

## Basic Principles of Extremity Joint Mobilization Using a Kaltenborn Approach

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**Context:** Knowledge and understanding of the principles and applications of joint-mobilization techniques are becoming commonplace for entry-level certified athletic trainers. **Data Sources:** Various textbooks written on this topic. **Data Synthesis:** The authors collected information from commonly used textbooks on joint mobilization in both athletic training and physical therapy curriculums. **Conclusion:** Undoubtedly, before using joint mobilization, the clinician should demonstrate mastery-level understanding of joint biomechanics, application principles, and indications and contra-indications. This article provides basic information on the principles of joint mobilization. **Key Words:** joint accessory motions, knee rehabilitation, shoulder rehabilitation

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According to the National Athletic Trainers' Association, as of December 1999, 21% of all certified athletic trainers (ATCs) are employed in the rehabilitation setting, working closely with a physical therapist. This information indicates an increase in the potential exposure of ATCs to people with significantly limited joint motion. Whether working in a clinical or academic setting, athletic trainers need to understand the variety of principles and techniques used to restore joint motion after injury. ATCs, like all health-care professionals, continually challenge themselves to learn new practices and techniques for enhancing patient outcomes. Joint mobilization is one such tool. Joint-mobilization techniques are a popular topic for ATC continuing-education programs. In addition, some athletic training curricula now include the basics of joint mobilization in the formal education of student athletic trainers.<sup>1</sup> Because some undergraduate athletic training curricula do not, however, we see a need to present this information to the growing population of ATCs. The joint-mobilization presentation in this article is a combination of efforts between athletic trainers and physical therapists. Our goal is to present this information in an understandable

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manner with unique and what we think are more understandable examples of how these techniques work.

We are not suggesting that ATCs should apply joint-mobilization techniques to each articulation in the body. Specifically, mobilization of the spine is beyond the skills and knowledge of entry-level ATCs. For ATCs who routinely treat shoulders, knees, and ankles, however, the skill of joint mobilization for extremities can be helpful in returning an injured athlete to a competitive level. Always remember, those who perform joint mobilization should be specifically trained in such techniques.

The purpose of this article is to initially review joint biomechanics, discuss joint-mobilization techniques, and suggest appropriate applications for joint mobilization by ATCs. We hope you will gain a better understanding of joint mobilization from the pictures representing the various techniques and the examples we provide in the narrative.

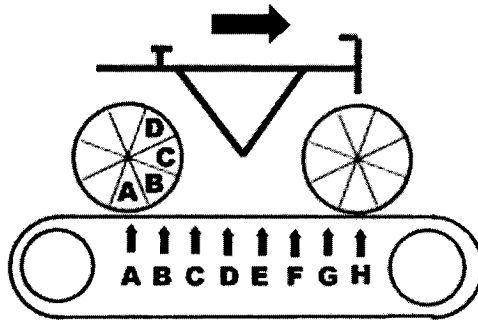
## Joint Biomechanics

Most authors separate joint biomechanics into 2 categories: osteokinematics and arthrokinematics.<sup>2</sup> *Osteokinematics* refers to the movements of the bones making up a limb.<sup>2</sup> This is typically assessed by range-of-motion (ROM) measurement. For example, *knee active ROM of 0–130°* refers to the osteokinematics of the knee joint. The term *arthrokinematics* refers to the movement of joint surfaces. For example, in open-chain knee extension, the tibial plateau moves on the femoral condyles.<sup>2</sup> Specifically, within a joint the opposite joint surface is used as the reference point for the described motion. These movements are sometimes referred to as accessory movements or joint play.<sup>2</sup> Arthrokinematics has an important role in overall joint movement, but because these movements occur between joint surfaces they are difficult to assess with standardized instruments such as a goniometer.

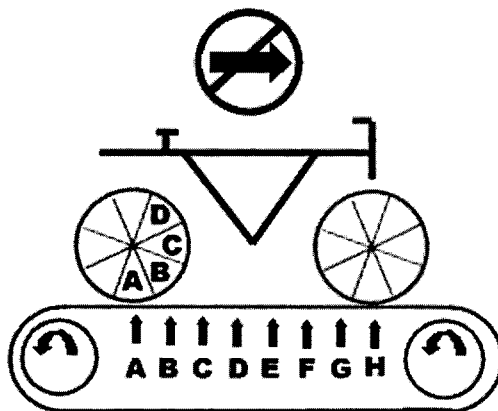
In well-functioning synovial joints, one of the surfaces is relatively fixed or stable while the other surface moves as the limb goes through a range of motion. During knee extension in a seated position, the knee moves from a flexed position to an extended position. In this example, the tibia moves on a relatively fixed femur. Regardless of the motion, the 2 joint surfaces must work in tandem to maintain the stability of the joint (eg, in the shoulder, reduce impingement, subluxation, and possibly dislocation). This is possible through the occurrence of short-range arthrokinematic or accessory movements. These accessory movements are more specifically known as “roll,” “slide” or “glide,” and “spin.” Following is a detailed discussion of each term to give a better understanding of the role of the accessory movements in maintaining joint stability.

To illustrate the accessory movements, an analogy of a bicycle being ridden on a treadmill will be used. Joint roll is similar to the relationship between the tire of the bicycle being ridden on a treadmill that is turned off and the treadmill base. Visualize each point on the bicycle tire passing over

a different point on the treadmill base (eg, point A on the tire passes point A on the treadmill, point B on point B, etc) as the bicycle moves along the treadmill (Figure 1). Imagine that the wheel of the bicycle corresponds to a condyle of an articular surface and the treadmill to an opposing joint surface such as a fossa. If the bicycle comes to the end of the treadmill and the tire continues to roll, the bicycle will run off the treadmill, much like the dislocation of a joint in the body if one surface rolls past the end of the opposite surface. To prevent the bicycle from running off the end of the treadmill, the belt can be started. In the human body the accessory movement of slide or glide is analogous to the moving belt and must take place to prevent joint dysfunction. With the treadmill now turned on, the bike can be maintained in a constant position on the treadmill (Figure 2). In this example, as the tire rotates, points A, B, C on the tire always pass over a fixed point, point A, on the treadmill base. The treadmill belt



**Figure 1** Bike moving along a stationary treadmill, demonstrating the accessory movement of “roll.”



**Figure 2** Bike rolling along a moving treadmill, demonstrating the accessory movement of “glide,” or “slide.”

provides a sliding surface that allows multiple points of the tire to pass a single point on the treadmill base. The combination of these 2 accessory movements is seen in the human body when the humerus interacts (rolls and slides) with the glenoid fossa during shoulder movement. Roll and glide must occur together for the joint to function properly. Without one or the other, the joint will have difficulty moving through the normal ROM. Understanding these 2 accessory movements promotes the application of joint-mobilization rules.

One of the most fundamental concepts or rules of joint mobilization is the “convex–concave rule” of synovial joints. Visualize the shoulder joint, head of the humerus, and the glenoid fossa. As the arm is abducted the head of the humerus rolls superiorly (point A is contacting point A, etc). If only rolling occurs, the head of the humerus will eventually impact the acromion. Therefore, at the same time that rolling is occurring the head of the humerus is also gliding inferiorly on the glenoid surface. The combined accessory movements of roll and glide allow the shoulder to fully abduct, thus maintaining the integrity of the joint. Generally, failure of the humerus to adequately glide inferiorly on the glenoid fossa results in a common shoulder dysfunction known as impingement. A convex surface such as the head of the humerus always glides in the opposite direction of the rolling movement.<sup>2,3</sup>

When a concave surface moves on a convex surface, roll and glide occur in the same direction.<sup>3</sup> This can perhaps be best explained by visualizing a person sitting on a table and extending his or her knee. The tibia is concave, and as it moves into extension, the tibial joint surfaces roll anteriorly, with glide occurring in the same direction over the convex surface of the distal end of the femur. If the sliding were to occur in the opposite direction, the tibia would slide off the femur posteriorly. This convex–concave rule can be applied to help understand the movements of the synovial joints in humans.

The third accessory movement is spin, which is a pure rotary motion.<sup>2,4</sup> A classic example of this movement is internal and external rotation of the humerus where the head of the humerus spins on the glenoid surface. In many movements of the human body, all 3 of these accessory motions occur simultaneously to maintain joint integrity.

## Mobilization Procedures

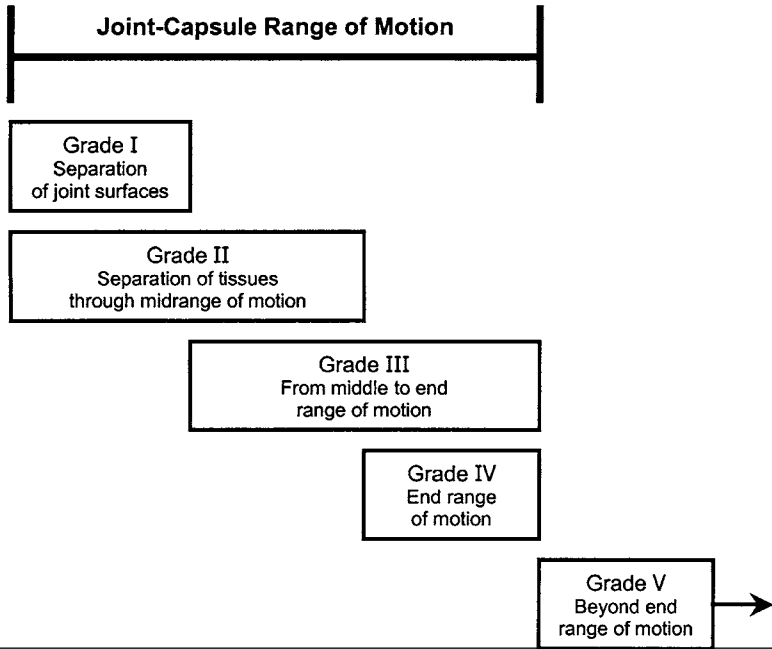
The most common use for joint mobilization is to treat hypomobility. Hypomobility of joint motion can result in decreased function or compensatory motions. Hypomobility generally refers to decreased capsular mobility. Each synovial joint is surrounded by a joint capsule, which maintains the integrity of the joint and contains the synovial fluid allowing for adequate lubrication of joint surfaces. If this capsule becomes taut, hypo-mobility results. In other words, a decrease in capsular mobility affects both arthrokinematics and

osteokinematics of the joint and is most evident by decreased ROM. For example, athletes with hypomobility who fail to reach normal ROM of the shoulder joint will compensate with shoulder “hiking” to achieve elevation to reach for an object above their head. Joint mobilization for hypomobility uses translatory gliding movements. Rolling motions are not used for mobilization because of the high potential for joint injury.<sup>4</sup>

To begin joint mobilization, the administrator needs to determine the appropriate plane of treatment. The treatment plane passes through the joint and lies at a right angle to the axis of rotation.<sup>4</sup> For clinical purposes, it is said to pass over the concave articular surface of the joint.<sup>4</sup> Therefore, a clear understanding of joint surfaces is paramount before any joint-mobilization technique is used. For example, if the moving arm of the limb to be mobilized has the concave surface, as with the tibia, the treatment plane moves with movement of the tibia. If the moving bone has a convex articular surface, such as the humerus, then the treatment plane stays over the glenoid fossa regardless of the position of the humerus. Joint mobilization occurs by moving the bone parallel to the treatment plane. One final point that must be addressed when discussing treatment-plane identification and joint-mobilization techniques is that the entire segment must be mobilized parallel to the treatment plane. For example, when mobilizing the tibia on the femur, the entire tibia is moved in the same direction. This approach removes the possibility of adding torque to the joint, resulting in potential injury to the athlete.

After treatment-plane identification, an understanding of joint position is also necessary to most appropriately perform joint-mobilization techniques. To maximize the assessment or function of these movements the joint should be placed in the “open-packed” position, in which the surfaces are free to move and the ligaments and capsule are relatively slack. The opposite position is termed “close-packed.” In this position the joint surfaces are in approximation and the ligaments and capsule are in a tightened state, providing maximum joint stability. Clearly, any mobilization technique should be performed cautiously, but any mobilization performed out of the open-packed position should be considered advanced and only be used with adequate training, supervision, and practice.

Synovial joints typically contain a normal amount of joint play. Joint play is the ability of the joint to exhibit some looseness or slack.<sup>4,5</sup> Depending on reference source, joint-mobilization techniques can be divided into 3 or 5 grades of movement. According to Kaltenborn,<sup>6</sup> grade I movements involve simply tractioning of the joint. Tractioning refers to the separation of joint surfaces in a perpendicular motion. In this case, there is just enough force applied to offset the compressive forces of the joint without an appreciable separation of the joint surfaces. Grade II mobilization involves tractioning combined with joint glides. The traction removes the joint play with separation, and glides are added in a direction parallel with the treatment plane. A grade III mobilization uses an increase in both traction force, to ensure



**Figure 3** Range of motion in which each grade of mobilization is applied.

complete tightness of the joint capsule, and the force of the glides.<sup>4</sup>

A more common method of grading mobilization techniques is with a 5-grade (I–V) classification system.<sup>7</sup> Grade I mobilization techniques merely involve a separation of joint surfaces and small-amplitude movement. Grade II mobilizations are large-amplitude movements that occur from the separation of the tissues through the middle of the range of available capsular motion. Grades I and II mobilizations are most often used for pain reduction.<sup>5</sup> Grade III mobilizations are also large-amplitude movements that occur from the middle of the range of capsular motion to the end of the available ROM. Grade IV mobilizations are small-amplitude movements at the end range of available capsular motion in which the clinician remains at the end range. Grades III and IV mobilizations are most often to be considered techniques that increase ROM.<sup>5</sup> Finally, grade V mobilizations involve a high-velocity thrust beyond the available end ROM. The grade V manipulation requires advanced training and experience beyond the initial manual-therapy training in joint mobilization. Figure 3 illustrates the grading of mobilization.

The following 2 lists are adapted from Bandy and Sanders.<sup>8,p68</sup> The first includes tips to help with mobilization technique:

- The athlete should be relaxed and not exhibit muscle guarding.
- The athletic trainer should be in proper position, ideally one that allows for maximal energy output for the entire treatment.

- The athletic trainer's grasp should be firm but painless.
- One bone should be stabilized (eg, via the table, wedge, belt, athletic trainer's hand) while the other bone is acted on with the athletic trainer's hand or belt.
- When mobilizing the extremities, a grade 1 traction force should be applied at all times.
- Both the stabilizing and the mobilization forces should be as close to the joint line as possible.
- Mobilization might cause discomfort resulting in muscle guarding; pain should be monitored and minimized during the treatment.
- Only 1 joint should be mobilized at a time.
- The athletic trainer should reexamine joint play after each treatment to determine the effectiveness of the treatment.

Following are general guidelines for dosage of mobilization treatments:

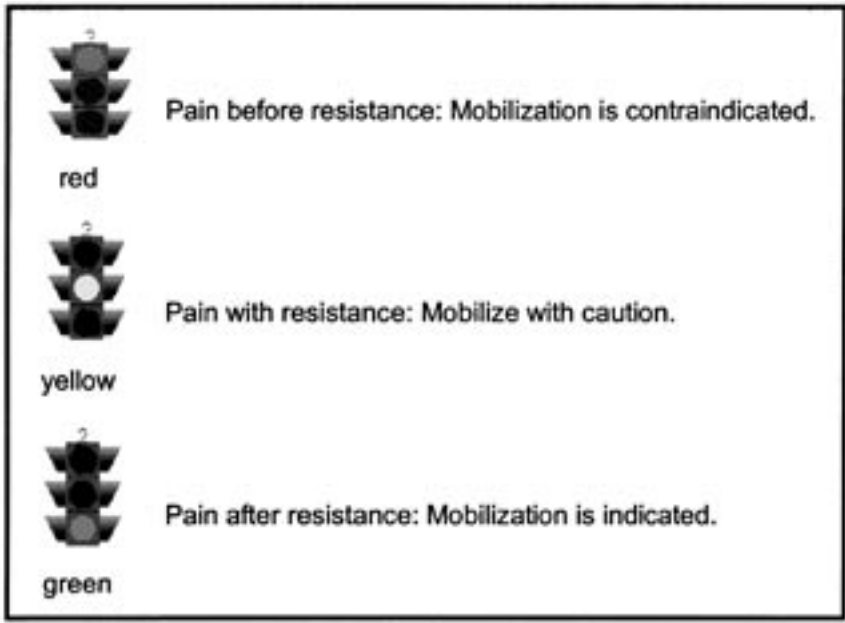
- Perform 2 to 3 oscillations per second.
- Apply a series of oscillations for 20 seconds or more.
- Use grades 1–3 often and learn to control the rhythm and smoothness of how they are applied.
- Grades 1–3 are important in improving ROM, as are grades 4–5.

In assessing hypomobility before a mobilization, it should be determined whether and when pain and resistance occur. Using a stoplight scenario, a red light means that no mobilization should be performed if the athlete reports pain before any resistance. A yellow light means that mobilization should be performed cautiously if pain and resistance are felt simultaneously. A green light means that mobilization is indicated if pain is felt after resistance (Figure 4).

Any mobilization procedure should be followed by therapeutic exercise. For example, if an increase in knee flexion is a goal, active ROM into knee flexion should follow the applied mobilization. Mobilization is extremely effective if the ROM gained is further used through active movements by the athlete.

## Examples of Joint-Mobilization Technique

Athletic trainers are often in need of specific techniques to restore normal mobility of the joints of the extremities. Two of the most common uses of joint mobilizations are for improving both knee extension and flexion after surgical procedures (eg, ACL reconstruction) and restoring normal glenohumeral mechanics in the shoulder after injury or surgery.



**Figure 4** Contraindications and indications for mobilization.

As a result of swelling after surgical procedures in the knee, an athlete will tend to maintain the knee in a slightly flexed position. The open-packed position of the tibiofemoral joint is  $25^\circ$  of flexion.<sup>4</sup> This position allows for the accommodation of joint swelling. Maintaining this position for a prolonged period of time might result in capsular tightening, thus hypo-mobility, and eventually a decreased ability to fully extend the knee. Full extension of the knee is necessary for functional movements (eg, gait). Therefore, to facilitate full knee motion, athletic trainers can employ joint-mobilization techniques to restore accessory movements.

### **Knee-Mobilization Techniques**

In the open chain, the tibia (concave) moves on the femur (convex). Therefore, applying the convex–concave rule discussed earlier, the tibia should be glided on the femur anteriorly to improve knee extension and posteriorly to improve knee flexion.

The first procedure is to place the joint in its open-packed position (for the knee,  $25^\circ$  of flexion). To mobilize the tibiofemoral joint posteriorly to increase knee flexion, the patient should be positioned long-sitting or supine. Stabilize the thigh segment with a belt or place a bolster under the thigh segment to aid stability. Hand placement is on the anterior surface of the tibia, and a posteriorly directed force is applied (Figure 5). Be cautious not

to add a rotary component to this movement. This mobilization should be a posteriorly directed force only. In performing this mobilization, if you are not providing a “pure gliding” movement, the accessory motion you are emphasizing loosens its effectiveness. First note the separation of the joint surfaces and feel for the end range of the tissue. Apply the appropriate grade of mobilization for the goal of your treatment.

A second mobilization technique for posterior-capsule restriction uses a position out of the open-packed position. With the athlete positioned in long-sitting, flex the restricted knee to less than 90°. The mobilizing hand is placed on the anterior proximal surface of the tibia, and a posteriorly directed force is applied (Figure 6).

One additional technique can be used to mobilize the posterior capsule for restrictions in knee flexion. With the athlete positioned at the edge of the table and knee flexed, apply distraction force by placing the athlete’s tibia between your knees. The distraction should be just enough to separate the joint surfaces. Next, with the mobilizing hand placed on the anterior proximal tibia, apply a posteriorly directed force (Figure 7).

If the tibiofemoral joint is limited in extension, an anterior glide should be applied. As with the posterior glide, first position the athlete. For this mobilization, the athlete should be prone with the knee in the resting or open-packed position. Stabilize the thigh on the posterior surface with the athlete’s leg resting on your thigh, then apply an anteriorly directed force. Ensure that the entire segment moves anteriorly and that you do not apply a rotational force (Figure 8).

Second, to increase terminal knee extension through mobilization of the tibia on the femur, the patient can be positioned in long-sitting. Place a towel roll under the distal femur. The mobilizing hand is placed on the



**Figure 5** Posterior glide of tibia on femur (open-packed position).



**Figure 6** Posterior glide of tibia on femur (for end-range restrictions in non-open-packed position).



**Figure 7** Posterior glide of tibia on femur using traction.

proximal posterior surface of the tibia, and an anteriorly directed force is applied (Figure 9).

Finally, a third approach to increasing terminal knee extension is through mobilization of the femur on the tibia. In a closed-chain position (eg, weight bearing), the femur moves on the tibia. Therefore, this technique is often used to gain the final few degrees of terminal extension.<sup>4</sup> Position the athlete supine, stabilize the tibia, and apply a posteriorly directed force to the femur. Although the desired movement is extension, the femur must be mobilized posteriorly because it is a convex surface moving on a concave surface (Figure 10).

## **Glenohumeral Mobilization Techniques**



**Figure 8** Anterior glide of tibia on femur with athlete in prone position.



**Figure 9** Anterior glide of tibia on femur with athlete in supine position.



**Figure 10** Posterior glide of femur on tibia.

Movement at the shoulder involves movement at the scapulothoracic, acromioclavicular, sternoclavicular, and glenohumeral joints. The arthro-kinematics of all 4 joints must be smooth to allow for quality shoulder motions in all directions. The scope of this article is not to address all components of shoulder arthrokinematics but rather to introduce the athletic trainer to joint-mobilization techniques. Therefore, this section focuses on the mobilization techniques most commonly used with the glenohumeral joint (eg, distraction with posterior and inferior glides).

The glenohumeral joint is a ball-and-socket joint with a convex humerus articulating with the concave glenoid fossa. Therefore, with flexion of the glenohumeral joint, the humerus glides inferiorly on the glenoid fossa. To perform an inferior glide of the humerus on the glenoid, the glenohumeral joint is placed in its open or resting position.

With the athlete supine, grasp the humeral head proximally with both hands. The table assists in this technique by stabilizing the scapula. Rest the athlete's distal humerus on the shoulder closest to you. Apply your hands to the proximal humeral head and apply a slight lateral force to separate the joint surfaces. Next, apply a caudally directed force under the parameters of the grade of mobilization desired (Figure 11).

A subsequent technique for inferior glide can be used if you are unable to grasp the proximal humeral head because of increased shoulder mus-



**Figure 11** Inferior glide of humerus on glenoid with lateral traction.

culature. For this technique, you can flex the glenohumeral joint slightly more than in the previously described technique. Grasping the proximal humerus with the athlete's elbow bent allows you to more easily mobilize a large extremity (Figure 12).

Last, a technique that is very commonly used for capsular restrictions near end ROM places the humerus out of the open-packed position. For this technique, position the glenohumeral joint in slight abduction. Standing superiorly to the shoulder, place the mobilizing hand on the proximal humerus and apply an inferiorly directed force (Figure 13).

Because the glenohumeral joint follows the mobilization convex-concave rule, limitations in internal rotation require a posterior mobilization tech-



**Figure 12** Inferior glide of humerus on glenoid with lateral traction (alternative position).



**Figure 13** Inferior glide of humerus on glenoid in non-open-packed position for capsular restriction near end range of motion.

nique. This technique is also indicated if the patient has signs of shoulder impingement. At times the posterior capsule is tight, resulting in a slight shift of the glenohumeral joint to a more anterior orientation. Therefore, if the posterior capsule is mobilized, the humerus has an improved resting position within the glenoid fossa. The athlete is positioned supine with the shoulder at edge of mat. Place the shoulder in slight abduction. Stand between the athlete's abducted arm and trunk and place the arm between your elbow and side farthest from the patient. Use the hand closest to the patient to apply the mobilizing force. Place a towel or foam pad under your hand to prevent pressure on the anterior surface of humerus. Using an extended elbow posture, generate your mobilizing force by leaning over



**Figure 14** Posterior glide of humerus on glenoid.



**Figure 15** Posterior glide of humerus on glenoid with padding to protect shoulder structures.



**Figure 16** Distraction of the glenohumeral joint.

the straight arm. The amount of force used is dictated by the parameters of the grade of mobilization desired (Figures 14 and 15).

If numerous joint mobilizations are necessary, the shoulder-distraction technique is a good choice. Distraction helps relax muscle spasms and decrease pain. With the athlete supine, stabilize the scapula by placing one hand on the axilla, grasp the humerus, and apply a distraction force to separate the joint space (Figure 16).

## Summary

The premise of this article is that ATCs possess the basic skills needed to perform joint mobilizations to articulations typically involved in athletic injuries. Paramount to use of these techniques is a thorough understanding of anatomy, the healing and rehabilitation process, joint biomechanics (osteokinematics and arthrokinematics), mobilization techniques, and the rehabilitation process. An extended period of hands-on experience under a well-trained supervisor is extremely valuable and highly recommended in learning the art of joint mobilization. The skill of the person applying the mobilizations will definitely affect the results of the treatment. Obviously, the better the technique the greater the result for the athlete. As with any technique in any setting, one of the key principles is to know one's limitations and work within them. To reduce your limitations in the area of joint mobilization you must continually practice and learn.

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