THORACIC MOBILITY AND ATHLETIC PERFORMANCE

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All performance training methods within Arizona Diamondbacks Major League Baseball (MLB) Strength and Conditioning Team's philosophy share the commonality of aiming to maximize the baseball athlete's ability to function at their peak capacity and enabling the highest possibility of succeeding in competition. Of the many variables directly impacting the baseball athlete's performance, thoracic mobility exists as one area deserving special attention. Although targeting mobility seems to be most commonly referenced for the extremities in the performance training world, the thoracic spine is considered a particularly important location due to the wide-ranging effects a freely moving thoracic spine can have on the body's performance, potentially impacting such critical areas as scapular positioning, shoulder health, rib cage mobility, and diaphragm function. Gaining a thorough understanding of thoracic spine anatomy, the causes and effects of limited thoracic mobility, and the diverse strategies that may enhance thoracic mobility are critical to successfully maximizing the performance potential of the thoracic complex.

Efforts that impact the movement capabilities of any structure in the human body can begin with a solid foundational understanding of the anatomy and physiology of the involved structure. In other words, the identification of what is "normal" form and function need to be understood. The thoracic spine (t-spine) is only one element of an interdependent 136-joint system. This system, because of the structures involved, importantly including the diaphragm, plays a critical role in affecting the movement capabilities of all other aspects of the body as it can directly impact alignment via respiratory and neurological influences (10,15). While referencing the "t-spine" in this article, we are in fact describing the entire thoracic system, since the function of the thoracic vertebrae go together with the other key structures of the area, such as the ribs, sternum, costal cartilage, diaphragm, and pleural cavity. The thoracic spine is composed of 12 vertebrae sharing intervening intervertebral discs and connected posteriorly and bilaterally via facet joints. The specific orientation of these facet joints allows for tri-planar (i.e., lateral flexion, rotation, flexion/extension) movement capability (Table 1) (10).

TABLE 1. THORACIC SPINE NORMS (10)

Static Curve	30^{o}
Flexion/Extension	45^{o}/28 – 30^{o}
Lateral Flexion	30 – 35^{o}
Rotation	30 – 35^{o}

Due to the existence of 12 sets of rib attachments on the costovertebral joints of each segment, any movement of the thoracic vertebrae in any plane is coupled with the corresponding multi-planar movements of each rib and vice versa. For example, in the transverse plane, right rotation of a thoracic segment is accompanied by coupled left-side bending along with right rib external rotation and simultaneous left rib internal rotation (Figure 1) (18,21).

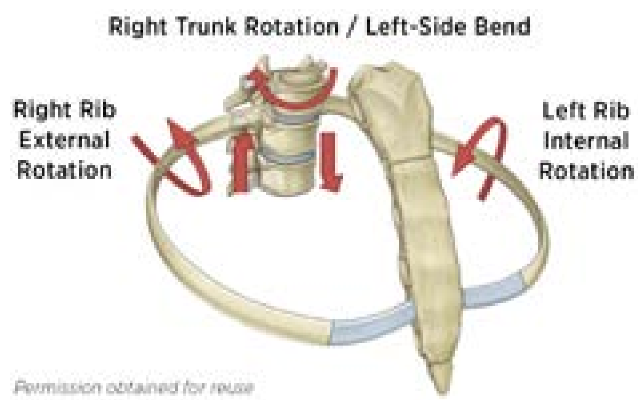


FIGURE 1. EXAMPLE OF THE EFFECT OF RIGHT TRUNK ROTATION AND LEFT-SIDE BENDING ON THE RIBS

It is important to note the role of the left and right leaflets of the diaphragms as critical structures of the thoracic system. With some left-to-right differences, the diaphragm approximately spans T8 (dome) to L2/3 with direct, crural attachments to the lower thoracic/upper lumbar vertebrae in addition to the undersurface of the sternum and lower six ribs (20). As the main inspiratory muscle, the diaphragm contracts and flattens to allow air inflow and thoracic cavity expansion with the help of proper eccentric rib cage control of the abdominals. During proper full exhalation involving full rib internal rotation (IR) and accompanying thoracic vertebral flexion, in addition to concentric abdominal activity, the diaphragm relaxes and assumes a normal dome-like resting state (10,18). Because of its anatomical attachments and the body's average normal breathing rate of 22,000 breaths per day, the diaphragm serves as perhaps the most influential structure of the thoracic system and overall body's posture and movement capability (10). Above all, an ideally positioned and performing thoracic system has complete access to all planes of anatomical movement and the capability to freely move in and out of its fully available motion when needed (10).

Although the alignment and functioning "norms" of the thoracic complex are the universal goals, the human structure often deviates away from these ideals due to any number of societal/cultural, emotional, congenital, habitual, and/or environmental influences. Whatever the cause, a mobility-limited thoracic system often manifests in a variety of easily identifiable and predictable ways. In our collective experiences within the world of professional baseball, some of the most commonly observed potential indicators of thoracic system rigidity involve the presence of a visually flat thoracic spine curvature (<30°), bilaterally stiff and flaring ribs in the supine position, and excessive lumbar spine lordosis (>40°) (10,16). These three findings all share the commonality of being physical representations or consequences of a system patterned in extension. Although not inherently deleterious by itself, extension posture of a joint, region, or system of the body can become detrimental if the posture becomes continuous or habitual. Patterned extension of any structure most often signifies the body's need for stability in that region as it moves through space and contends with gravity. Unfortunately, where extension posture gains in stability, it simultaneously lacks in tri-planar mobility. In other words, habitual extension posture signifies a region "locked" mainly in the sagittal plane, severely limiting the available uncompensated range of motion (ROM) in both the frontal and transverse planes. Over time, the lack of mobility in any one area due to the habitual extension posture can consequently lead to faulty positional and movement compensations elsewhere. These compensations occur as a result of the body attempting to access the other planes of movement albeit in ways that can increase the potential for structural breakdown and less-than-ideal performance. As stated in the previous paragraph, the body's ideal state of performance potential occurs when free, unrestricted access to all planes of movement exist.

A loss of the normal thoracic curvature of the spine (flat t-spine) is one common indicator of limited thoracic mobility and can often result from hypertonic, overtrained, and dominant bilateral pectoralis major and latissimus dorsi. Due to their anatomical locations and attachment sites, both muscles possess the leverage when overactive to heavily assist in protracting the thoracic complex and upwardly rotating the ribs to which they have direct attachments. This rib cage movement and center of mass shifting forward and up involves corresponding extension and "flattening" of the thoracic vertebral column. The new more vertical or "stacked" orientation of the vertebral facets combined with the constant resting hypertonicity of the pectoralis major and latissimus dorsi can significantly limit the thoracic complex's access to the frontal and transverse planes especially. This position, when prolonged, can also leverage secondary muscles of respiration, such as the anterior and middle scalenes of the neck resulting in habitual faulty breathing mechanics as the system now incorrectly "pulls" air in and contributes potentially to the development of forward head posture (1,3,4,10).

A bilaterally stiff and flaring rib cage is another common finding that can be associated with thoracic system immobility (2,10). This phenomenon can easily be assessed in a supine position with a quick visual assessment identifying a raised or upwardly tipped and externally rotated rib cage and hollowing of the anterolateral abdominal wall bilaterally often accompanied by a well-defined rectus abdominis. The stiffness component of the ribs can be assessed by placing both hands on one side of the rib cage (one upper and one lower) and instructing the athlete to take a full, slow breath in through the nose then out through the mouth. Gaining a feel of how much resistance is present and how much movement occurs as the rib cage attempts to internally rotate and drop upon exhalation can determine the level of relative stiffness of the structure. Given their previously stated anatomical connections with the thoracic vertebrae in addition to the diaphragm and thorax musculature (i.e., intercostals, internal obliques, external obliques, transversus abdominis, etc.), the ribs are undeniably meant to move and move often. However, chronic abdominal disuse as prime muscles of exhalation and trunk frontal and transverse plane movers combined with faulty habitual breathing habits (e.g., mouth breathing, shallow exhalations, upper chest inhalation dominance, etc.) can lead to the development of rib cage stiffness and consequently thoracic complex immobility (2,10).

Going together with the presence of a flat t-spine and stiff rib cage is the existence of excessive resting-state lumbar spine lordosis which can be another strong indicator of a lack of thoracic complex mobility. Although its cause can be attributed to a wide-variety of variables, as the body seeks constant stability upright against gravity, this finding is usually indicative of overactive paralumbar musculature and hip flexors, combined with positional disuse of the abdominals, hamstrings (for pelvic control), and the diaphragm's inability to achieve a resting dome-like state during full exhalation. Consequently, thoracic system immobility can develop due to the chronically challenged abdominals' positional inability to IR the ribs during exhalation and fully access the frontal and transverse planes of trunk movement. In addition, the anterior pull of the constantly leveraged hip flexors aids in holding the diaphragm and rib cage in states of chronic inhalation with the inability to reverse and achieve balanced respiratory activity (1,10).

Above all and regardless of the causes, chronic thoracic system immobility forces the body to develop compensatory positional and movement strategies in other locations, which can be potentially harmful to the performance and health longevity of those structures involved due to the added load placed upon them. Once the presence of limited thoracic mobility is accurately identified, the next logical question becomes, "what can be done to correct it?"

As part of the Arizona Diamondbacks' continuous philosophical evolution over the past decade, we have been fortunate to have been exposed to a wide array of treatment and training systems (5,6,7,8,9,10,11,12,13,14,21). This experience has allowed us the opportunity to discover what seems to work or not work in addressing the presence of limited thoracic system mobility among the athletes in our specific setting. With the saying, "methods are many, but principles are few" in mind, we have identified, at least in our perspective, three simple yet powerful concepts that we have found to be critical for successfully impacting limited thoracic spine mobility among our professional baseball population: 1) exhalation, 2) reaching, and 3) posterior pelvic tilting. Regardless of the method employed, these key principles, if performed correctly, provide the essential foundation for any exercise attempting to reverse the presence of thoracic spine immobility.

Achieving a state of full exhalation is a critical element of expanding thoracic complex mobility and should be incorporated into every exercise designed to maximize movement, at least in our perspective. Complete exhalation requires thoracic spine flexion and rib internal rotation, together bringing the thoracic system's center of mass (COM) posteriorly, which reverses the chronic thoracic spine extension, rib external rotation, and protracted rib cage positions associated with limited thoracic system mobility (10,19). Exhalation also possesses the effect of expelling the trapped inhaled air in the pleural cavity associated with an extended, forwardly positioned COM, which is a position that reflexively demands persistent paralumbar muscle tonicity as the body's attempt to stay balanced upright and prevent it from falling forward. Above all else, properly performed exhalation via concentric abdominal activity ultimately is the crucial setup for the ideal uncompensated 360° rib cage expansion that is controlled by eccentric abdominal activity during full inhalation (1,10,11,12,13,14).

The act of reaching forward allows the opportunity for activation of the thoraco-scapular (TS) serratus anterior to position the thoracic complex posteriorly. This backwards movement of the rib cage shares the same mechanical effect as the previously described state of exhalation and, when combined with exhalation, powerfully enhances the thoracic complex's availability to unrestricted tri-planar movement. Reaching forward during an exercise can be accomplished either bilaterally or unilaterally.

Bilateral reaching has a primary influence on the sagittal plane by "unlocking" the extension dominant patterning, while unilateral or alternating reaching has a heavier influence on frontal and transverse plane movement restoration.

Posterior pelvic tilting essentially sets the foundation for thoracic mobility by enhancing the movement leverage of the abdominals' ability to internally rotate the rib cage, as well as assist in rotating the trunk. This restored positioning of the abdominals also allows them to now concentrically and eccentrically control rib movement during the breathing cycle, which maximizes the diaphragm's ability to function correctly and powerfully. In addition, the hamstring activation required to move the pelvis into the posteriorly rotated position assists in reducing the chronic leveraging of the paralumbar musculature and hip flexor group which play major roles in holding the thoracic complex in a persistent mobility limiting, extension-based posture.

As stated previously, a variety of exercise methods currently exist in the world of sports medicine and performance for treating limited thoracic spine mobility. We have found several exercises that seem to have established themselves as reliably impactful choices. From our experience, these exercises have been shown to be effective in increasing mobility and are often utilized together within the same programs. The following section describes our top choices in detail.

SQUATTING BAR REACH (FIGURES 2 AND 3)

**Modified and used with permission from the PRI Integration for Fitness and Movement Course (7)*

Position/Movement: Arms straight, lean back with bodyweight in the heels. Inhale deeply and posteriorly.

WHY IS THIS EFFECTIVE?
Emphasizes posterior shifting of the thorax's COM to inhibit paralumbar/hip flexor hypertonicity and redirect air flow more posteriorly in the thorax (7). Passively incorporates reach, posterior pelvic tilt, and exhalation together.

90 – 90 SHIN BAR SLIDE WITH HAMSTRINGS (FIGURES 4 AND 5)


**Modified and used with permission from the PRI Fitness and Movement Course Manual (7)*

Position/Movement: 90 – 90 position for knees and hips, pull heels down as the athlete exhales and reaches bar forward, driving ribs down and back.

WHY IS THIS EFFECTIVE?

Emphasizes hamstring activity in gravity-eliminated position to posteriorly tilt the pelvis. Actively incorporates reach, exhalation, and leveraged abdominal activity.

TWO-POINT BEAR (FIGURES 6 AND 7)


**Modified and used with permission from the PRI Fitness and Movement Course Manual (7)*

Position/Movement: All fours position, drive opposite hand and foot into floor while connecting elbow and knee.

WHY IS THIS EFFECTIVE?

Emphasizes more challenging abdominal activity and thorax rotational control with unilateral resisted reaching (into ground). Resistance from pushing into ground heightens TS serratus anterior activity to retract rib cage.

WALK AROUND (FIGURES 8 AND 9)

**Modified and used with permission from the PRI Fitness and Movement Course Manual (7)*

Position/Movement: From push-up position, walk feet around the outsides of hands while driving heels and hands into the floor.

WHY IS THIS EFFECTIVE?
Emphasizes more challenging abdominal activity and thorax rotational control with bilateral resisted reaching (into ground). Resistance from pushing into ground heightens TS serratus anterior activity to retract rib cage.

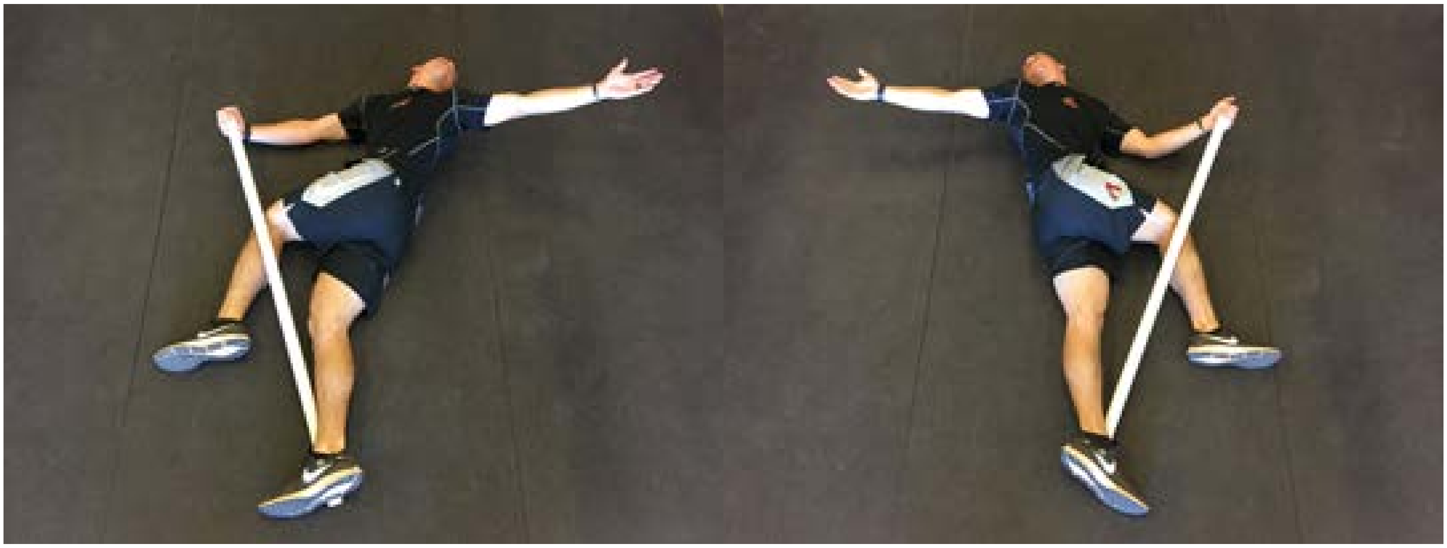
LUNGE INDIAN CLUB ROTATION (FIGURES 10 AND 11)

**Modified and used with permission from the PRI Fitness and Movement Course Manual (7)*

Position/Movement: Isometric hold in walking lunge position with rotation over front leg.

WHY IS THIS EFFECTIVE?
Emphasizes upright dynamic control of pelvis and thorax during maximal rotational trunk movement against gravity. Highly challenges tri-planar rotational control of thorax and pelvis.

SIDE LYING ROTATION (FIGURES 12 AND 13)



**Modified and used with permission from the PRI Fitness and Movement Course Manual (7)*

Position/Movement: From side lying position, rotate torso while maintaining stacked hips.

WHY IS THIS EFFECTIVE?
Isolates torso rotation without compensatory rotation from pelvis.

QUADRUPED T-SPINE ROTATION (FIGURES 14, 15, AND 16)

**Modified and used with permission from the PRI Fitness and Movement Course Manual (7)*

Position/Movement: Push the floor away while simultaneously rotating torso away and counter-rotating the hips.

WHY IS THIS EFFECTIVE?
Pushing the hands through the ground contributes to making this an active thoracic ROM exercise.

Maximizing thoracic mobility is a critically important focus for athletic performance training within the Arizona Diamondbacks Strength and Conditioning Team. Owning a solid, fundamental understanding of the thoracic complex anatomy provides the foundation for being able to accurately identify normal versus abnormal functioning. Visually flat thoracic spine curvature, a bilaterally stiff and flared rib cage, or excessive lumbar lordosis are three common abnormal assessment findings that can potentially indicate the existence of thoracic system rigidity. Once identified, we prioritize and incorporate full exhalation, bilateral or unilateral reaching activities, and posterior pelvic tilting into our exercise programming to counteract the deleterious effects of limited thoracic system mobility. As our treatment and training philosophy continues to evolve, we strive to embrace and improve upon the principles and methods we currently employ to address thoracic system immobility as part of the greater plan of maximizing the on-field performance of our athletes.

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