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Physiological and Psychological Fundamentals of Training Systems Used in Tennis at Beginner Level

Dana Ioana ION-MUŞAT[1], **Andreea TUPAN**[2]

[1] National University of Physical Education and Sport, Faculty of Physical Education and Sport, Bucharest, Romania.
[2] National University of Physical Education and Sport, Faculty of Physical Education and Sport, Bucharest, Romania.

Abstract: In the current game of tennis, it is very important for competitive players to possess a high level of perceptual, cognitive and motor skills. To reach this level, many sciences have contributed to the substantiation of the training process: physiology, psychology, biochemistry, etc. In recent years, specialists have been concerned with identifying and determining new factors that facilitate the learning of technical elements and tactical actions used in tennis. Contemporary tennis, through its specificity, requires coaches to understand and have the ability to implement different forms of practice that will increase the efficiency of the tennis learning process. The present paper makes an analysis of specialised perceptions that underlie the tennis learning process and guide the optimisation of the training process at beginner level. Associations that lead to functional results are a distinctive mark of sports performance in tennis. Thus, understanding how tasks, the environment and the body interact to influence the formation of these synergies is essential. Depending on the results achieved, we will be able to determine the importance of developing coordination abilities (spatiotemporal orientation ability, the ability to combine and connect movements, balance ability, kinaesthetic differentiation ability, motor reaction ability, movement transformation ability, rhythmic ability) in order to optimise the game of tennis for children aged 8-10 years.

Keywords: *tennis, training systems, beginner players, children.*

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Introduction

Success in sports activity is measured by performance and depends on physical, motor, psychological and biochemical factors. An individual's sports performance is influenced by a number of variables such as "somatotype, motor skills, age, nutritional status, physiology, psychology, training level, genetic endowment, and injury risk" (Sagdilek E., Sahin S.K., 2019, p. 246).

In competitive tennis, it is necessary for the player to possess a high level of perceptual, cognitive and motor skills. During a tennis match, these skills will help the athlete to both adapt the game depending on the opponent, the court surface, the weather conditions, etc., and maintain a highly efficient level of technical and tactical actions performed against a background of physical and mental fatigue. Studies (Sagdilek E., Sahin S.K., 2019) have shown that these skills are crucial for the differences in performance between athletes.

Given that the optimal period for the development of athletes' skills is between 5 and 12 years, tennis specialists are constantly seeking to identify new physiological and psychological mechanisms whose use in the training process will lead to an increase in the efficiency of technical and tactical training at beginner level.

Topic Addressed

Physiological and psychological characteristics of motor learning

One of the challenges experienced by children when learning a tennis-specific technical skill is the initial lack of consistency of their somatosensory perceptions. The permanent somatosensory comparative analyses resulting from multiple repetitions generate a process of refinement of the kinaesthetic perceptions that underlie the production of movements.

The neural networks that condition this stage of motor learning are largely unknown and are the focus of consistent research. A number of neuroimaging studies have investigated motor learning from the perspective of motor adaptation and highlighted the role of some brain areas in this process (Sidarta et al., 2016). The paradigm of motor adaptation is based on the idea that repeated errors cause "some form of perturbation", which "impairs movement to well-learned sensory targets" (Sidarta et al., 2016, p. 11682). These systematic errors are followed by repetitions that lead to their progressive reduction "through adjustments to motor commands" (Sidarta et al., 2016, p. 11683) and implicitly to muscle contractions.

The cerebellum is considered a key point in correcting motor errors, while the posterior parietal cortex is involved in sensorimotor analyses that allow reassessing movements in relation to different spatial benchmarks (Bernier & Grafton, 2010). Therefore, the role of cortical areas is to configure the sensorimotor targets that will guide the learning process. Bernardi et al. (2015) show that somatosensory experience delivered through passive movements has generated kinaesthetic perceptions comparable with those seen in individuals trained with active movements.

On the other hand, brain networks that support reward-based learning and reinforcement have been studied (Bischoff-Grethe et al., 2009). The process of learning a motor skill depends on each one's memory ability, which means that a person must repeat the correct movements and be able to refine incorrect movements by eliminating unnecessary muscle contractions (Sidarta et al., 2016).

During the execution of motor actions, there is an intensification of activity in the neural networks of the prefrontal cortex. A correct movement can shape the learning process and compensate for the lack of detailed error information in the early stage of learning (Bernier & Grafton, 2010).

Somatic memory and neural networks that support the decision-making process underlie exploratory learning and help reduce movement variability (Sidarta et al., 2016).

Using perceptions in the tennis learning process

Specialists unanimously agree that the intuition of top players is based on their ability to select relevant information from the environment. This ability underpins specialised perceptions as somatosensory syntheses of the visual, auditory and kinaesthetic perceptions resulting from the motor learning process.

In the training process for beginners, it is important to understand that, at the age of childhood (8-10 years), the capacity for somatosensory differentiation and motor memory are emerging. The kinaesthetic analyser is still underdeveloped, which is why accuracy is impaired in terms of spatiotemporal characteristics of movements. Also at this age, loose neural connections are easily erased, and the cerebral cortex tends to become unable to retain the created functional connections; for this reason, learning ability is not associated with the long-term retention of learned movements (Demeter, 1981).

For learning the game of tennis, visual information is the most important; it underlies the perception of space, along with kinaesthetic and auditory information (Radu & Ulici, 2003). Visual information ensures

movement execution towards a predefined interception point in relation to the ball. This strategy is known as the "load angle strategy". In other words, when a fly ball has a sagittal motion towards the intercepting eye of the player, the image of its optical height linearly increases as the ball approaches. Thus, when travelling towards the ball, the child must move forward when it decelerates visually or step back whenever the tennis ball accelerates visually. This tactic takes the player into an interception position, even if he does not know in advance exactly where the ball will land (Chohan et al., 2008).

Several researchers have investigated the coincidence-anticipation behaviour of athletes when they coordinate their movements in relation to visual information. In ball interception tasks, children adapt their movements depending on the spatiotemporal characteristics of the ball and the spin imparted to it (Peper et al., 1994). Ricken et al. (2004) made a comparison between interceptive actions performed by children, who were required to reach and grasp a static or a flying ball. Into each situation, the tennis ball was in a predefined position, accessible from the place where they were standing. These researchers found that beginner players showed greater variability during the impact between racket and ball when the stroke was performed in motion, namely when trying to intercept the moving ball. When doing this, children had a tendency to decelerate longer towards the ball and perform unnecessary arm and trunk movements.

In visual anticipation behaviour, it is essential to analyse the visual field information (e.g., velocity of the ball and the spin imparted to it). In this regard, researchers have noticed an improvement with age but comparatively equal motor reactions to adolescents or adults.

We summarize that, in most of the cases, younger players find difficult to interpret the optical messages and its may get less precise as much as motor demands increase in complexity (Chohan et al., 2008). To exemplify, the players are often getting ready for a superior ball velocities and have difficulty transferring the motion-related information when the ball goes very slow, like is demonstrated both by arriving too early at the interception point and by performing inadequate movements (Crohan et al., 2008). Due to the fact that young players are using coincidence anticipation, its demonstrates that optical information helps in the interception of the tennis ball (in our case) but the model of relevant visual information they are using through interceptive tasks is not known yet.

In tennis, as anticipatory perceptual abilities are developing, the players become capable to choose important knowledge to undertake a certain motor activity adapted to their own movement capabilities.

Making an efficient and quick decision requires corroborating perceptual information with the knowledge gained from previous experiences but also using various cognitive resources according to the complexity of the task to be performed and how sports performance is closely related to the motor memory.

For example, in the game of tennis, performing a successful forehand stroke when the opponent is in motion requires selecting the appropriate technique in combination with the execution of fast and efficient movements. An explanation for the best decisions made by a tennis player is the changeover of brain levels responsible for movement control, which shift from a high level of conscious control to a high level of unconscious control. Therefore, certain movements are independent of motor memory but give it sufficient resources to achieve other goals such as making decisions quickly and efficiently. Instead, there are actions that depend on motor memory to consciously access knowledge so that the motor system can control the appropriate movement for a game-specific situation.

Perceptual training in tennis

As regards light perception training, it is recommended to practise on a court facing the sun and to perform the serve with the sun in the face in order to enhance kinaesthetic perceptions. Also, training on tennis courts with portions of shade and sun is very important because ball speed perception is different from dark to light and vice-versa.

The visual perception of colours is determined by the white lines, the tennis court background and the tennis players' equipment. Athletes must be trained to know how to react to the opponents' equipment, especially the one with bright phosphorescent colours that, by increasing cortical excitability, make the tennis player tend to send the ball to these targets, which benefits the opponent. This trend first appeared in football goalkeepers who used equipment with bright phosphorescent colours such as green, yellow or orange, precisely to cause players to unconsciously send the ball to the goalkeeper. It is forbidden for the tennis court background (advertisements, banners) to be yellow or white in order to avoid overlapping with the yellow ball or white lines, which may alter the players' perception during the game. In fact, the lines of the tennis court are white because it has been proven that, in conditions of fatigue, athletes have better resistance in the presence of this colour.

Auditory perception refers to the game-specific sounds, namely how the ball hit by the opponent is heard or the sound of tennis shoes and the

ball on the playing surface. The tennis player can quickly differentiate between a slice ball and a flat ball, for example, and can thus anticipate the trajectory and bounce of the ball so as to adopt an optimal position for that ball. Also, the sound heard when the opponent hits the ball can adjust the player's pace depending on how quickly the ball is hit after touching the playing field. Auditory perception can provide a lot of information based on the sound of the slide step so that the player can become aware of the clay moisture level and thus the weight of the ball.

Kinaesthetic perceptions are extremely important because the sense of the racket is decisive during training and play, which is why the racket grip or overgrip must be perfect. Also, the only technical element allowing the player to touch the ball is the service; therefore, while throwing the ball, the player can feel its characteristics, namely if the ball is dry or wet, light or heavy, and thus can choose the most efficient type of service. For this reason, tennis players need to be trained to identify these perceptions and increase the efficiency of their motor behaviour accordingly.

We want to highlight that the athletes who are trained to identify these perceptions and use them during the game benefit from the premises of reaching an increased level of sports performance.

Systems for learning tennis techniques

Starting from the aforementioned issues, training systems promoted by the tennis learning methodology for the age group 8-10 years highlight a number of aspects that confer them originality and especially effectiveness in relation to tennis-specific perceptual training.

• Methodical learning system 24

Training adaptation to the somatosensory characteristics of the learning process is illustrated by the *Methodical learning system 24* (Stănescu, 2005). Its specificity consists in the use of certain action systems for learning the technical elements of tennis and in the fact that practice relies on the rule of maintaining the movement structure in relation to changing the hitting distance.

Exercises with combinations between the movement complexity and the spot where the exercise is performed are initiated at the end of preparation (thus eliminating racket preparation as a motor task) on the service line and continue with exercises also performed at the end of preparation on the baseline instead of moving to the starting position from the service line. Therefore, the exercise structure is preserved, and this is a crucial element for making the learning process more efficient.

Another specificity of the *Methodical learning system 24* is that it uses different types of perceptions in tennis-specific contexts. Visual perception

is based on light and colour, which is why a first requirement is to determine the tennis player's dominant eye. By determining it and learning how to move during training and play, athletes can improve their reaction speed during the game because the transmission speed of the dominant eye is 13 times faster than in the case of the non-dominant eye. If any information coming from the opponent is first perceived by the dominant eye, then the player's chances to react in an ideal way will considerably increase.

• CHANGE IT system

In learning the game of tennis, a very important aspect refers to changing the game rules. The modification of these rules allows coaches to emphasize special tennis characteristics and to maintain the tennis fundamental components.

The *CHANGE IT* method is used for modify constraints by "eliminating, refining, or adding to game rules and playing conditions to focus attention on specific technical or tactical game understanding" (Hewitt, Pill, McDonald, 2017, p. 52).

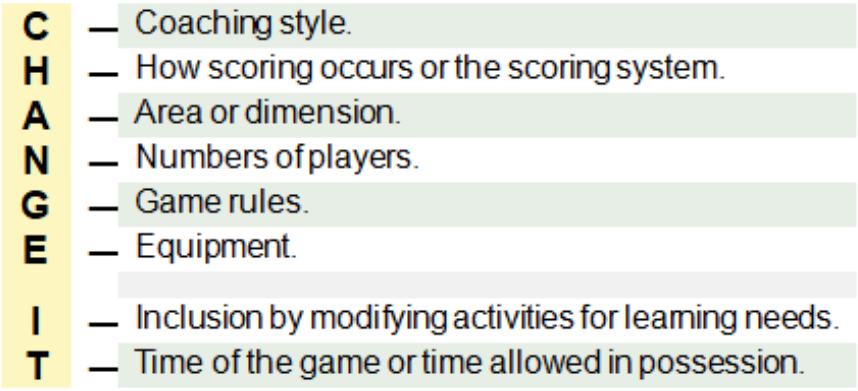


Figure 1. The *CHANGE IT* formula (Hewitt, Pill, McDonald, 2017, p. 52).

Therefore, when changes to the game of tennis are methodically used, constraints (physical, environmental and goal-conditioned learning factors) influence and shape motor abilities and consequently the tennis game (Hewitt, Pill, McDonald, 2017). These deliberate changes lead the athlete to find solutions to achieve the goals imposed by these constraints, and the solutions will vary depending on the conditional factors. When the adopted pedagogy places emphasis on learning through discovery, the player is called a "problem solver" (Coker, 2010; Pill, 2013).

The solutions for effectively solving the different moments of the game change with the constraints. Also, learning goals can be created for each player, and the game model could be projected to meet the personal requirement of any athlete.

The methodological benchmarks for operating changes to the game of tennis involve:

- changing the playing area (reducing the tennis court);
- changing the equipment (rackets of different sizes or balls of different sizes or compression levels);
- changing the rules (the ball is allowed to bounce twice before hitting it).

• Mini tennis system

The Italian Tennis Federation, through the Fit Junior programme, has made a proposal to implement the *Mini tennis system* with the help of which athletes who is improving through the game and where the tennis rackets, the balls, the surfaces and also the principles of the game are customised according to the physiological characteristics of children, thus allowing them to learn the technical skills correctly and quickly (Santopietro et al, 2020).

This learning system is based on several principles and takes into account a number of technical and psychological factors. One of its goals is to convey positive emotions to players, thus helping them to develop a good image of themselves and their abilities. Even though tennis-specific movements seem complex because these demand vision, synchronisation and also some special motor coordinating qualities, younger tennis players must understand and be confident that they can perform these movements (Santopietro et al., 2020).

The specificities of mini tennis refer to the small size of the court, net and rackets as well as the use of depressurised balls that bounce less than those used by adults. All these aspects facilitate children's learning and turn tennis into an accessible sport but most importantly allow greater efficiency in the execution of strokes. Moreover, by using rackets suitable for children and balls that bounce to their appropriate heights, proper movements will be performed and thus the physical effort will be in accordance with the age of players. In this system, it is recommended that the development of the coordination skills to be achieved through games and activities that stimulate spatial orientation, balance, reaction speed and the sense of rhythm (Santopietro et al, 2020).

• System 5

This system has been developed for learning tennis by The United States Professional Tennis Association. They also called it *The Five Keys to Tennis* because it is a very easy method to teach and learn which is based on a strategic positioning on the field, a proper game tactics and a shots selection corresponding to each moment of the game.

System 5 includes the following five keys for teaching and training the game of tennis:

1. – five zones
2. – five phases
3. – five swings
4. – five heights
5. – five responses

The five zones indicate that a tennis court is not merely a surface that determines the spatial limits of the game and is used to establish if the tennis ball is in or out the court. These distinct zones correspond to the real strategic decisions that players should take in a tennis match. Moreover, they are assigned a number, a location, a color and a tactical phase that find alternative strategies to use the most appropriate shot in the given situations (Helfrich, 2006).

The particularities of the five stages refer to the adequate way to return every tennis ball that is sent to a player in a tennis match. It is fundamental to make two mentions: the area where the player is when he receives the ball and the characteristics of the ball coming from the opponent, such as: length, height, direction, velocity and spin. Thus, each return zone of the player will correspond to one of the five zones and also to the characteristics and to the difficulty level of the approaching ball.

In *System 5* we have the colours of a traffic light to recognize the five stages of the game: the defence phase (flashing red), the counterattack phase (red), the ball exchange phase (yellow), the challenge phase (green) and the attack phase (flashing green) (Helfrich, 2006).

• Five-segment swing

In tennis, in order to facilitate the communication in the learning process, it is recommended that technicians use, in the explanations related to the backswing and the folow-through, the concept of sectional swing. Both backswing and follow-through are fractionated into five identical segments indicated by numbers from one to five. Zero is the point of ball contact with the tennis racket. The first numbers are all the time assigned to recognize a swing. The first one represents the backswing's length, and the second number, the length of the follow-through. Therefore, a 3/5 swing

means that the athlete would have a backswing in the third phase and a follow-through in the fifth (Helfrich, 2006).

In order to minimize the number of mistakes when the tennis balls goes in the net or outside the playing field, five different heights are used to return them over the net. The varied heights are calculated at the moment when the tennis ball passes over the net, and every number is equivalent to the width of a medium-sized tennis racket head (approximately 10 inches).

The fundamental feature of this theory is to establish the area where the tennis player is positioned when he hits the tennis ball and to transpose that number to the appropriate height. These heights will not allow ball to enter the net and will position it long up the court to maintain the opponent in a defensive position. The rhythm of the shot, the spin imparted to the tennis ball and the rival's place on the field can influence as well the selection of a player's shot height. When a player chooses to return with a lob, the height of the area where the player returns the lob should be multiplied with the number five; for example, the height of a lob sent from the fith section should be 25 x the width of the racket head above the net (Helfrich, 2006).

The particularity of the five answers refers to a player's capacity to constantly use strong and tactically placed shots to give the ball a spin effect appropriate to the situation. *System 5* formulates a series of game characteristics that condition its efficiency:

1) Consistency – is the capacity to maintain the tennis ball in play and not to do mistakes. In tennis, this quality will prevent players from making unforced errors.

2) Proper direction and length of the ball – are very important to approach a strategic game and keep the opponent on the defensive, along with knowing the four previous keys of *System 5*. Also, knowing how to manage the direction and the length of the tennis ball will offer to the players the opportunity to control their opponents.

3) The velocity of the ball– is the capacity to return shots at a speed similar or bigger than that of the opponent's ball speed. This strategy will put extra pressure on the rival by not giving enough time to react and respond, that will lead to many forced errors, and will not allow the opponent to lead the point.

4) Changing the pace of play and the spin of the ball – gives players the opportunity to interrupt the opponents' pace, which may cause them to make forced errors and thus lose the game.

5) A main strategic advantage is hitting the ball up (shortly after it has bounced). This strategy gives opponents less time to react and prepare to return the ball (Helfrich, 2006).

• Tennis 10 System

Tennis 10 is a programme created and implemented by the International Tennis Federation in the early 2000s. This system aims to promote tennis as an easy-to-play game in order to maintain children's health and ensure that all beginner players can serve and hit the ball from the very first lesson (Bucătaru & Moisescu, 2020).

In Romania, the *Tennis 10* concept is known but unfortunately is not implemented in many tennis clubs. The characteristics of this modern system require approaching the tennis learning technique with a focus on players aged up to 10 years. Emphasis is placed on the use of learning methods for the adult game but facilitated by light materials, small-sided courts and different types of depressurised balls, depending on children's age (Bucătaru & Moisescu, 2020).

In order to promote the use of this learning system, tournaments are organised based on the *Tennis 10* rules. Moreover, during these tournaments, matches are played according to a reduced system of sets and games (e.g.: 2 sets of 4 games each with a tie-break at 4-4, and in the case of a decisive set, this is in the form of a 10-point maxi tie-break).

Comparative analysis of tennis learning systems

From our point of view, one of the most interesting and complex learning systems is *System 24* (Stănescu, 2014), whose specificity consists in the use of certain action systems for learning the technical elements of tennis and in the fact that practice relies on the rule of maintaining the movement structure to the detriment of changing the hitting distance. The added value of this system compared to other methods is given by the elimination of the racket preparation phase as a motor task, which somewhat simplifies the hitting technique and obviously provides it with execution speed. The system is based on four variables that permanently exist in the game of tennis. Also, the way of sending the ball gives the child the opportunity to get used to balls that are getting closer and closer to the actual game.

The system is based on exercises that range from easy to difficult and from simple to complex, allowing the coach to choose the exercises to be learned depending on children's abilities. The exercises can be adapted to the age and training level of athletes and can be used either as proposed by the system or skipping some of its parts. According to coaches' experience

and inventiveness, a multitude of exercises can be created relying on the structure provided by the system.

Another advantage of the system is that coaches can assess children by quickly establishing their technical levels at the time of assessment as well as the exercises to be done. The system is designed for both children and adults involved in the learning process.

Compared to the previous system, we believe that *System 5*, although it can be an effective method for learning the tennis-specific technical and tactical content, is quite difficult to implement, at least at the age of 8-10 years. One of the reasons that makes it hard to use in this age group is that it is a very complex system based on five "keys" for learning the game of tennis (five zones, five phases, five swings, five heights, five responses).

We also consider that this system is difficult to use, at least in our country, because it requires special equipment (traffic lights) to identify the five game phases. In addition, at this age, there are few athletes whose motor skills and acquired specific technical elements allow them to learn tennis through this training system.

Mini tennis is a learning system through which athletes learn by playing. This method is based on several principles and takes into account a number of technical and psychological factors, besides motor and tactical ones. Thus, it can be considered as a basic, simple learning system. The physical effort required when using this system is quite low, and the emphasis is on conveying positive emotions to players. In conclusion, the core feature of the *Mini tennis* system is that it helps players develop a good image of themselves and their abilities, so it refers less to the development of motor skills, even though a correct and effective technique is based on the good development of motor skills.

We believe that the *CHANGE IT* method is also a very effective training system aimed to make us understand how changing the game rules and conditions helps to direct the players' focus of attention on understanding the technical or tactical aspects of tennis. If the changes brought to the game after applying this system are pedagogically used, the constraints that may occur influence the development of motor skills and knowledge of the game. Therefore, we think that this system substantially contributes to optimising the game of tennis for children aged 6-10 years. Another very important aspect and additional advantage of this system compared to others is its adaptability to any type of athlete, which allows establishing learning goals according to the individual characteristics of each player. Moreover, the game model can be designed so as to meet the individual needs of each athlete.

Tennis 10 is a game system used for children aged up to 10 years, where the focus is on the implementation of learning methods for the adult game but facilitated by the use of light materials, small-sided courts and different types of depressurised balls.

During training, connections can be created based on both visual and auditory perceptions, which generates ball hitting strategies according to the situation. This aspect derives from the fact that the balls used in this system have three colours (red, orange and green) and specific exercises can be performed by reacting to the colour or sound of balls, which have different pressures and their sounds are completely different.

Compared to other training methods, this system has a great advantage: the organisation of tennis tournaments based on the *Tennis 10* rules. Due to these features, we think it is one of the most effective systems for learning the game of tennis, especially at the age of 6-10 years.

Conclusion

In conclusion, associations that lead to functional results are a distinctive mark of sports performance in tennis. Thus, understanding how tasks, the environment and the body interact to influence the formation of these synergies is essential.

Depending on the results achieved, we will be able to determine the importance of developing coordination abilities (spatiotemporal orientation ability, the ability to combine and connect movements, balance ability, kinaesthetic differentiation ability, motor reaction ability, movement transformation ability, rhythmic ability) in order to optimise the game of tennis for children aged 8-10 years.

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