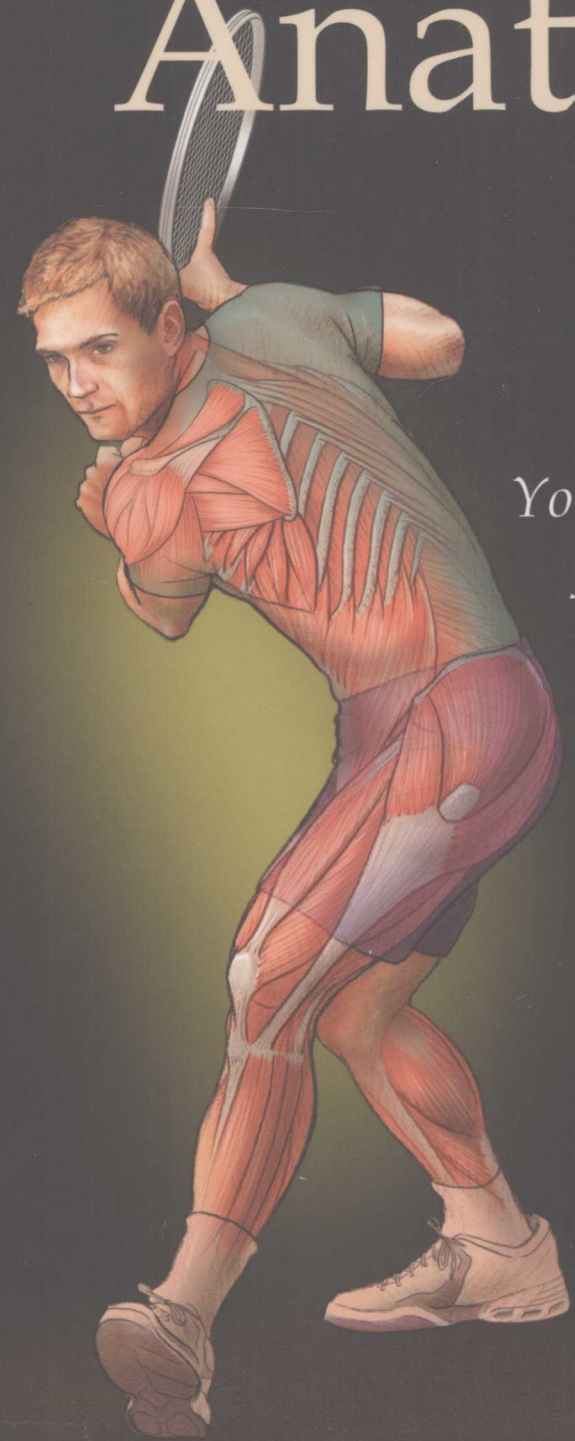
TENNIS Anatomy



Your illustrated guide for tennis strength, speed, power, and agility

E. PAUL ROETERT • MARK S. KOVACS

TENNIS ANATOMY

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Human Kinetics

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PREFACE

This book is written for serious competitive and recreational tennis players. Many tennis books emphasize fitness or strength and conditioning. *Tennis Anatomy* takes the next step and focuses on why and how you should get fit to play tennis. In this book, we highlight the different muscle groups involved in each of the strokes and show you how to best train those specific muscle groups as part of a comprehensive approach to tennis-specific training.

With the support of the United States Tennis Association (USTA), we provide the most up-to-date, relevant information on tennis conditioning available. As the national governing body of tennis in the United States, the USTA has a responsibility to grow and develop the sport. Through its player development program, the USTA shares the latest training techniques with competitive players in the United States. That mission encouraged us to take on this project and provide you with these training methods based on the anatomy of tennis.

Tennis was once considered a sport that could be played by people from age 8 to 80, but that range has expanded because of new training methods. The USTA offers 10 and Under Tennis for players age 10 and younger, who learn the sport while using modified equipment. In addition, national-level tournaments are offered for players age 90 and over. This shows the tremendous health, fitness, coordination, and psychological benefits that can be derived from the sport. Clearly, being a well-conditioned tennis player can assist in a long tennis career.

Of course the number of years someone can play is only one aspect of enjoying the game. The quality of play also is greatly enhanced by good training and conditioning. That is the true focus of this book. Whether you are getting in shape for league play, trying out for a high school or college team, or wanting to perform at a higher level in tournaments, this book provides you with up-to-date, practical training information based on the latest research available.

The first chapter provides an in-depth overview of the demands of the sport, the relationship of court surfaces and playing styles, the anatomy of each of the tennis strokes, and the physiological considerations of designing a training program. Chapters 2 through 7 systematically explain the role of each major body part in tennis play, focusing on muscle anatomy and its relationship to the strokes and providing specific exercises. Each exercise includes a tennis focus section that highlights how the exercise directly translates to improved on-court stroke performance or movement. Chapters 8 through 10 follow a similar format but highlight the importance of body rotation, movement skills, and injury prevention, respectively. The anatomical illustrations that accompany the exercises are color coded to indicate the primary and secondary muscles featured in each exercise and movement.

You will enjoy and benefit from this information. Challenge yourself to learn more about the anatomy of your body as well as the tennis strokes, and improve your game by adding tennis-specific conditioning methods to your training. By incorporating these training techniques, you will surely be able to take your game to the next level.

ACKNOWLEDGMENTS

This book would not have been possible without the dedication, coaching, and support we have received over the years from the many sport science and medicine experts that have crossed our paths. All of our thoughts and ideas have been shaped by these dedicated people through courses, individual meetings, publications, and conferences. We cannot begin to name all of them, but we are truly indebted to them.

Another group of people instrumental in our lives is the many coaches and tennis teaching professionals who have taught us and helped us in the areas of player training as well as coaching education.

Human Kinetics came up with the idea and pursued our interest, and the United States Tennis Association (USTA) allowed us to take on this project. We very much appreciate the opportunity both organizations provided us. The Boca West Country Club made their tennis courts and fitness facilities available to us, for which we are very grateful.

Finally, we would like to thank our families, particularly Paul's wife, Barbara, and Mark's wife, Mary Jo, for their support and encouragement.

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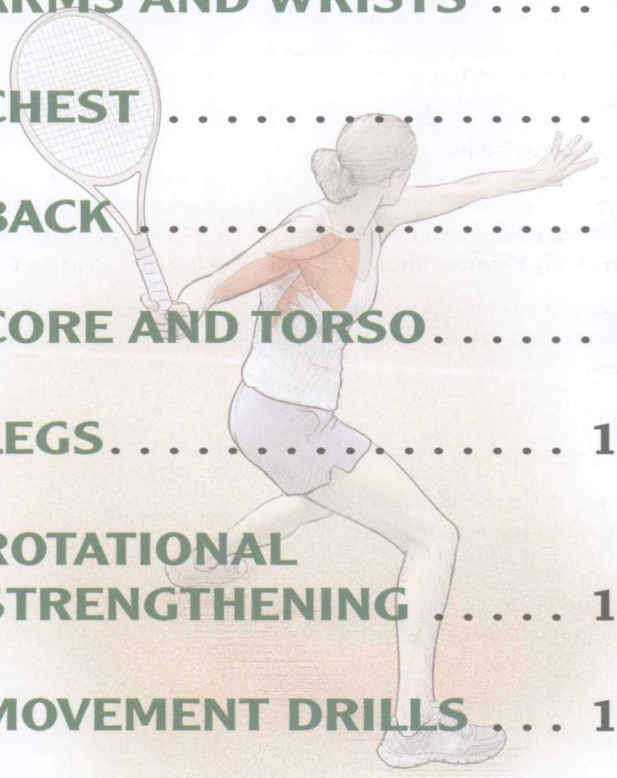

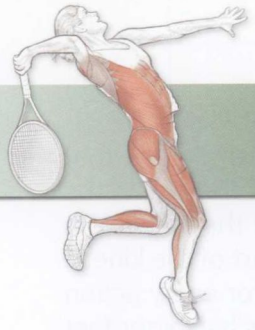

CHAPTER 1

THE TENNIS PLAYER IN MOTION

Elite tennis players make it look so easy and effortless. By comparison, your movement skills, strokes, and fitness may leave something to be desired. Good coaches can help you improve technique and fitness, but keep in mind that there are many individual differences, even at the professional level. You can see that Roger Federer and Rafael Nadal don't play exactly the same way. They do have in common a desire to perfect their skills and a drive to continue to improve both technique and physical preparation. Proper technique, however, can be attained only if you can produce all necessary movements throughout the range of motion required for optimal positioning and stroke execution.

The sport of tennis requires strength, flexibility, power, endurance, and speed. Each of these components requires a well-trained muscular system. In addition, each court surface provides a different challenge. For example, clay courts require players to play longer rallies—sometimes as much as 20 percent longer—than do hard courts, and grass courts are even faster than most hard courts. Therefore, players who usually play on clay should train muscular endurance, while players who usually play on faster surfaces such as hard or grass courts may want to train more for muscular power or at least a combination of endurance and power.

Tennis is a lifelong sport, and the goal for many of us is to continue to enhance our performance while staying injury free, whether playing recreationally, in tournaments, at the college level, or even at the professional level. The best way to do this is to train effectively and use proper technique, seeking to produce effective and efficient tennis strokes. Consider the demands of tennis, but keep in mind your unique playing style and body structure.

Physical Demands of Tennis

Proper movement skills are critical for successful tennis. A successful tennis player must be able to get to the ball early and set up properly. Typically, this requires quite a few adjustment steps as you recognize the path, spin, and pace of the incoming ball. In fact, tennis often has been characterized as a game of emergencies. It involves constant movement, short sprints, and frequent directional changes. On average, 3 to 5 directional changes are required per point, and it is not uncommon for players to perform more than 500 directional changes during a single match or practice. Matches can last several hours, which requires aerobic fitness, but the short sprints, explosive movements, and directional changes are clearly anaerobic. Therefore, both the cardiorespiratory and muscular systems should be trained using movement patterns representative of those seen during tennis play.

A big focus of the United States Tennis Association (USTA) Player Development training program is good movement and positioning. It is clear that if you can't get to the ball and set up properly, you won't hit the ball in the most balanced way to produce a forceful stroke. The legs are the first link in transferring forces from the lower to the upper body. This is part of the kinetic link, or kinetic chain, system. Newton's third law states that for every action there is an equal and opposite reaction. When you hit a tennis ball, your feet push against the ground, and the ground pushes back. This allows you to transfer force from one body part to the next, through the legs, hips, trunk, and arm all the way to the racket. The key is to do this in the most efficient and effective manner by timing the segments correctly, not leaving out any segments, and preparing your body to be strong and flexible enough to handle the stresses imposed. Proper technique and preparation of the muscular system should go hand in hand. The lower body, midsection (the core or torso), and upper body are important in tennis, but each segment has different needs and training requirements.

Training the legs is vital for efficient movement on the court. Research shows that the muscles in both legs are stressed equally in tennis, so training programs should reflect this. Since the vast majority of tennis movements are side to side, it is important to focus 60 to 80 percent of training on these movement patterns. In other words, working on lateral movements incorporating the abductors, the muscles that move the leg away from the center of the body, and the adductors, the muscles that bring the leg toward the center of the body, is at least as important as training the other muscle groups of the legs.

Think of the midsection of the body as a cylinder when it comes to training. Exercises should be designed to move the front, back, and side of the torso through multiple planes of motion. Tennis strokes require rotational movements as well as flexion and extension, frequently all in one stroke.

The dominant side of the upper body is much more involved in each stroke than the nondominant side. Therefore, in addition to training the dominant side for performance purposes, you need to train the nondominant side for balance and injury prevention. Since the game tends to be dominated by serves and forehands that involve the muscles of the front of the shoulders and the chest, be sure to train the muscles in the rear of the shoulders and the back. During forehands and serves, these muscles experience eccentric, or lengthening, contractions and shorten during the backhand stroke through concentric contractions.

When designing a training program for tennis players, it is important to balance upper and lower body, left and right sides, and front and back. *Tennis Anatomy* takes you through each of the body parts and provides you with appropriate exercises for optimal performance.

Playing Styles and Court Surfaces

Muscular balance is key for all players regardless of surface or playing style. However, your playing style and the surface you play on most often will influence your training goals and affect your exercise choices. For example, if you

play a lot of long points on clay courts, you will want to train for endurance, especially in the lower body, instead of muscular strength and power, which would be more appropriate for a player who plays shorter points on hard courts. The same principle holds for the upper body, but to a lesser extent. You will still likely hit the ball just as hard when playing on a slower court; however, muscular endurance becomes more important since the points are longer. Regardless of playing style or surface, the upper body should be trained for both muscular power and endurance.

Playing Styles

Do you know what your playing style is? Do you like to come to the net and put the ball away with a volley or overhead? Or are you the type of player who likes to outlast your opponent by never missing a ball? Or do you like to hit the ball hard from the baseline, trying to dictate points and go for winners? All three styles can be very effective. Which style you use depends on your skills, personality, and possibly the court surface you play on most frequently. Most coaches categorize players into four different playing styles:

1. Serve and volleyer
2. Aggressive baseliner
3. Counterpuncher
4. All-court player

At the top professional level, the aggressive baseliner is the most prevalent, followed by the all-court player. The traditional serve and volleyer and the stereotypical counterpuncher are no longer preferred playing styles on either the men's or women's tours. However, tennis players at other levels can be seen playing each of these different styles.

The serve and volleyer (figure 1.1, page 4) relies on the serve to help dictate the point. After the serve, she explodes forward to the net. Typically, a serve and volleyer moves forward 20 to 40 percent more than a counterpuncher or an aggressive baseliner and about 20 percent more than an all-court player. Because of this forward movement, a serve and volleyer often finds herself at the net, trying to finish the point. Good volley technique is imperative and requires excellent leg strength, particularly in the quadriceps, gluteus maximus, and gastrocnemius. Strong leg muscles are key, especially for hitting low volleys that require significant knee flexion. Functional flexibility is very important to the serve and volleyer because she is required to get very low to the ground dozens of times throughout the match. Similarly, flexibility of the wrist is helpful, especially in reaching for volleys that stress the end range of the joint. This flexibility needs to be trained regularly.

The aggressive baseliner (figure 1.2, page 4) is more comfortable hitting groundstrokes but is also looking to put pressure on his opponent by hitting hard, aggressive strokes. This player's goal is to move less than the counterpuncher, and he prefers to move inside the court and take balls earlier to reduce the opponent's time between strokes. Muscular strength and

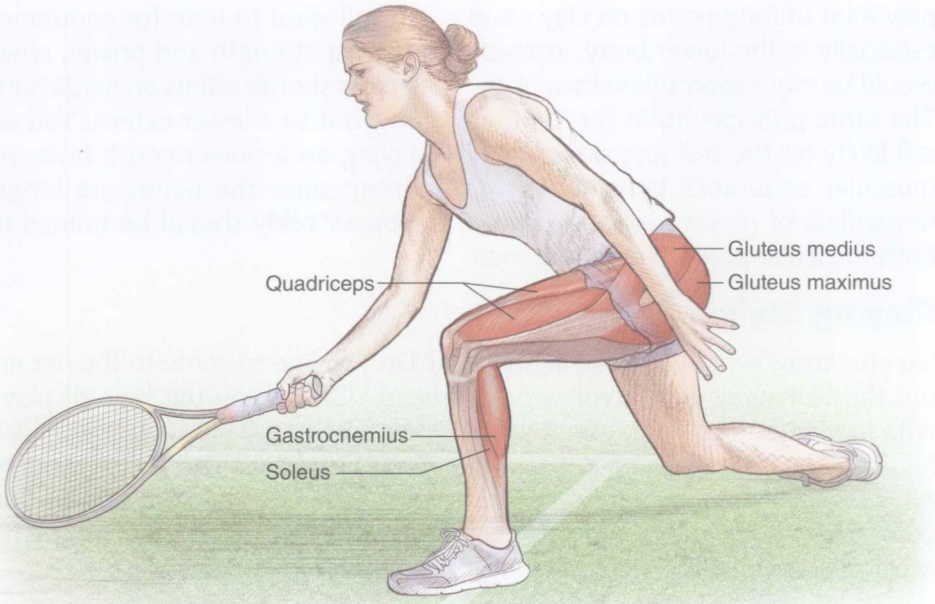

Figure 1.1 Serve and volleyer on a grass court hitting a low volley.

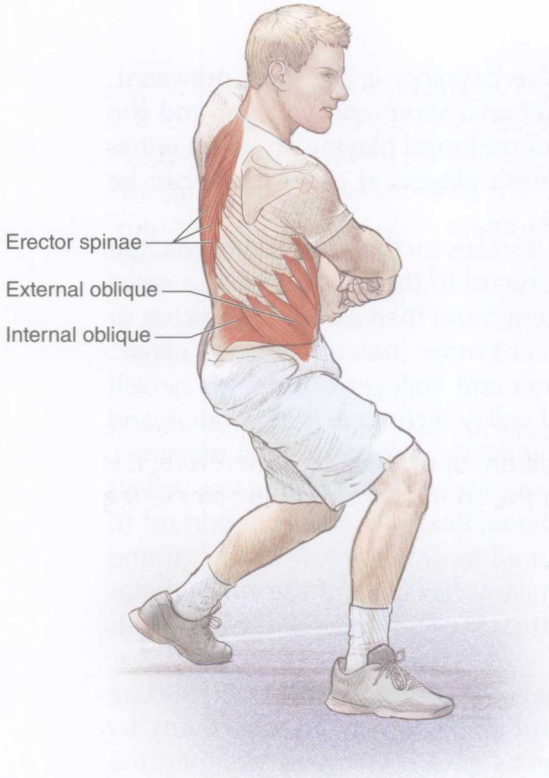

Figure 1.2 Aggressive baseliner on a hard court hitting a two-handed backhand.

endurance are required, but overall power is the major physical component that helps the aggressive baseliner dictate points. Having a major weapon such as a big forehand or strong two-handed backhand is very beneficial. Powerful strokes require strength as well as speed. Training exercises should take this into account. Exercises for the lower body and midsection should be very similar to those mentioned for players with other styles, but a greater emphasis on upper body power is helpful. The muscles of the chest and front of the shoulders are important for producing force, but don't neglect the muscles of the back of the shoulders and upper back. They help protect the shoulder complex and prevent injury.

The goal of the counterpuncher (figure 1.3) is to chase down every ball and make sure the opponent has to hit many balls each rally to win any points. This game style is based on great side-to-side movement and stroke consistency.

Figure 1.3 Counterpuncher on a clay court sliding to hit a wide forehand.

The counterpuncher moves laterally 60 to 80 percent of the time. Often she will stretch out to hit open-stance forehands or backhands. Therefore, it is critical to train the abductors and adductors as well as the muscle groups mentioned for the serve and volleyer in a well-rounded training program. This includes training flexibility as well as strength. The counterpuncher must depend on speed, quickness, and the ability to change direction since she may not often put the ball away for a winner. This type of game style is most effective on slower courts. Muscular endurance of the upper and lower body is critical. The obliques must be trained to assist in the rotational movements of all groundstrokes since the counterpuncher hits so many strokes, most with an open stance. Also, when playing great defense, the counterpuncher may hit many strokes when on one leg, out of position, or off balance. Therefore, it is imperative to train for these situations on the court by performing single-leg activities and training in unstable or irregular environments.

The all-court player (figure 1.4, page 6) looks to be aggressive when hitting groundstrokes but is also happy to follow aggressive shots to the net to finish points. All shots, from serves to groundstrokes to volleys, require equal attention in training. In addition, significant time should be spent on the transition game, training for shots that help the all-court player get to the net. The all-court player should regularly practice approach shots, such as a big forehand or slice backhand hit from half court, and follow each shot to the net. These shots require excellent movement and positioning, most often with a more closed stance than regular groundstrokes. Exercises for both the upper

Figure 1.4 All-court player on a hard court hitting a one-handed slice backhand approach shot.

and lower body are beneficial, especially exercises that help develop weight transfer and movement into the court such as the spider drill (page 174) and the split step with stimulus drill (page 177) in chapter 9. It is important to train all muscle groups. The main focus should be on balancing between left and right, front and back, and upper and lower body.

Court Surfaces

Court surface does dictate playing style to a certain extent. In general, a serve and volleyer can be more successful on a faster grass court than on a clay court. A counterpuncher typically is more successful on a slower clay court than on any other surface.

Since balls bounce lower on grass courts and fast hard courts, players must be able to bend their knees well. Training should focus on exercises that take the body through the same range of motion expected during a match (e.g., full-range lunges and squats), with powerful recoveries. Players who play on clay often have to slide into their shots while hitting a wide forehand or backhand. Since playing on clay requires not only front and back leg strength but also muscular strength of the inside and outside of the legs, it is vital to train the abductors and adductors. Muscular endurance should be the focus. Researchers have compared the ball speed on hard courts and clay courts. After the ball lands on a clay court, the ball speed is typically reduced by 15 percent compared with the same ball on a hard court. This is a major reason

why points are longer on clay courts and more strokes are hit per rally. Longer points on clay courts will slightly increase heart rate compared with shorter points on hard courts. Therefore, training to prepare for playing on a clay court will require a greater emphasis on aerobic conditioning versus training to play on a hard court. Service games are more physically demanding than return games, so players with weaker serves need to be prepared to play longer points and use a more physically demanding style.

Tennis Strokes

Tennis Anatomy features many exercises to improve your tennis game. Some are multijoint exercises, such as the lunge, which uses the hips, knees, and ankles. Others are single-joint exercises, such as the calf raise, which uses just the ankle joint. All exercises will be useful to prevent injuries and enhance performance. It is just as important to get fit to play tennis as it is to use tennis to get fit. Therefore, the exercises in the following chapters will help you prepare to take your game to the next level.

To identify how each exercise benefits your game, we provide icons to indicate the specific strokes—groundstrokes (forehand and backhand), serves and overhead shots, and volleys (forehand and backhand)—that will benefit from the conditioning exercise. In this section, we explain the major strokes and how actions, muscles, and muscle contractions are interrelated to produce effective and powerful strokes.

Forehand and Backhand Groundstrokes

Over the past 30 years, the greatest changes in tennis likely have occurred because of changes in racket technology. Rackets are made out of a variety of materials and are wider and stiffer, featuring a larger sweet spot. This has had a tremendous impact on the game, nowhere more than in the groundstrokes. The larger sweet spot is more forgiving on off-center hits, and the racket materials allow for more forceful swings. Because of these changes, forehand and backhand swings have changed as well. The long, flowing swings and follow-throughs in the direction of the target have given way to more violent, rotational swings that end up across the body in a variety of positions depending on the type of shot. These swing patterns allow players to hit the ball from a more open stance, particularly when hitting forehands but also when hitting two-handed backhands. This rotational component can put a significant amount of stress on the midsection. Therefore, exercises preparing the body for these stresses are vitally important.

Many of the muscle actions in the lower body are similar for all of the tennis strokes. There is an interplay between eccentric (lengthening) and concentric (shortening) actions that allows the body to store and release energy based on the phase of each stroke. In addition, each stroke requires trunk rotation, more so for groundstrokes, serves, and overheads than for volleys. The forehand, serve, and overhead strokes differ from one- and two-handed backhand strokes in that the upper body muscles are activated in the opposite way. The muscles in the upper back and back of the shoulder act concentrically (shorten) in the

loading phase and eccentrically (lengthen) in the follow-through. The muscles of the chest and front of the shoulder first contract eccentrically during the backswing and then concentrically during the forward swing. The backhand swing follows an opposite pattern.

Forehand Groundstroke

The forehand groundstroke may be hit from an open stance, a square stance, or a closed stance. Each body position requires different lower and upper body mechanics, although all three stances use a combination of angular and linear momentum to power the stroke. Linear momentum is a product of both mass and velocity and can be generated in both a vertical and horizontal direction. Angular momentum refers to the rotational component of the stroke and takes into account both the moment of inertia about an axis (resistance to rotation about that axis) and the angular velocity about that axis. Both linear and angular momentum are fundamental for the successful generation of power in the forehand. The amount of linear momentum created affects the amount of rotational force that is generated about each of the body segments.

The open-stance forehand (figure 1.5) results in the greatest total body rotation and requires greater strength and flexibility throughout the core and lower body than the square-stance or closed-stance forehand. The square- and closed-stance forehands require less rotation at the core, and ball contact is made more in front of the player and closer to the net. It is important to understand that each of the stances is situation specific. In other words, where

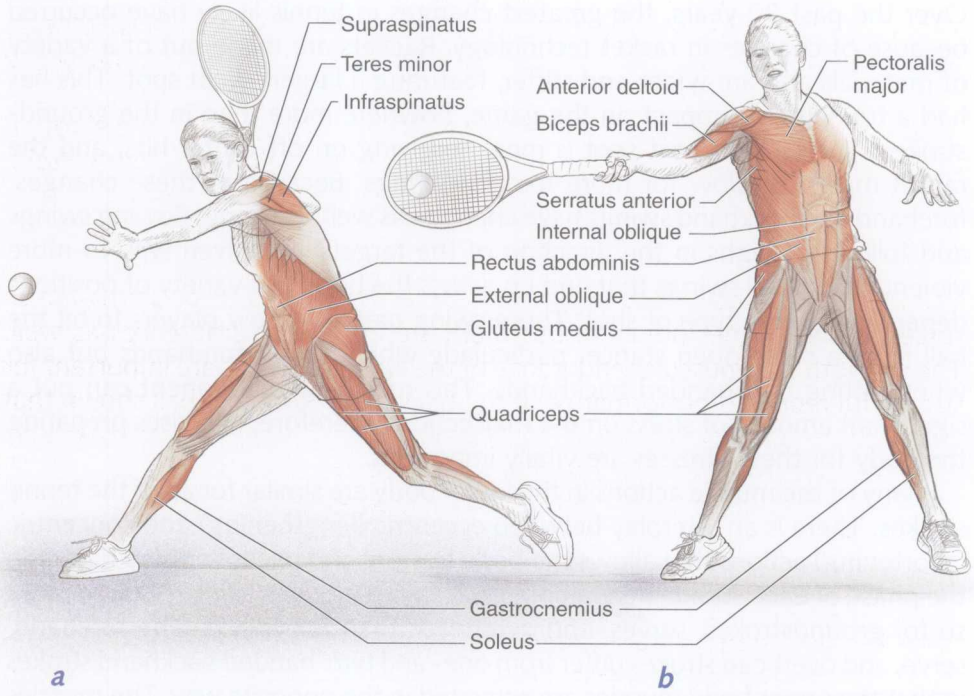

Figure 1.5 Open-stance forehand: *(a)* backswing; *(b)* forward swing.

you are on the court, the type of ball coming at you (both speed and spin), and the shot you are trying to hit often affect your stance.

The open-stance forehand is the most commonly used forehand in today's game. This shot requires vigorous hip and upper trunk rotation to provide effective energy transfer from the lower body through the core and into the racket and ball at impact. Trunk rotation, horizontal shoulder abduction, and internal rotation are the main motions that create racket speed in the forehand. After ball impact, eccentric strength helps decelerate the racket. This is particularly important as it relates to injury prevention.

During the backswing of the forehand groundstroke (figure 1.5*a*), the gastrocnemius, soleus, quadriceps, gluteals, and hip rotators contract eccentrically to load the lower legs and begin the hip rotation. The concentric contractions of the trunk rotation phase involve the ipsilateral internal oblique and contralateral external oblique, while the eccentric contractions pull in the contralateral internal oblique, ipsilateral external oblique, abdominals, and erector spinae. The concentric contractions of the shoulder and upper arm rotation in the transverse plane are performed by the middle and posterior deltoid, latissimus dorsi, infraspinatus, and teres minor and are followed by contractions of the wrist extensors. The eccentric contractions of the shoulder and upper arm rotation in the transverse plane are performed by the anterior deltoid, pectoralis major, and subscapularis.

During the forward swing (figure 1.5*b*), the gastrocnemius, soleus, quadriceps, gluteals, and hip rotators contract both concentrically and eccentrically to drive the lower body and hip rotation. Concentric and eccentric contractions of the obliques, back extensors, and erector spinae cause the trunk to rotate. The latissimus dorsi, anterior deltoid, subscapularis, biceps, and pectoralis major all contract concentrically during the acceleration phase to bring the racket to the ball for contact.

During the follow-through, the upper arm movement decelerates through the eccentric contractions of the infraspinatus, teres minor, posterior deltoid, rhomboids, serratus anterior, trapezius, triceps, and wrist extensors.

One-Handed Backhand Groundstroke

The one-handed backhand (figure 1.6, page 10) involves the summation of forces similar to the forehand, but there are important differences as well. The strength and muscular endurance of the wrist extensors are important for successful repeated performance of the backhand. Research has shown that torque at the wrist can create a rapid stretch of the wrist extensors, especially in players who have a history of tennis elbow (lateral epicondylitis).

For a one-handed backhand, the dominant shoulder is in front of the body. Typically, the stroke uses less trunk rotation; however, it requires a more coordinated action of the different body segments, including shoulder and forearm rotation, than the two-handed backhand. The front leg is more involved during a one-handed backhand than during a two-handed backhand. Similar racket speeds can be achieved with one- and two-handed backhands. Strength and flexibility, particularly of the muscles of the upper

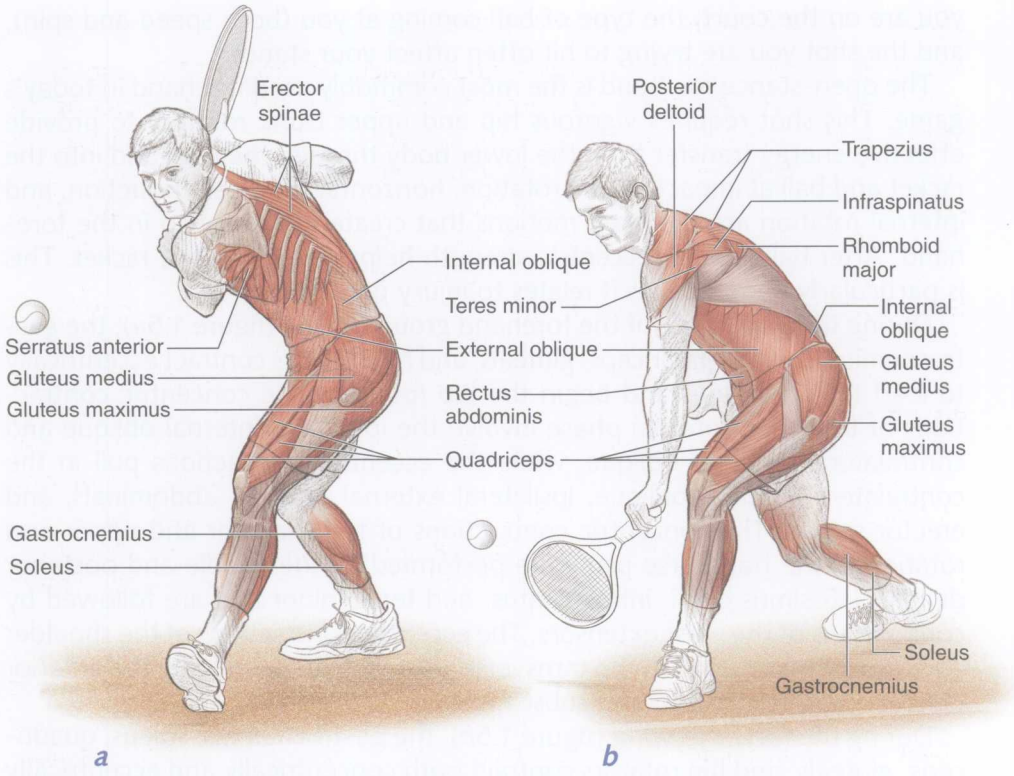

Figure 1.6 One-handed backhand: *(a)* backswing; *(b)* forward swing.

back and back of the shoulders, are key. Perform training exercises bilaterally to achieve muscular balance.

During the backswing of the one-handed backhand (figure 1.6*a*), the gastrocnemius, soleus, quadriceps, gluteals, and hip rotators contract eccentrically to load the legs and begin the hip rotation. The concentric contractions of the ipsilateral internal oblique and the contralateral external oblique are balanced by the eccentric contractions of the contralateral internal oblique, ipsilateral external oblique, abdominals, and erector spinae to rotate the trunk. The anterior deltoid, pectoralis major, subscapularis, and wrist extensors contract concentrically to rotate the shoulder and upper arm through the transverse plane as the posterior deltoid, infraspinatus, teres minor, trapezius, rhomboids, and serratus anterior contract eccentrically.

During the forward swing (figure 1.6*b*), the lower body and hip rotation is driven by the concentric and eccentric contractions of the gastrocnemius, soleus, quadriceps, gluteals, and hip rotators. Concentric and eccentric contractions of the obliques, back extensors, and erector spinae cause the trunk to rotate into the shot. The acceleration phase of the upper arm is performed through concentric contractions of the infraspinatus, teres minor, posterior deltoid, and trapezius.

During the follow-through, the subscapularis, pectoralis major, biceps, and wrist flexors contract eccentrically to decelerate the upper arm.