

# **MODERN TENNIS: BIOMECHANICS, ERGONOMICS, PLAYING TECHNIQUES**

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## **Summary**

Modern information concerning biomechanics of playing techniques of tennis players and interaction of a racket with a ball, is presented and description of the basic tennis techniques is given.

## **1. Introduction**

The world tennis over the last 5 years has changed drastically, including playing rate, mastership of shots performance, speed of movement of players. So it is necessary to determine the reasons for such significant growth and to improve the theory of tennis and methodology of training of sportsmen and trainers on the basis of new scientific information, concerning playing techniques of the strongest tennis players of the Earth.

Popularity of tennis, its mass character practically on all continents, interest in tennis from the side of businessmen as to a certain commercial enterprise, bringing great profit, - all these factors have led to unpredictable growth of sports results in the world tennis. Owing to natural complex biological selection of players according to many indices and sufficient investments into research of playing parameters in respect of their conformity to needs and physical qualities of players, the training and competitive process has been significantly improved. Currently on the basis of information about motor activity of tennis players sports specialists develop special health keeping techniques of training of sportspersons, these techniques are grounded on perfection of an ergonomic system "HERE" ("Human + Equipment + Racket + Environment").

Actually, only on the basis of conformity to ergonomic requirements of properties of rackets, courts surface and conditions of human activity, tennis players can play all the year round, ensuring longevity of sports.

The major requirements of modern players and trainers are the following:

- 1) ability to sustain great sports loads;
- 2) ability to choose correctly corresponding techniques, taking into account specific features of a tennis player;
- 3) ability to provide tennis players with optimum ergonomic conditions of their sports activity;
- 4) ability to discover reserves of growth of sports results.

These requirements motivate trainers to trace main trends in tennis and, first of all, changes of playing techniques, as crucial approaches to success over their contenders.

## **2. Biomechanics of Playing Techniques of Modern Tennis Players**

### **2.1. Playing Techniques**

The essence of tennis is mutual counteraction of playing sides, aimed at performance of certain game tasks by means of a wide series of different actions.

Any playing technique consists of a set of methods and means of achievement of a certain goals, owing to coordinated motor actions, finally directed to scoring points.

Any playing technique should be considered both from positions of biomechanical expediency and strategic-tactical productivity. The main indicators of productivity of a certain playing technique are the following: fast adaptation to different conditions; minimum disclosure of information, concerning techniques and tactics; efficiency of movements; great force and accuracy of shots; high rate of shots; speed of movements and maneuverability of a tennis player; timeliness and stability of actions of a player at high variability of plans.

Efficiency of sports struggle depends on many objective and subjective factors. Knowledge of these factors, ability to use them in practice in a real game are major conditions for achievement of high sports results in tennis.

Objective factors include: a contender with all specific features of his playing technique and tactics; conditions of competitions, taking into account the type of surface of the court, playing time of a match, weather, illumination, quality of balls; behavior of spectators and their reaction to a game, etc.

Subjective factors include: properties of personality of the sportsperson, his/her sports knowledge, skills, sportsmanship, his/her general state at the beginning of the match. An in-depth analysis and consideration of objective factors allow a tennis player and his/her trainer to organize strategy and technical-tactical actions more correctly.

Any playing technique is directed to performance of current motor tasks, connected with movement of a sportsperson on a court and performance of shots (interaction with a ball). There are many playing techniques in tennis (Figure 1), rationality of application of which is dictated by current playing conditions.

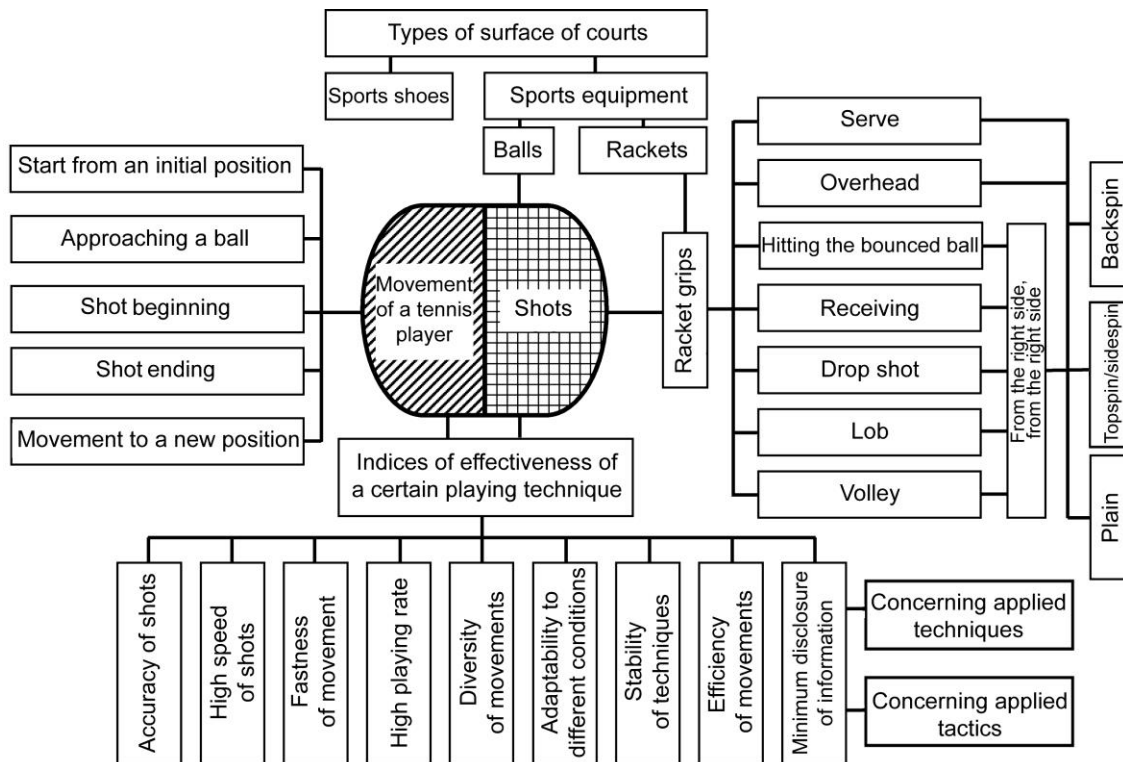


Figure 1. The basic playing techniques in tennis

Each of the indices of effectiveness of a certain playing technique depends on many factors and is determined by many corresponding mechanisms of technique implementation. Effectiveness of performance of a tennis player in matches is estimated not only by score. The victory over a contender is not a determining factor, since real work of a sportsperson can be characterized by successful implementation of corresponding techniques, implying perfection of the following parameters:

- speed of shots;
- playing rate;
- number of winning serves not touched by the opponent (“aces”);
- variety of hitting actions;
- distance and speed of movement of a player on a court;
- accuracy and stability of shots/receiving and other indices.

Technical actions of a tennis player (Figure 1) include a group of different movements and a group of shots, which are differentiated by principle and special features of their implementation, for example, forehand, backhand, volley, half-volley, overhead, drop shot, lob. Hitting actions are divided into bounced ball hitting and shots returned to the opponent before the ball bounces. Both these kinds of shots can have the same purpose: to finish point play, to send shot into a certain zone of the court, to slice a ball, to forward it over the top of the opponent.

Receiving in tennis is always performed when the ball bounces from the court. It happens to be one of the most difficult techniques, since the ball after serving flies a distance of approximately 16 m at a speed of 240 km/h for only 0.3 sec. It is an

extremely short time for human reaction. Therefore, all return actions of a receiver must be accurate and fast, based on motor automatism and prognostication (anticipation) of the zone of bounce in space and time. Perfect ball receiving, as the most complex technical action, requires great experience and sportsmanship. Only good skills help a player to predict correctly the direction of shot and to appear at the right time in a corresponding point of the court.

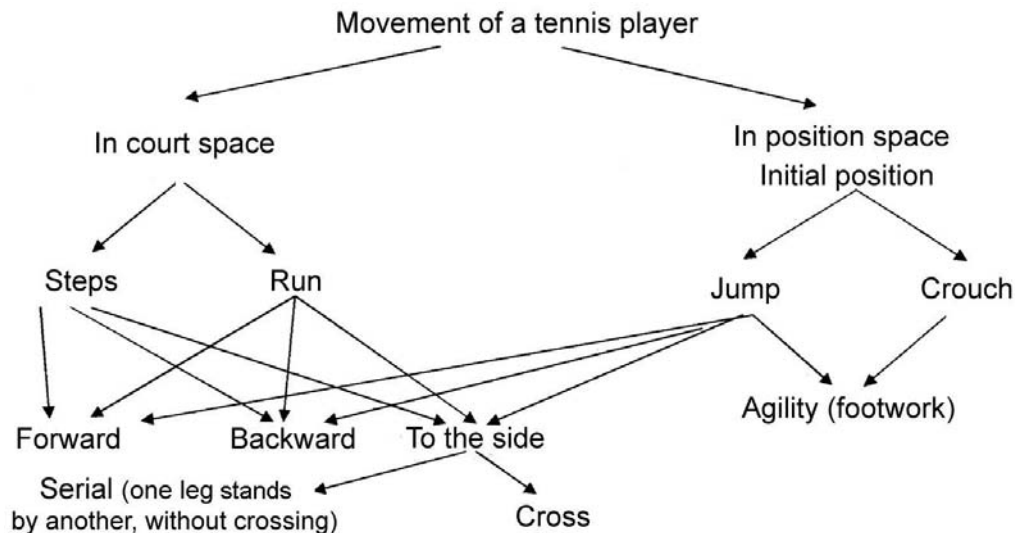


Figure 2. The scheme of movement of a tennis player

In the movement on a court a tennis player has to solve the following problems:

- in proper time approach the ball from the most favorable side to create the best conditions for fast play;
- to prepare the trunk and feet for shot performance at the most convenient point with reference to height and distance from the tennis player to the ball;
- to provide free and fast “shot ending (shot position leaving)” and timely appearance in the other tactically right point on the court, allowing himself/herself to prepare successfully for subsequent actions.

Movements begin from dynamically steady starting position and include:

- start from a starting position;
- movement to the ball before a shot;
- body movement directly at shot performance;
- “shot ending (shot position leaving)” and new start to take a new position.

All parts of movement are closely connected and follow one from another.

## 2.2. Beginning Position (Beginning Stance)

Any shot preparation starts from the beginning position. Speed of response to the shot of a contender and speed of further preparatory actions of a player significantly depend on the choice of right stance in each concrete situation.

In starting positions the tennis player's face is turned to the net, the shoulder girdle is parallel to it, and shoulders are a little lowered. The player's trunk forms with the hip an angle approximately equal to  $120^\circ$ ; it is bent forward, the longitudinal axis of the human body forms with the plane of support an angle equal to  $150^\circ$ . Legs are placed on width of shoulders and also bent. Feet are parallel to each other and keep body weight on "feet pillows", heels are slightly raised over the court surface. The racket is held by two hands at the waist level. The racket head is turned to the grid. Arms are bent in the elbow joint, keeping an angle of approximately  $135-150^\circ$ . The player's head is slightly swung relative to his/her body, his/her eyes are turned towards the contender.

Such beginning position traditionally precedes almost all tennis shots. To leave this position it is necessary to perform specific "start", named by V. N. Yanchuk "raznozhka" (*eng.* - agility, footwork). Agility (footwork) essence implies that yet before the shot of the contender the player performs a small jump or even jumping up (pushing by one or two feet, depending on the previous movement) and at the moment of contact of the racket of the contender and the ball the receiver is in an unsupported position.

For "disclosure of intentions" of a contender and definition of the direction and characteristics of a shot about 0.08-0.20 sec is required. Within this small period of time a receiver is in an unsupported position (actually, in air). However, by the moment of landing he/she already knows what to do, where to rush.

At such interaction with a support a tennis player performs an "impact" push, imparting to his/her own body greater impulse in comparison with start from the usual stationary position. This is provided by significant kinetic energy of the human body, increased by the time of landing, and by corresponding elastic forces in a musculotendinous apparatus of lower extremities, providing fast and efficient contraction and stretching of muscles. The leg of a tennis player, corresponding to the side of his future shot, works first in the course of agility. The center of mass of the tennis player is relocated to the other leg, located at a distance of approximately 0.7-1 m. Pushing force is increased due to counterwork of muscles-extensors of joints of this leg for replacement of projection of the center of mass of the human body further, close to the point of a future shot. Such order of action is typical for classical shot from the right or from the left when the ball bounces from court surface and when there is sufficient time to prepare for receiving. In modern variants of shots "in motion (in air)" a tennis player does not fix the second leg, but continues natural running movement. The moment of contact of the racket with the ball corresponds to an unsupported position of the tennis player, when the sportsperson combines simultaneously his/her next shot and one from steps or jumps.

### **2.3. Ball Approaching (Receiving)**

Timely and correctly performed ball receiving movement determines the efficiency of each shot. Special features of this movement of a tennis player significantly depend on the distance to the ball, height of its trajectory of flight, the point of his contact with a racket and on the type of the shot, on the position of the player relative to the ball, on available time for shot preparation. Qualified players move on a court with moderate intensity and more uniformly in comparison with beginners. Such uniform mode of

movement allows them to lower power consumption down to a minimum, to create good conditions for performance of shots and for faster shot ending (shot position leaving).

All players move on the court, using steps, run and jumps (Figure 2). More than half of all movements are steps, the less part - run, and only the small part - jumps. The basis of ball approaching is simple steps. The player performs them when it is necessary to meet the ball, flying from the left, from the right, or appearing in front of him/her. Players use the so-called serial steps (one leg is standing by another, without crossing) for fast returning to the center of their court end after performance of shots from a side line and also to prepare for receiving of long shots of a contender. Actually, these serial steps themselves represent movement, carried out by low side jumps (by right or left side forward), however, general body pose remains similar to the initial.

Cross steps are used to approach the ball, which is 3-4 steps from the player, to prepare for an overhead shot and volley or to receive bounced ball.

Run for movement on a court is used in the following general cases:

- to appear by the net after a serve;
- to appear by the net after ball play;
- to approach the ball at lob;
- to remove to a side line;
- to approach the ball at drop shot.

Lunges, jumps and side spurts are performed by a tennis player, located close to the net, when his/her opponent tries to dodge him by an unexpected and sharp shot.

A tennis player jumps up-back at overhead performance. Shots, performed in motion, especially striking an ascending ball, allow him/her to increase game speed. Such shots are more powerful, they create good conditions for timely appearance in a zone close to the net.

Movements of tennis players are extremely individual and varied, as are game situations. However, it is noticed that skilled tennis players begin movement to the ball with higher acceleration; they increase speed faster, but to a certain smaller value in comparison with unqualified players.

*Movement of a tennis player at shot performance.* The old classic rule of work of tennis player legs at shots says that performing shots from the right side (forehands) a tennis player advances the left leg and do it vice versa at backhands performance, at the same time the center of mass is displaced from far to a close to the ball leg when the tennis racket goes forward. Such movements are typical for closed tennis stances. In modern tennis at high speeds tennis players use open stances, where the same side leg and arm are closer to the received ball.

During a vertical movement of a tennis player's body, for example, in preparation of a serve or a spun shot (at receiving a bounced ball), support reaction is changed, that allows the player to jump up higher.

The trajectory of movement of the general center of mass of a human body at plain shots is rectilinear, at slices it is directed slightly downwards, at spins - slightly upwards.

In the modern fast tennis a tennis player has no time to carefully choose a stance and to fix legs firmly on the support, the majority of holds and techniques is implemented in motion (“in air”). So, for example, in motion to a ball player receives shots, performs volleys at the net, responds to drop shots with subsequent appearance in a zone close to the net.

*Shot ending (leaving) and appearance in a new position.* When the ball leaves the string surface of the tennis racket, the player with the racket still moves by inertia; at the same time the player displaces the “rear” leg closer to the “front” leg and prepares for footwork to appear timely in the corresponding place of the court for the next shot. Fast “shot ending”, immediate taking of the next position on the court and timely prognostication of the direction of the response shot of the opponent created good preconditions for successful play of a professional.

#### **2.4. Phases of Shots in Tennis**

The shot technique (hold) represents itself a uniform motor action, consisting of separate parts - phases, each of which is relatively independent and performs a certain motor task. In each shot there are 4 phases: 1 - preparatory – racket winding up and coiling, 2 – pre-strike - racket acceleration, 3 – strike - interactions of the racket with the ball, 4 - final, including the phase of racket deceleration and shot ending.

*The preparatory phase – racket winding up and coiling* begins from an initial position and finishes when the racket is in the most remote position from the point of “ball-racket” contact . The preparatory phase is intended to solve the following problems: in due time to perform racket winding up and coiling (with corresponding amplitude, form and duration), to choose a “ball-racket” point of contact, and, accordingly, to appear in the most favorable position for performance of a powerful shot. All actions of a player are focused on provision of certain rough orientation of the racket in space and the necessary support for all links of his/her body due to work of corresponding muscles at acceleration of the racket with maximum possible amplitude. Racket winding up can have different form (loop-shaped, direct and blocking), different duration (short or long), and therefore time of the preparatory phase varies from 0.24 to 0.64 sec, depending on the type of a particular shot, speed of the ball and qualification of the player.

*The pre-strike phase or phase of tennis racket acceleration* begins directly when racket winding up finishes and lasts till the moment of contact of the string surface of the racket with the ball. This phase creates specific conditions for accumulation of optimum amount of energy in the “tennis player-racket” kinematic chain by the time of impact interaction, and also corresponds to provision of necessary rigidity in the joints of human body, including tight grip.

*The phase of strike (shock interaction)* is the major phase of shortest term, corresponding to contact of the ball and the racket. Duration of contact of the ball with

racket strings, according to information from different sources, varies from 5 to 40 msec; it is shorter than the simplest motor reaction of a human to an irritant. This phase can be divided into two sub-phases: deformation of physical bodies and restoration of their initial form. During this contact mutual energy exchange takes place, and the ball for this short period of time gains corresponding speed and rotation, according to the tactical plan of the player.

*The final phase* begins at the moment of disconnection of the ball from the racket and ends with appearance of the tennis player in another initial position, ready for the next shot.

Each hold of shot technique in tennis has corresponding specific phases with their special features and forms, except for the phase of impact interaction. Only the contact phase at all shots is the same, it corresponds to energy exchange between the racket and the ball. However, a human can manage this energy exchange. Details of this management during such a short time interval are a puzzle for sports pedagogy, but undoubtedly these details precisely determine efficiency of a certain shot technique, implemented by a human biosystem. For this reason biomechanics of motor actions of a human in the contact phase is of special interest.

Laws of impact interaction of a biosystem with the ball are very complex, so they require application of specialized scientific methods, helping to discover corresponding phenomena and to understand importance of experience, training (fitness) of a sportsperson and role of advanced technologies, and also new materials in the development of sports equipment and court coating, development of balls with new properties and design of modern rackets, quality of which directly influences play and sportsmanship of tennis players.

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## Biographical Sketch

**Ivanova Galina Pavlovna** was born in Leningrad in 1937. She graduated from the Lesgaft Institute of Physical Culture specializing as a teacher of physical culture; after that, she did postgraduate studies at the Department of Physiology at the same institute. In 1968, she defended her Ph.D. thesis. In 1992, she became Dr. Biol. Sci. and Professor, specializing in biomechanics. Currently, she works at the Lesgaft National State University of Physical Education, Sport and Health as the professor of the Department of Biomechanics and Theory and Methodology of Sports Games. She is the Master of Sport in tennis.

Prof. Ivanova was a member of the Commission on Biomechanics at the Russian Academy of Sciences; now, she is a member of the Federation of Tennis of St.-Petersburg, she works in the scientific commission of the Federation of Tennis of Russia, carries out scientific support of top-rank female tennis-players.

She is the author of several chapters in textbooks on sports games, manuals on biomechanics, ergonomics, tennis, more than 100 scientific articles represented in books, scientific, sports journals and materials of congresses and conferences, held in Russia, France, Hong Kong, Czechia, Latvia and Ukraine.