Strength and Conditioning Techniques in the Rehabilitation of Sports Injury

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KEYWORDS

• Strength • Conditioning • Power • Flexibility
• Sports performance • Coach • Fitness

The role of strength and conditioning coaches is to use current best practices to design exercise programs for athletes to assist them in developing their bodies to resist injury, enhance performance, and compliment the needs of the sport head coach. Additionally, strength and conditioning coaches must develop an open, consistent dialog with the sports medicine staff to aid in the rehabilitation of injured athletes and to collaborate in designing programs to prevent new injures.[1]

As an integral part of an athlete's sports performance team, strength and conditioning coaches are responsible for regular communication with the physicians, physical therapists, athletic trainers, and sport head coach.[1] It is through this constant dialog that strength and conditioning coaches formulate an athlete's training program. If a strength and conditioning coach lacks current information from any member of a sports performance team in regards to an athlete's health status, that program will more than likely be only marginally effective and potentially damaging to the athlete's health and performance. Cross-discipline communication and collaboration are a must for all parties in the sports performance team.

Most often, because of schedule conflicts and logistics, strength and conditioning coaches do not have face-to-face communication with physicians involving an athlete's care. It is a good idea, when applicable, however, that physicians and strength and conditioning coaches meet and exchange dialog pertaining to an athlete's health. In the absence of this communication, the proper channel for this information is for it to be passed down through the performance team via the athletic trainers. Therefore, it is imperative that athletic trainers and strength and conditioning coaches have a daily vehicle of communication regarding athlete health status (ie, face-to-face meeting, daily injury status report, or daily phone call).

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HOW CAN A PHYSICIAN ASSIST THE STRENGTH AND CONDITIONING COACH?

The most important common ground for the performance team members is the athletes whom they serve. With this understanding, strength and conditioning coaches should make a special effort to work up the performance team chain to reach the medical doctors and establish an open relationship of trust and camaraderie. With an open channel of communication between the physician and the strength and conditioning coach, everyone on a sports performance team can have a dialog and a vested interest in athletes' total health status. Conversely, the doors to the weight room and any strength and conditioning venues should be open to any and all members of a sports performance team, and all means of training should be open for discussion between team members. Through mutual respect and open discussion, a sports performance team becomes a better-educated and more stable unit, ultimately leading to a stronger service for athletes' betterment.

STRENGTH AND CONDITIONING PERFORMANCE PRINCIPLES

Scientific research has confirmed that the following principles, when used synergistically, stimulate ability to achieve peak athletic performance.

Progressive Overload

The load or amount of weight lifted for each exercise is the most fundamental component of a strength and power training program.[2,3] The application of load has a crucial impact on the specific development of certain neuromuscular qualities. When muscles are stressed to a level beyond their normal training capacity, overload occurs. This overload causes the active muscles to fatigue to a point of breakdown or catabolism. The body then responds, with the aid of proper nutrition and rest, by building up the affected muscles (anabolism).[4]

It is this building up or anabolic phase that develops new strength, power, size, and endurance within the muscles.[4]

Intensity and volume are the key factors that can be manipulated to progressively control the overload of the neuromuscular system. By increasing the load, intensity is increased, and by increasing repetitions, volume is increased. Each of these methods brings about specific adaptations. Lifting heavy loads for low repetitions develops muscular strength; lifting varied loads explosively develops power; and lifting lighter loads for high repetitions develops muscular endurance.[2,3,5]

Periodization Application

Strength and power eventually plateau and even diminish if the same combinations of sets and repetitions are followed. The way to avoid this is by applying periodization or cycling to training plans. Cycling uses different combinations of volume and intensity, or phases, each translating into different responses by the body. Traditionally, a cycle begins with a base phase and progresses to a strength phase, finishing with a peak phase.[2,3,5]

Split Routine

Whether or not 2, 3, or 4 days per week workout is prescribed, a split routine should be implemented. A split routine means alternating the type of exercises performed or body parts trained on alternate days. An example is performing explosive lifts on Mondays and Thursdays and slower strength lifts on Tuesdays and Fridays. Another example of a split routine is training chest, shoulders, and triceps on Mondays and Thursdays and legs, back, and biceps on Tuesdays and Fridays. The benefits of using

a split routine are allowing for greater recovery between workout and greater specialization or specificity.[2,3,5]

Heavy–lighter System

More progress can be made over longer periods of time if maximum loads are not work at during each workout. The heavy–lighter system eliminates overtraining and mental burnout. With it, there is only one maximum workout per week for each type of lifting or body part. The second day is a lighter workout, in which the volume or intensity is reduced. With only one heavy workout a week for the explosive exercises and one for the strength exercises, readiness for physical and mental demands improve. Generally the first workouts of the week are the most challenging days (the body is less fatigued after a weekend of rest), and the last workouts are the lighter.[2,3,5]

Specific Energy System Training

The primary objective of conditioning is to improve the energy capacity of athletes to improve performance. For effective conditioning, training must occur at the same intensity and duration as those at which an athlete competes to develop the proper energy system predominately used (training specificity).

ATP is the immediate energy source for all muscle contractions. It comes from the breakdown of food. It is supplied by the interaction of three types of energy systems. The first system is the ATP-phosphocreatine (PC) system. High-intensity, short-duration activities, such as the 40-yard dash or push press, are performed using energy from this system. Energy is supplied immediately, and the amount of force generated from the muscle contraction is high, but the amount of energy readily available is limited and ATP is depleted within approximately 6 to 10 seconds (**Table 1**).

The second energy system is the lactic acid system (glycolysis). The amount of force generated by this system is less than from the ATP-PC system. This system has two phases. During the first phase, ATP is produced from the breakdown of glycogen in the absence of oxygen and a metabolic by-product called lactic acid is produced. The highest accumulation of lactic acid is reached during activities that last from 1 to 3 minutes. Too much lactic acid builds up when the energy system is depleted. This causes pain, which results in a loss of coordination and force production, as often happens at the end of a 400- or 800-m run.

The third system is the aerobic system. This system is more specific to the slow-twitch muscle fibers used during activities requiring endurance over a long duration at a low intensity. After approximately 3 minutes of low-intensity exercise, ATP is almost completely supplied from the aerobic system.

The system ATP is supplied from depends on the intensity and duration of the exercise. The first step used in setting up a conditioning program is to determine the energy system used by the activity according to the intensity and duration of it.

Table 1
Effect of event duration on primary energy systems used

Duration of Event	Intensity of Event	Primary Energy Systems
0–6 s	Very intense	Phosphagen
6–30 s	Intense	Phosphagen and anaerobic glycolysis
30 s–2 min	Heavy	Anaerobic glycolysis
2–3 min	Moderate	Anaerobic glycolysis and oxidative system
>3 min	Light	Oxidative system

Then a similar type of activity is used for conditioning. That way the proper energy system is trained. Different sports use different energy systems and, therefore, require different metabolic demands (**Table 2**).[2,3,5]

Multiple Joint Actions

In order to optimally develop athleticism, strength and conditioning programs are based on exercises and drills involving multiple joint actions. Sport skills, such as jumping, running, or taking on an opponent, require multiple joint actions timed in the proper neuromuscular recruitment patterns.

An example of this multiple joint action is the execution of the hang clean. It requires joint actions at the hips, knees, ankles, shoulders, elbows, and wrists working together as a unit, generating explosive force. Isolating a single joint action might work for body building to target a single muscle, but athletes need to concentrate on activities involving multiple joint actions to improve functional strength and performance.[2,3,5]

Ground-based Exercises

The majority of sport skills are initiated by applying force with the foot against the ground. When possible, lifting exercises and conditioning drills are selected that apply force with the feet against the ground, such as squats, dead lifts, lunges, hang cleans, push presses, or plyometrics. The more force athletes apply against the ground, the faster they run, the higher they jump, and the more effective they are in sport skills.[2,5]

Table 2
Primary metabolic demands of various sports

Sport	Phosphagen System	Anaerobic Glycolysis	Aerobic Metabolism
Archery	High	Low	—
Baseball	High	Low	—
Basketball	High	Moderate to high	Low
Diving	High	Low	—
Fencing	High	Moderate	—
Field events	High	—	—
Field hockey	High	Moderate	Moderate
Football	High	Moderate	Low
Gymnastics	High	Moderate	—
Ice hockey	High	Moderate	Moderate
Lacrosse	High	Moderate	Moderate
Softball	High	Low	—
Soccer	High	Moderate	High
Swimming, sprint	High	Moderate	—
Swimming, distance	High	Moderate to high	Moderate to high
Tennis	High	Low	—
Track, sprint	High	Moderate to high	—
Track, distance	—	Moderate	High
Volleyball	High	Moderate	—

Explosive Movements

Not only are strength gains determined by the size of the muscles but also many times an athlete gets stronger because of an improved ability of the nervous system to recruit motor units. A motor unit is a motor nerve and all the muscle fibers that it innervates. The more fibers a motor unit consists of, the more force it can generate. Through heavy training ($\geq$80% of maximum) and explosive training, the body learns to recruit more motor units so that more force can be generated.

The amount of force required for a given activity is regulated by the use of two different types of motor units found in the body, fast twitch and slow twitch, which differ in their ability to generate force. The number of fibers a fast-twitch motor unit innervates is greater than that of a slow twitch, and the contractile mechanism of fast-twitch muscle fiber is much larger. These factors combined mean a fast-twitch fiber generates a force 4 times greater than a slow-twitch fiber. Heavy or explosive training allows more fast-twitch muscle fibers to be recruited and in return improves an athlete's performance potential. The aims of anaerobic versus aerobic training differ[2,5] (**Boxes 1** and **2**).

3-D Movement

Sport skills involve movements in the three planes of space simultaneously: forward-backward, up-down, and side-to-side. Strength and conditioning programs improve functional strength and power with exercises and drills approximating these 3-D skills.

In strength and power training, only free weights allow movement in three dimensions simultaneously. This makes the transfer of strength and power easier to merge with the development of sport skills. Machines limit the development of sport skills. For example, when free weights are used, the muscles regulate and coordinate the movement pattern of the resistance, whereas machines use lever arms, guide rods, and pulleys to dictate the path of the movement. An additional benefit of free weights is their ability to help prevent major joint injuries. The smaller synergistic muscle groups involved in free weight exercises develop joint integrity better than machines do due to the balancing action required with free weights. For example, squatting using free weights requires the back and abdominal muscles to stabilize the torso isometrically. This allows the legs and hips to work with the back and abdominals as a unit to perform the lift. In contrast the adjustable seat back on the hip sled or leg press substitutes as the back and abdominal stabilizers restricting movement and isolating muscle contractions to the hips and legs.

When developing a running program, explosive footwork and agility drills similar to specific sport movements are used. It is important for athletes to be quick and to possess breakaway speed, but they must be able to control their bodies and execute change of direction quickly on the field or court to be effective.[2,5]

Box 1
Aims of anaerobic training

To develop speed and power

To develop your anaerobic threshold—the ability to repeatedly perform high-intensity work

To decrease recovery time

Quicker removal of lactate from muscles

Prolong the onset of fatigue

Box 2
Aims of aerobic training

To increase oxygen uptake

To increase the muscle's ability to use oxygen

To increase the body's endurance base

To decrease recovery time

Interval Training

Conditioning programs can be based on interval training principles. Interval training is work or exercise followed by a prescribed rest interval. Programs should be designed to meet the specific conditions of each sport. Interval training stresses not only the work phase but also the recovery phase between work intervals. If a rest period is too short, the amount of energy is not sufficient to meet the demands of the next maximum intensity effort, and force output is reduced. The higher the exercise intensity, the longer the recovery phase should be in relation to work time.[2,5]

STRENGTH AND CONDITIONING TRAINING PHILOSOPHY

Athletics are an integral part of any school's overall educational program, but academics come first. A scholastic or collegiate strength and conditioning program should include these policies:

- Athletes are never asked or expected to participate in a strength and conditioning activity in conflict with their academic obligations.
- The welfare and safety of the athletes is paramount and always takes precedence when they are asked to perform an activity.
- Athletes are never asked or allowed to perform a strength activity that the strength and conditioning staff thinks is beyond their capacity to safely execute.

Athletes competing at a high level are expected to produce performances of elite magnitude to be competitive. In order to prepare athletes to compete at this elite level, training must be intense and physically demanding. The strength and conditioning staff encourage and coach athletes to work at their maximum capabilities and, although all precautions are taken to safeguard against injuries, realistically, injuries are not avoidable.

The strength and conditioning staff are motivators and educators; they lead by guiding rather than ruling. Simple principles that can be adhered to in an effort to guide athletes include

- Athletes need feedback to improve their performance. Strength and conditioning coaches should project positive influence and feedback with the power of attitude and example. They should not berate or denigrate athletes to get a point across. Strength and conditioning coaches should follow a simple, direct approach and concisely and clearly explain the principle-based reasons for everything they do.
- Strength and conditioning coaches should inform athletes as to what is expected of them and reward those who achieve these expectations.
- Strength and conditioning coaches should constantly strive to be creative and innovative in all their endeavors. All staff should be encouraged to bring forth new and better ideas for improving performance, whatever their responsibilities.

- Strength and conditioning coaches should be partners with all those on a sports performance team, working together in the pursuit of the same mission and strategy.[1] They should strongly value team work and want every staff member to be motivated to succeed.
- Strength and conditioning coaches should value integrity. Underscoring all their professional life - their professional image, both on the job and in the community. Every activity must be able to pass the test of public and internal scrutiny at all times. A sports performance program should demand openness and honesty throughout its operations to engender trust and integrity.

A quality strength and conditioning program should be based on the principles of exercise science: kinesiology, exercise physiology and biomechanics, and direct proved experience.[2] Additional considerations include, but are not limited to, the following:

- Do not train athletes to become bodybuilders, power lifters, or Olympics-style weightlifters; rather, train athletes to become better athletes. Train athletes to develop the components of athleticism: strength, power, flexibility, speed, agility, footwork, endurance, metabolic condition, body composition, mental focus, and motivation.
- Utilize the principle of specificity, and, therefore, use free weight training as much as possible. Free weights allow athletes to move athletically and not in a fixed motion pattern, unlike most machines. Train movements and thereby train the muscles that produce these movements, but, realistically, certain movements are not ideally trainable with free weights, in which case, use specific machines.
- Utilize explosive power training (plyometrics, power shrugs, power cleans, push presses, jerks, and power squats). Athletes with great power and explosiveness, for the most part, dominate athletics. If all other factors are equal, an athlete with the greatest power and explosiveness dominates his opponent. Follow a sequential progression to maximize safety and optimize success for all explosive power movements.

DYNAMIC FLEXIBILITY AND MOBILITY

A proper workout should have a prescribed warm-up. A 3-minute total body warm-up (ie, jogging, rope jumping, and total body movement) should always precede a dynamic flexibility series. The warm-up raises the body temperature, increases blood flow to the muscles, and lubricates the joints.[2,6] Always remember warm-up to stretch, do not stretch to warm-up. Dynamic movements are one of the best ways to prepare the body for dynamic workouts. Contrary to old beliefs, the best time to work on static flexibility is at the end of a workout, not in the beginning. After every workout, an athlete should follow a 4- to 6-minute total body static stretching series. An example of a standard dynamic flexibility series is described.[2,6]

Walking High Knees

Purpose: to flex the hips and shoulders and stretch the gluteus, quadriceps, lower back, and shoulders (**Fig. 1**).

Procedure

1. Take an exaggerated high step, driving the knee as high as possible simultaneously pushing up on the toes of the opposite foot.
2. Use the proper arm swing: 90° angle at the elbows, hands swing up to chin level and back beyond rear pocket.

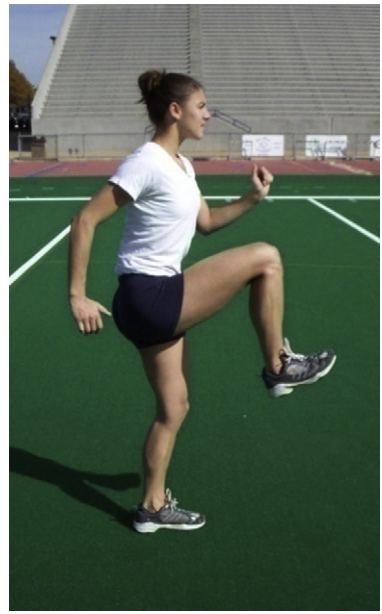

Fig. 1. Walking high knees. (*Photo taken by* Greg Werner. Athlete: Carla Gessler.)

Key point: drive the knees up as high as possible.
Variation: high knees pull; walking high knees as described previously but grab the knee and pull it up and in with each stride.

Walking Lunge

Purpose: to stretch the gluteus, hamstrings, hip flexors, and calves (**Fig. 2**).

Procedure
1. Step out with a long stride, striking the heel of the forward foot and extending onto the toes of the back foot.

Fig. 2. Walking lunge. (*Photo taken by* Greg Werner. Athlete: Carla Gessler.)

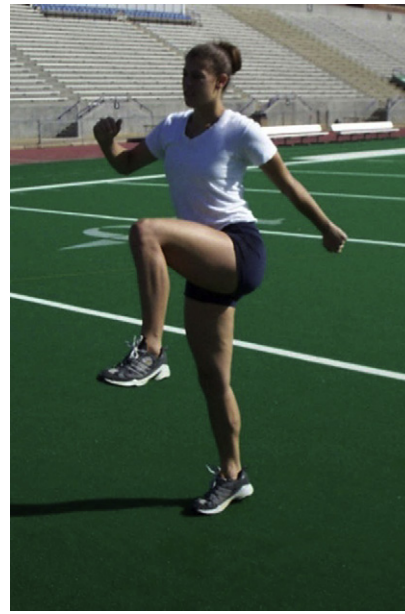

Fig. 3. Walking high knee lunge. (*Photo taken by* Greg Werner. Athlete: Carla Gessler.)

2. Complete the cycle by bringing the trail leg through and standing upright.
   Key points
   1. Position hands behind head while keeping eyes focused forward.
   2. Flex front knee to 90° and keep back knee from striking the ground.

Fig. 4. Walking straight leg kicks. (*Photo taken by* Greg Werner. Athlete: Carla Gessler.)

Walking High Knee Lunge

Purpose: to stretch the gluteus, hamstrings, hip flexors, and calves (**Fig. 3**).

Procedure
1. Drive the forward knee up as high as possible and then step out with a long stride striking the heel of the forward foot and extending onto the toes of the back foot.
2. Complete the cycle by bringing the trail leg through and standing upright.

Key points
1. This drill is performed identically to the walking lunge, with the exception of the high knee action.
2. Position hands behind head with eyes focused forward.
3. Flex front knee to 90° and keep back knee from striking the ground.

Walking Straight Leg Kicks

Purpose: to stretch the hamstrings, calves, and lower back (**Fig. 4**).

Procedure
1. Walk forward keeping front leg straight.

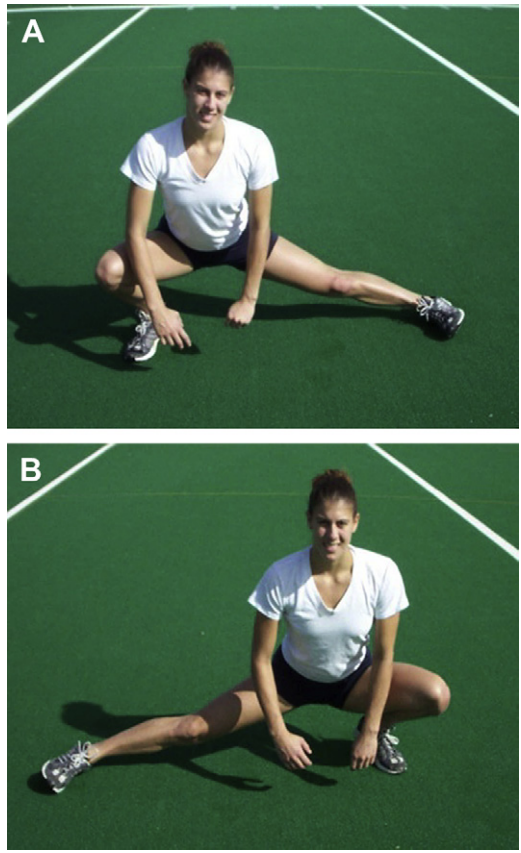

Fig. 5. Walking side lunge, over (*A*) and back (*B*). (*Photo taken by* Greg Werner. Athlete: Carla Gessler.)

2. Kick leg up and touch toes to the fingers of opposite hand.
3. Repeat the cycle with opposite leg.

Key points

1. Keep arm extended out parallel with the ground.
2. On first set of this drill, only kick to 75% capacity; then on second set, kick to full capacity.

Walking Side Lunge, Over and Back

Purpose: to stretch the groin, gluteus, hamstrings, and ankles (**Fig. 5**).

Procedure

1. Keep torso upright and take a long stride out to the side.
2. Lunge out bending forward knee to 90° while keeping trail leg straight.
3. Lower hips and shift body weight to the opposite leg.
4. Recover by bringing the feet together and standing upright.

Key points

1. Repeat the drill for 10 yards.
2. Keep head focused forward with arms hanging down in front of body.

Running Butt Kicks, 20 Repetitions

Purpose: to stretch the quadriceps and hip flexors (**Fig. 6**).

Procedure

1. Begin running by flexing knee and bringing heel back and around to buttocks.
2. Maintain a slight forward lean throughout the drill and stay on the balls of the feet.
3. Complete 20 kicks within 10 yards.

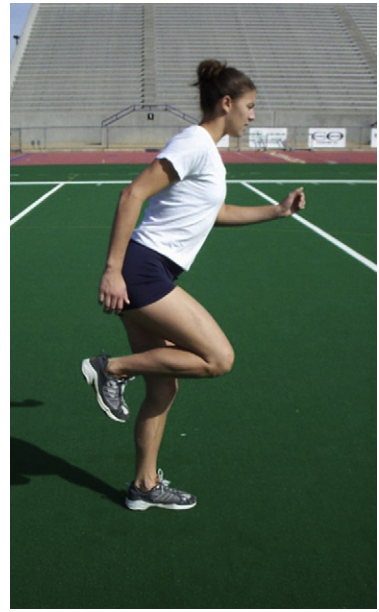

Fig. 6. Running knees forward butt kicks. (*Photo taken by* Greg Werner. Athlete: Carla Gessler.)

Key points
1. Maintain a quick yet shallow arm swing, keep elbows at 90°, and drive hands from chest to front hip pocket.

Running High Knees, 20 Repetitions

Purpose: to stretch the gluteus, quadriceps, low back, and shoulders (**Fig. 7**).

Procedure
1. Execute proper running form; keep elbows at 90° and drive hands up to chin level and back to rear pocket.
2. Stay on the balls of the feet and drive knees up as high as possible, then down as quickly as possible.

Running Carioca

Purpose: to stretch the abductors, adductors, gluteus, ankles, and hips (**Fig. 8**).

Procedure
1. Stay on the balls of the feet with hips in a low semisquat position.
2. Begin the drill by twisting hips and crossing one leg in front of the other, bring trail leg through, and cross lead leg behind the trail leg.
3. Shoulders remain square through the entire drill.

Back Pedal

Purpose: to stretch the hip flexors, quadriceps, and calves.

Procedure
1. Keeping hips and knees bent with shoulders positioned over the balls of the feet.
2. For the first 10 yards, use short choppy steps.
3. For the second 10 yards, open up stride and kick back.

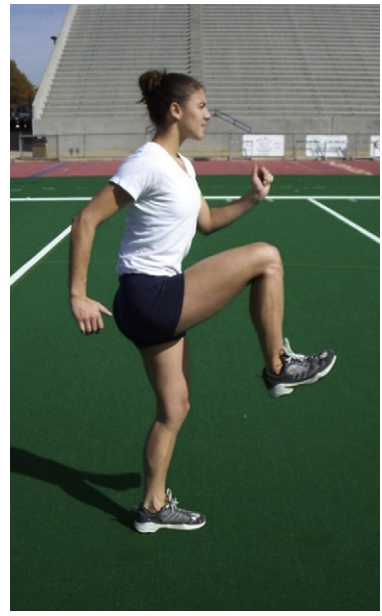

Fig. 7. Running high knees. (*Photo taken by* Greg Werner. Athlete: Carla Gessler.)

Fig. 8. Running carioca. (*Photo taken by* Greg Werner. Athlete: Carla Gessler.)

Lying Scorpion

Purpose: to stretch the hip flexors, abdominals, quadriceps, and shoulders (**Fig. 9**).

Procedure
1. Lie down in a prone position.
2. While keeping the chest in contact with the ground, cross one leg behind the other to the opposite side of body.

This drill should be done in a continuous manner.

Fig. 9. Lying scorpion. (*Photo taken by* Greg Werner. Athlete: Carla Gessler.)

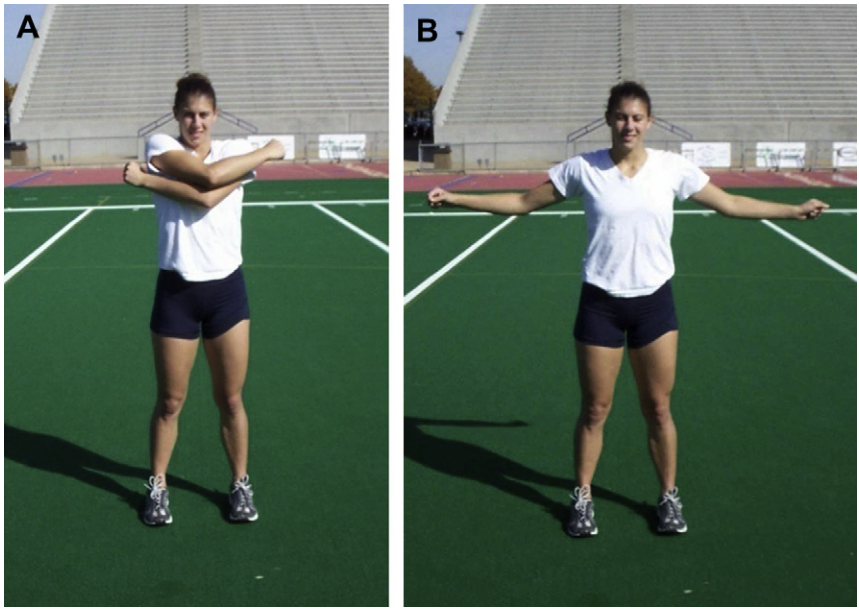

Fig. 10. Arm swings, forward (*A*) and back (*B*). (*Photo taken by* Greg Werner. Athlete: Carla Gessler.)

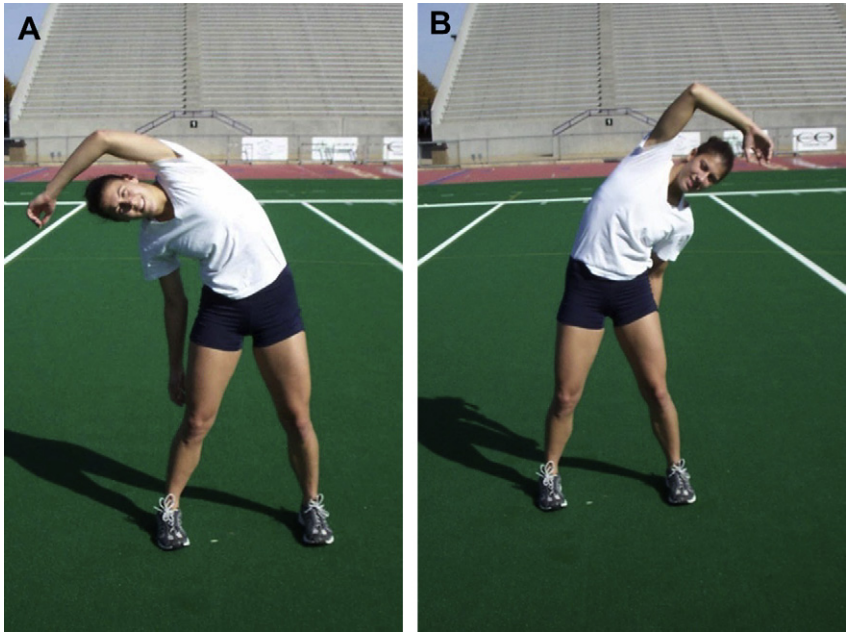

Fig. 11. Side bend, over (*A*) and back (*B*). (*Photo taken by* Greg Werner. Athlete: Carla Gessler.)

Arm Swings, Forward and Back

Purpose: to stretch the chest, shoulders, and upper back (**Fig. 10**).

Procedure
1. Swing arms forward, so they cross, and swing them back as far as possible.
2. This drill should be done in a controlled continuous fashion for 10 repetitions.

Side Bend, Over and Back

Purpose: to stretch the triceps, upper back, abdominals, and obliques (**Fig. 11**).

Procedure
1. Bend to one side while holding opposite arm overhead; quickly reverse direction and stretch the other side.
2. This drill should be done in a controlled continuous fashion for 10 stretches on each side of the body.

Power Skip

Purpose: to further prepare the body for full speed action.

Procedure: the power skip is executed by doing an explosive, exaggerated skip while emphasizing height rather than distance. Emphasize a big arm swing and explosive knee lift.

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