td>flexion.</td>
<td></td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>Variable</th>
<th>Initial visit</th>
<th>Final visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quadruped</td>
<td>Increased thoracic flexion with rocking back.</td>
<td>No thoracic spine motion with rocking back or arm raises.</td>
</tr>
<tr>
<td></td>
<td>Single-arm raises right upper extremity positive for trunk rotation.</td>
<td></td>
</tr>
<tr>
<td>Sitting</td>
<td>Slumped alignment.</td>
<td>Able to control trunk motion during lower extremity motion.</td>
</tr>
<tr>
<td></td>
<td>Terminal knee extension: lumbar and thoracic flexion with rotation noted bilaterally.</td>
<td></td>
</tr>
<tr>
<td>Length tests</td>
<td>Excessive length noted at biceps and hamstring muscles.</td>
<td></td>
</tr>
<tr>
<td>Manual muscle testing</td>
<td>Serratus anterior 3/5 bilaterally.</td>
<td>4/5 right and 3+/5 left.</td>
</tr>
<tr>
<td></td>
<td>Lower abdominal strength &lt; 1/5.</td>
<td>2/5.</td>
</tr>
<tr>
<td></td>
<td>Upper abdominals 3/5.</td>
<td>4/5.</td>
</tr>
<tr>
<td></td>
<td>Middle trapezius 3+/5 bilaterally.</td>
<td>4/5.</td>
</tr>
<tr>
<td>Running</td>
<td>Asymmetrical trunk rotation with noted right trunk side bending during left rotation, sternal depression with thoracic flexion. Symptoms improved with cue to lift chest during running.</td>
<td>Symmetrical arm motion with straight thoracic and lumbar spine.</td>
</tr>
<tr>
<td>Special tests</td>
<td>Beighton score = 8.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hooking sign = negative.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oswestry Disability Index = 12.</td>
<td>Oswestry Disability Index = 0.</td>
</tr>
<tr>
<td></td>
<td>PA testing at spinous processes and facets demonstrated pain reproduced at right side of abdomen for T9, 10, and 11. Posterior-to-anterior testing at ribs 8, 9, and 10 increased right-side abdominal pain (no stiffness noted).</td>
<td>No pain response to posterior-to-anterior testing of the thoracic spine or ribs.</td>
</tr>
</tbody>
</table>
Because of trunk and upper extremity muscle insertion on the ribcage and the reciprocal arm, leg, and trunk motions necessary for running, movement tests for the thoracic spine and ribcage (trunk flexion, extension, side bending, and rotation) and movements of the extremities (shoulder flexion and abduction, hip flexion and abduction, lateral rotation, and knee extension) were included in the physical examination. During the movement examination the patients were asked to perform movements of their spine and upper and lower extremities in a variety of positions (standing, sitting, supine prone, and quadruped) to assess the effect on the ribcage and thoracic spine. See Appendix B for a list of movement tests. The examination also included assessment of muscle length, strength, and recruitment patterns that could be contributing to the TAPR. Running on a treadmill was included in the examination to assess symptom behavior with running, to observe possible movement impairments associated with the symptoms, and then to assess the effect on the symptoms of correcting the impairments. Tests for ribcage expansion during inhalation were performed to assess the expansion of the lower ribcage, the length of the abdominal muscles, and the effect of ventilation on the alignment of the thoracic spine. Validity and reliability of the movement examination have been addressed for the lumbar spine but not for the thoracic spine and ribcage. Based on prior reports of positive thoracic-spine spring testing in individuals with TAPR, passive vertebral spring testing of the thoracic and lumbar spines and ribs was performed. Functional limitations and disability measures included mODI scores, a visual analog scale, a body-pain diagram (see Figure 1), and subjective reports. In patient 2, excessive joint range of motion at the elbows and knees was noted during passive movement testing, so a Beighton score for benign joint hypermobility was included. The Beighton score rates joint laxity at the trunk, elbows, knees, and hands using a 9-point system; the higher the score the higher the laxity. The threshold for joint laxity in a young adult ranges from 4 to 6. Thus a score above 6 indicates hypermobility. See Appendix C for the criteria for scoring. See Tables 2 and 3 for all positive test results for each of the patients.

Diagnoses

The movement diagnosis determined for both patients was thoracic flexion with rotation. The key signs and symptoms that supported this diagnosis (for both patients) included alignment impairments of increased thoracic flexion, posterior trunk sway, and ribcage asymmetry; movement impairments during testing and running of asymmetrical rotation, side bending, or flexion of the thoracic spine; and reduction of abdominal pain during running with cuing to reduce thoracic flexion and rotation. Contributing factors to this diagnosis that were similar between the patients included short or stiff abdominal muscles as determined by standing alignment, decreased ribcage circumferential expansion during inhalation, and a narrow subcostal angle (<90°) both at rest and with inhalation. (Tables 2 and 3)

Key differences were noted between the 2 patients. Patient 1 demonstrated muscle impairments related to excessive use during sport, including shortness of the shoulder lateral rotators, pectoralis major and minor, and latissimus dorsi muscles. Patient 2 demonstrated excessive joint flexibility, supported by her high Beighton score, across multiple regions with no restriction in her shoulder-girdle range of motion. Additional test results that were positive in patient 2 but not in patient 1 were (1) excessive flexion of the thoracic spine during forward bending (see video of forward bending, avail-
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able in the online version of the journal), (2) translation (side gliding) with rotation of the trunk to the left, (3) asymmetry at the subcostal margin during ventilation and bilateral shoulder flexion in standing, (4) increased thoracic flexion with posterior trunk sway during exhalation (see video of sway during exhalation, available in the online version of the journal), and (5) thoracic-spine flexion before cervical-spine flexion when testing cervical-flexor muscle strength in the supine position. In patient 2, we propose that the development of the shortness of her rectus abdominis muscle was from the excessive flexibility of her thoracic spine and the lack of counterbalancing activity in her thoracic back extensors, resulting in an increase in thoracic-spine flexion and posterior trunk sway during functional activities. Habitual posturing into thoracic flexion with posterior trunk sway in standing and sitting resulted in decreased recruitment of the thoracic paraspinal and external oblique muscles and an increase in the recruitment of the rectus abdominis muscles.57,58

Finally, on initial examination both patients experienced TAPR on a treadmill. Asymmetrical trunk rotation with slight thoracic flexion was noted in each case. (Videos of patient 1 and patient 2 running are available in the online version of the journal.) Verbal cuing to extend their spines and equalize their arm swing during the task resulted in alleviation of TAPR in patient 1 and decreased its intensity in patient 2. Thus, this change in transient abdominal pain during the examination supported the belief that there was insufficient recruitment of the thoracic-spine extensors and excessive pull from the abdominal muscles during this activity.

Treatment

The emphasis for treatment in each of the patients was to determine a strategy for correcting motion during running to reduce or abolish the transient abdominal pain. Correction of extremity movements (shoulder flexion and abduction, hip flexion and abduction, lateral rotation, and knee extension) that caused movement of the spine or ribcage was included in the treatment programs. See Table 4 for details on the therapeutic intervention prescribed for each patient. Initially, the therapeutic exercise for both patients focused on trunk impairments noted on exam. Specifically, rectus abdominis muscle length was addressed to increase thoracic-spine extension during running. The patients performed bilateral shoulder flexion with inhalation to stretch the abdominals by elevating the sternum, expanding the ribcage, and extending the thoracic spine. (Videos of patient 1 and patient 2 performing shoulder flexion while inhaling are available in the online version of the journal.) In contrast to patient 1, who needed to deemphasize abdominal strengthening, patient 2 required treatment that included thoracic paraspinal muscle strengthening and improving abdominal muscle recruitment in positions that avoided thoracic flexion. (A video showing prone shoulder flexion is available in the online version of the journal.) Differences in shoulder impairments were addressed for each patient. The exercise program for patient 1 included exercises in supine and standing to improve the length of the shoulder lateral rotators, pectoralis minor, and latissimus dorsi muscles. Patient 2 was instructed in strengthening exercises in the prone, quadruped, and standing positions to improve her control of shoulder motion at end-range muscle weakness of the serratus anterior and middle trapezius and her generalized hypermobility. For each patient, modification of functional activities and static positions used during typical daily activities such as sitting in class and sleeping position were addressed. Specific treatment programs, cues for the activities, goals of the exercises, and progression of the treatment for each patient are found in Table 4.
### Table 4  Intervention

<table>
<thead>
<tr>
<th>Therapeutic activity</th>
<th>Patient 1</th>
<th>Patient 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward bending and return</td>
<td>Cues: Stick out seat as bending over. Goal: Increase hip flexion, increase paraspinal muscle control, limit thoracic flexion during task. Progression: Upper extremity support during task progressed to no support.</td>
<td>Cues: Stick out seat as bending over, keep chest up. Goal: Increase hip flexion, increase paraspinal muscle control, limit thoracic flexion during task. Progression: Upper extremity support during task progressed to no support.</td>
</tr>
<tr>
<td>Side bending</td>
<td>Increased abdominal pain after performance of corrected side bending, not initially prescribed as exercise. Progression: Manually supported side bending with inhalation at end range (3rd visit). Goal: Lengthen abdominal muscles, improve symmetry of side bending.</td>
<td>Increased abdominal pain after performance of corrected side bending, not prescribed as exercise.</td>
</tr>
<tr>
<td>Single-leg stance</td>
<td>Cues: Keep chest lifted during leg lift, try to keep trunk still. Goal: Decrease trunk rotation and side bending during single-leg stance. Progression: Upper extremity support progressed to no support.</td>
<td></td>
</tr>
<tr>
<td>Shoulder flexion facing wall</td>
<td>Cues: Shrug shoulders and bring armpits forward during lifting, inhale at top. Goal: Unload upper body on wall, increase scapular upward rotation and elevation, elongation of abdominal muscles. Progression: Arm off the wall for paraspinal muscle strengthening.</td>
<td>Cues: Shrug shoulders on elevation, contract muscles between shoulder blades while bringing arms down. Goal: Unload upper body on wall, improve spine alignment, improve scapular motion during shoulder flexion, control eccentric lowering of limb by scapulothoracic muscles.</td>
</tr>
</tbody>
</table>
### Table 4 (continued)

<table>
<thead>
<tr>
<th>Therapeutic activity</th>
<th>Patient 1</th>
<th>Patient 2</th>
</tr>
</thead>
</table>
| Shoulder flexion with back to wall | Cues: Keep spine aligned on wall, inhale at end range of motion for shoulder flexion.  
Goal: Lengthen abdominal and latissimus dorsi muscles, decompress thoracic spine and ribcage. | Cues: Keep spine aligned on wall, inhale at end range of motion for shoulder flexion.  
Goal: Lengthen abdominal muscles, decompress thoracic spine and ribcage.  
Progression: Abdominal muscle contraction in new position for strengthening. |
| Shoulder abduction with back to wall | Cues: Allow elbows off wall with fingertips on wall, align spine on wall, inhale at end range of motion for shoulder flexion.  
Goal: Lengthen the abdominal muscles and pectoralis minor and major, strengthen scapulothoracic adductors. | Cues: Align back on wall, inhale at end range of shoulder flexion.  
Goal: Lengthen the abdominal muscles, strengthen scapulothoracic, abdominal, and paraspinal muscles.  
Progression: Abdominal muscle contraction in new alignment, light weights to strengthen trunk muscles. |
| Supine hip abduction lateral rotation from a hip-flexed position | Cues: Contract abdominal muscles to keep pelvis and back still while moving legs. | Goal: Strengthen lower abdominal muscles, decrease motion at spine during lower extremity movements.  
Cues: Contract abdominal muscles to keep pelvis and back still while moving legs.  
Goal: Strengthen lower abdominal muscles, decrease motion at spine during lower extremity movements. |
| Supine heel sliding from a hook-lying position | Cues: Keep back on surface while raising arms overhead.  
Goal: Limit trunk motion during shoulder flexion to lengthen latissimus dorsi muscles. | |
| Supine shoulder flexion | |

(continued)
<table>
<thead>
<tr>
<th>Therapeutic activity</th>
<th>Patient 1</th>
<th>Patient 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supine shoulder medical rotation</td>
<td>Cues: Keep shoulder still while moving arm.</td>
<td>Cues: Keep ribcage still.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Progression: Light weights, unilateral arm raise in quadruped.</td>
</tr>
<tr>
<td>Side-lying lateral rotation</td>
<td>Cues: Keep trunk still with leg motions.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Goal: Hip lateral rotation strengthening, limit trunk rotation with leg motion.</td>
<td></td>
</tr>
<tr>
<td>Prone unilateral shoulder flexion</td>
<td>Cue: Keep ribcage still.</td>
<td></td>
</tr>
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<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prone unilateral shoulder flexion</td>
<td>Cues: Keep ribcage still.</td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quadruped rocking</td>
<td>Cue: Flatten thoracic spine, increase motion at hips.</td>
<td>Cue: Flatten thoracic spine, increase motion at hips.</td>
</tr>
<tr>
<td></td>
<td>Goal: Decompression of spine and ribcage.</td>
<td>Goal: Decompression of spine and ribcage.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quadruped arm lifts</td>
<td>Cue: Dig heel of hand into surface, lift other arm.</td>
<td>Cue: Dig heel of hand into surface, lift other arm.</td>
</tr>
<tr>
<td></td>
<td>Goal: Control thoracic rotation with arm motion, spinal extensor strengthening.</td>
<td>Goal: Control thoracic rotation with arm motion, spinal extensor strengthening.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sitting knee extension</td>
<td>Cue: Keep trunk still while moving legs.</td>
<td>Cue: Keep trunk still while moving legs.</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>Running</td>
<td>Cue: Pinch shoulder blades together while running.</td>
<td>Cue: Lift chest while running.</td>
</tr>
<tr>
<td></td>
<td>Goal: Increase thoracic paraspinal recruitment to reduce flexion with rotation during running, improve shoulder-girdle alignment with running.</td>
<td>Goal: Increase thoracic paraspinal recruitment to reduce flexion with rotation during running.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resting positions: Sitting</td>
<td>Cue: Use seat backs and avoid leaning on armrests or desktops during school.</td>
<td>Cue: Use seat backs and avoid leaning on armrests or desktops during school, avoid slumping.</td>
</tr>
<tr>
<td></td>
<td>Goal: Reduce flexion and rotational stress on spine during day.</td>
<td>Goal: Reduce flexion and rotational stress on spine during day.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resting positions: Sleeping</td>
<td>Cue: Pillow between legs with side lying.</td>
<td>Cue: Pillow between legs with side lying.</td>
</tr>
<tr>
<td></td>
<td>Goal: Reduce rotational stress at spine during sleep.</td>
<td>Goal: Reduce rotational stress at spine during sleep.</td>
</tr>
</tbody>
</table>
Compliance was monitored by patient verbal self-report at each of the visits. Patient 1 reported compliance during the first 3 visits across 2 months of treatment, performing each activity daily for 3 sets of 10 repetitions. In addition, she noted trying to adduct her scapulae and lift her chest during running, a cue intended to increase the recruitment of the thoracic paraspinal muscles. During the second month of treatment, patient 1 became noncompliant because a lack of TAPR, but on the fourth visit she noted an increase in symptoms during her most recent soccer game. On further questioning, she reported practicing sit-ups for the Presidential Fitness Awards at her school. She had been performing 40 bent-knee sit-ups a day for 1 week before experiencing TAPR. The patient was re instructed in her home program and advised to stop all bent-knee sit-ups at this time. On her final visit, patient 1 reported compliance with the exercises since the previous visit. She reported performing 3 sets of 10 repetitions of her exercises every other day. She had not experienced TAPR since the last visit 1 month prior. Patient 2 reported compliance of daily exercise, 3 sets of 10 repetitions, for the first 2 months with reduction to every-other-day exercise for the last month.

**Prognoses**

Prognoses for both patients were considered excellent. These prognoses was based on the positive moderators of age, general good health, minimal functional limitations (limited in length of participation in sport and low mODI scores), location of the symptoms being typical for individuals with TAPR, and the immediate relief or reduction of the TAPR with alignment correction during running.

**Outcome**

Both patients were seen in physical therapy for 5 visits over 3 months. The outcomes for both were excellent, with resolution of TAPR during the last month of their treatment. Symptom relief was confirmed by phone-call follow-up 1 and 2 years after discharge. Figure 2 demonstrates a comparison of the mODI scores, and Figure 3 compares numeric pain-scale scores for both patients.

![Figure 2](image)  
*Figure 2 — Modified Oswestry Disability Index scores.*
Mechanical stresses incurred during running have been theorized to contribute to transient abdominal pain, yet the etiology of TAPR is still unclear. We believe that musculoskeletal impairments related to the trunk muscles combined with the mechanical stresses of running could contribute to TAPR. Specific trunk impairments during running, such as thoracic-spine flexion, rotation, or a combination, might be further identifiable in other individuals with TAPR if a standard movement examination is used when assessing them. In both cases, addressing the impairments noted on examination reduced the TAPR not only across the course of intervention but for 2 years afterward. Based on the positive outcomes in both patients, addressing alignment, muscle, and movement impairments was believed to be key to the resolution of the symptoms. Although both patients had the same diagnosis and level of functional disability, the specific muscle and mechanical factors that contributed to their conditions were different. The differences in specific impairments in each patient demonstrate the need for specificity of treatment to achieve a reduction of the mechanical stressors that may be implicated in TAPR. Patient 1 required a treatment emphasis on activity modification to first increase the length and then decrease the recruitment of all of her abdominal muscles during running. In contrast to this, patient 2 required a treatment emphasis to first increase the length of her rectus abdominis and then progressively strengthen her thoracic paraspinal and oblique abdominal muscles to improve mechanical support of her trunk during running.

Motor control of aerobic exercise is a complex process.\textsuperscript{21,44,59,60} Pressure changes in the abdomen and chest need to be synchronized to maximize ventilatory

**Figure 3** — Severity of pain during running.
response. In the case of running, simultaneous increases in ventilatory demand occur with the demand to control rotational forces at the trunk because of motions of the extremities. Running increases demand for both ventilatory and trunk-stabilizing actions of the trunk muscles. Paraspinal extensors of the trunk have been reported to be active in phase with the relative amount of trunk flexion but do not demonstrate activity related to control of trunk rotation or ventilation. The abdominal muscles, on the other hand, have been found to be active in phase with both ventilation and the rotational demand of the trunk during running. In addition, variability in the control of ventilation as speed increases has been noted for each of the specific sections of the abdominal musculature, with the rectus abdominis staying consistently in phase with exhalation and inconsistent timing for the external oblique, internal oblique, and transverse abdominis. Because of the need to coordinate both trunk control and ventilation, we propose that movement-related impairments of the trunk and ribcage could be the source of TAPR.

Kinematically, trunk rotation and side bending are considered coupled motions of the thoracic spine causing approximation of the ribs on the ipsilateral site of side bending. Asymmetrical contraction of the transverse and oblique abdominal muscles could theoretically result in side bending or rotation of the rib cage and compression of an intercostal nerve. Neural compression thus could potentially create a pain that is referred to the abdomen. During the examination, trunk side bending in standing caused abdominal pain in both patients. In addition, when trunk side bending and rotation motions were reduced during running both patients demonstrated an improvement in their abdominal pain. These findings support the theory that the cause of the abdominal pain could be approximation of the ribs during the trunk motions of side bending and rotation.

Specific endurance-related impairments of the trunk muscles have not been studied in individuals with TAPR. However, exercise-induced fatigue of both the diaphragm and abdominal muscles has been reported in healthy adults. In addition, anticipatory trunk-muscle activity of the rectus abdominis and erector spinae was reduced, whereas internal oblique muscle activity was increased, in individuals who had performed sit-ups to fatigue the abdominal muscles. In individuals surveyed after a race, no consistent pattern was found related to the onset of TAPR. Thus, exercise-induced fatigue of the abdominal muscles does not wholly explain TAPR. In both patients onset of pain occurred after 15 to 30 minutes of running, increasing the possibility of endurance-related muscle fatigue as a source of the TAPR.

The mODI is a patient-based outcome measure typically used for individuals with lumbar-spine impairments. Recently, it has been used to document functional change in response to interventions for individuals with thoracic-spine pathology including idiopathic adolescent scoliosis. Unfortunately, the use of the mODI to document change in adolescents with spine impairments has not been validated. Currently there are no other outcome measures available that have been validated for adolescent athletes who present with thoracic-spine impairments. The mODI scores for both our patients improved by more than 6 points, demonstrating a clinically detectable level of change. These improvements combined with immediate changes in verbal report of pain during running supported the decision to continue with the prescribed treatment.
Conclusion

These 2 patients illustrate that developing a movement diagnosis and identifying the contributing factors based on a systematic examination can be used in treatment of TAPR. The diagnosis and the results of the examination provide specific direction for treatment. Emphasis on the correction of trunk motion during running aided in the treatment of both patients. Continued research is needed to determine characteristics of patients with TAPR that can best benefit from an examination of signs, symptoms, and impairments associated with movements of the trunk, as well as the limbs.

Acknowledgments

These 2 cases were seen at the Program in Physical Therapy at Washington University School of Medicine, Physical Therapy Clinic, St Louis, MO. At the time of the cases, Theresa M. Spitznagle was completing her capstone project for her postprofession doctorate in physical therapy. The options or assertions contained herein are the private views of the authors.

References

Abdominal Pain During Running


### Appendix A

**PATIENT HISTORY - SYSTEMS REVIEW**

<table>
<thead>
<tr>
<th>Patient Name:</th>
<th>Sex: [ ] M [ ] F Marital Status: [ ] Single [ ] Married [ ] Widowed [ ] Divorced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Currently living with: [ ] Alone [ ] Family/Relatives/Spouse [ ] Friends [ ] Attendant [ ] Other</td>
<td></td>
</tr>
<tr>
<td>Occupation:</td>
<td>Presently Working? [ ] Yes [ ] No</td>
</tr>
<tr>
<td>Emergency Contact:</td>
<td>Relationship</td>
</tr>
</tbody>
</table>

**CURRENT MEDICATIONS**

<table>
<thead>
<tr>
<th>DRUG</th>
<th>DOSAGE/FREQUENCY</th>
<th>DRUG</th>
<th>DOSAGE/FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**MEDICAL/SURGICAL HISTORY**

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tubercolosis (TB)</td>
<td>Diabetes Mellitus</td>
<td></td>
</tr>
<tr>
<td>Respiratory (COPD)</td>
<td>Cancer</td>
<td></td>
</tr>
<tr>
<td>Asthma</td>
<td>Kidney/Uriney</td>
<td></td>
</tr>
<tr>
<td>High Blood Pressure</td>
<td>Epilepsy/Seizures</td>
<td></td>
</tr>
<tr>
<td>Low Blood Pressure</td>
<td>Stomach/Gastrointestinal</td>
<td></td>
</tr>
<tr>
<td>Heart Disease</td>
<td>Heart Attack</td>
<td></td>
</tr>
<tr>
<td>Circulation/Vascular</td>
<td>Stroke</td>
<td></td>
</tr>
<tr>
<td>Arthritis</td>
<td>Skin Problems</td>
<td></td>
</tr>
<tr>
<td>Osteoporosis</td>
<td>Pacemaker</td>
<td></td>
</tr>
<tr>
<td>Thyroid problems</td>
<td>Psychiatric History</td>
<td></td>
</tr>
<tr>
<td>Pregnancy</td>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

List major surgical procedures & dates:

<table>
<thead>
<tr>
<th>Have you recently had any of the following complaints?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Shortness of breath</td>
</tr>
<tr>
<td>Pain/heaviness in chest</td>
</tr>
<tr>
<td>Pulsing pain in body</td>
</tr>
<tr>
<td>Pain or cramping in lower leg (calf)</td>
</tr>
<tr>
<td>Foot pain/discoloration</td>
</tr>
<tr>
<td>Swelling</td>
</tr>
<tr>
<td>Fatigue</td>
</tr>
<tr>
<td>Cough</td>
</tr>
<tr>
<td>Fever/night sweats</td>
</tr>
<tr>
<td>Unusual lumps or growths</td>
</tr>
<tr>
<td>Unexplained weight loss or gain in 2 weeks</td>
</tr>
<tr>
<td>Constant pain in body</td>
</tr>
<tr>
<td>Persistent pain at night</td>
</tr>
<tr>
<td>Swelling or redness in any joints</td>
</tr>
<tr>
<td>Unusual menstrual irregularities</td>
</tr>
<tr>
<td>Change or problems with bladder control/function</td>
</tr>
</tbody>
</table>
Appendix B: List of Thoracic-Spine Tests

**Standing**

Alignment: Thoracic spine, lumbar spine, cervical spine; scapulae; subcostal margin.

Forward bending: Observe rib cage for rotation, observe spine for amount and location of flexion.

Rotation: Emphasis on observation of thoracic spine.

Side bending: Observe thoracic and lumbar spine.

Single-leg stance

Monitor ventilation: Standing and with bilateral shoulder flexion.

Standing unilateral shoulder flexion: Observe scapulae, monitor spinous process.

Standing bilateral shoulder flexion: Observe spine for motion.

**Supine**

Position

Supine hip flexion

Muscle-length tests: Latissimus dorsi, scapulohumeral, pectoralis major, pectoralis minor, biceps, hamstrings.

Neck flexion: Observe effect on ribcage and thoracic spine.

**Side Lying**

Position

**Prone**

Position

Middle trapezius muscle test

Lower trapezius muscle test

**Quadruped**

Rock back

Arm raises

**Sitting**

Serratus anterior muscle test

Hip flexion

Knee extension

**Functional Activities**

Sitting

Sports/Running

Patient performs movement in preferred manner. Symptoms and characteristics of the movement are noted by examiner. Patient is then instructed in correct performance, and the effect on the symptoms is noted by the examiner.
### Appendix C: Beighton Score

<table>
<thead>
<tr>
<th>Joint</th>
<th>Finding</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left little (fifth) finger</td>
<td>Passive extension beyond 90°.</td>
<td>1</td>
</tr>
<tr>
<td>Right little (fifth) finger</td>
<td>Passive extension beyond 90°.</td>
<td>1</td>
</tr>
<tr>
<td>Left thumb</td>
<td>Passive flexion to the flexor aspect of the forearm.</td>
<td>1</td>
</tr>
<tr>
<td>Right thumb</td>
<td>Passive flexion to the flexor aspect of the forearm.</td>
<td>1</td>
</tr>
<tr>
<td>Left elbow</td>
<td>Hyperextends beyond 10°.</td>
<td>1</td>
</tr>
<tr>
<td>Right elbow</td>
<td>Hyperextends beyond 10°.</td>
<td>1</td>
</tr>
<tr>
<td>Left knee</td>
<td>Hyperextends beyond 10°.</td>
<td>1</td>
</tr>
<tr>
<td>Right knee</td>
<td>Hyperextends beyond 10°.</td>
<td>1</td>
</tr>
<tr>
<td>Forward flexion of trunk with knees fully extended</td>
<td>Palms and hands can rest flat on the floor.</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>9</strong></td>
</tr>
</tbody>
</table>