Research into Practice:
The Service Action

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The service is probably the most important stroke in tennis. It is however, also a difficult stroke to master as not only do the upper limbs prescribe different movement patterns and rhythms, but they must coordinate with the movement of the lower limbs and trunk. It is still logical to assume that service technique can best be improved through an understanding and then practice of the important components of the action. While this paper discusses the mechanical basis of the service action, it must be stressed that the most important consideration in any service technique is ***RHYTHM,*** and as such the *INDIVIDUAL FLAIR* of the player must always be the key ingredient.

1. The Grip

Although it is widely accepted by coaches that the continental grip is preferred for an advanced service action, no research data were available to substantiate this belief. Trial and error have led authors to claim that this grip allows maximum use of wrist flexion and also permits a variety of racquet-head positions at impact (Elliott and Kilderry, 1983; Groppel, 1984).

Principle:

The continental grip or a close approximation should be used for an advanced service technique.

2. *The Stance*

The position of the feet in the stance phase can best be decided through deliberation between the player and coach. The role of weight transfer as part of the preparatory movements should be addressed. Most coaches advocate that the weight should start on the front-foot so that it can be transferred backwards and then forwards during the serve (Ashe, 1975; Trabert, 1975; Segura, 1976). This position was supported by Elliott et al. (1986) who reported seven of eight State level performers began their service action with their weight on the front-foot. Smith (1979) reported that the initial weight distribution for five male varsity players was an individual characteristic with three subjects having their weight distributed in front of the rear-foot, one was evenly balanced and one had the weight predominantly placed on the front-foot. This individual weight pattern was consistent for the flat and slice serves. The movement pattern for all servers was for the weight to move back towards the rear-foot and then forward so that at contact the perpendicular line through the centre of gravity was 25 cm forward of the front-toe in the flat service and 41.5 cm forward of the front-toe in the slice service (Smith, 1979).

Principle:

While subject to individual variation, it is evident that the initial weight forward technique that permits a "rocking action" to begin the drive to the ball, is both preferred by most players and supported by research data.

3. ***Upper Limb Timing*** (Figures 1 and 2)

The "down-together" "up-together" synchronisation sequence in racquet and ball movement have not been researched. Some coaches may prefer the ball to just lag behind the racquet movement, while others prefer the reverse situation. A very large "racquet trail" is so often the cause of either a higher than needed ball toss or a cramped hitting position.

Principle:

A synchronised upward movement of the ball-arm and racquet-arm would appear to be needed for an efficient service action.

4. ***The Foot-up vs Foot-back Controversy*** (Figure ***2:*** The foot-up technique)

A range of foot placements during the lower limb drive from the foot-back technique through a variety of intermediate positions to the foot-up technique are used by high performance players. A study by Elliott and Wood (1983) found that the foot-back technique produced greater horizontal ground reaction forces and they concluded that this technique may enable a player to move more quickly toward the net at the completion of the serve. The foot-up technique generated larger vertical ground reaction forces which resulted in a better UP and OUT hitting action and a higher impact position than those who used the foot-back technique.

Principle:

The individual flair or preference of the server should be a major determinant in the technique selected, however if the foot-back technique is used coaches must emphasise the "leg drive" to produce an up and down hitting action while those who teach the foot-up technique must emphasis rapid movement to the net (for a serve-volley game) as part of the completion of the serve.

5. ***Lower Limb (leg) Drive*** (Figures ***2*** to 4)

A number of books have related the lower limb drive to the movement of the racquet. Braden and Bruns (1977) stated that an effective natural loop of the racquet was achieved by a "shoulder turn" while Elliott and Kilderry (1983) stated this loop would be enhanced by a correctly timed lower limb action. A study by Elliott et al. (1986) showed that as knee joint extension and foot plantar flexion drove the hip and shoulder upward a reaction force aided the movement of the racquet in its loop behind the back. Mean maximum elbow joint angles for eight State level performers of approximately 60° during this loop showed that while the term. "back scratch" position may be used as a coaching-cue it is not an accurate description of the position of the racquet behind the back.

Principle:

A combination of shoulder turn and lower limb drive produces a dynamic situation where the loop of the racquet behind the back is increased when compared to an action without these characteristics.

6. ***Sumntation of Body Segments***

A flow of energy from the lower limbs to the trunk and finally to the racquet-limb is required if an optimal velocity is to be achieved at impact. Van Gheluwe and Hebbelinck (1985) and Elliott et al. (1986) in 3-D cinematography studies of skilled servers both reported that this summation process did occur. The maximum resultant linear velocities of segment and end-points revealed a velocity increase in successive segments from the knee joint to the head of the racquet as the time of impact appraoched (Table 1). This table further shows that the lower limb drive producing knee and hip velocities are synchronised as are the shoulder and elbow velocities produced by trunk and upper arm actions. These actions are then followed by elbow extension and finally forearm pronation and wrist flexion. Groppel (1984) stated that elbow extension from the loop behind the back, forearm pronation and wrist flexion occur almost simultaneously. Jace et al. (1979), Gowitzke and Waddell (1986) and Van Gheluwe et al. (1987) in very detailed approaches to the question of the role of forearm prona-

tion reported that the velocity of the racquet prior to impact was increased by both pronation of the forearm and rotation of the upper arm.

Principle:

Rhythm is such a key ingredient of the service action that a well coordinated action will almost inevitably lead to an effective summation of body segments. The flow in this action is basically:

- lower limb drive (Figures 2 to 4)
- trunk rotation and upper arm flexion (Figures 3 to 5)
- forearm extension, forearm pronation, upper arm rotation and hand flexion (Figures 5 to 9)

TABLE **1**
Resultant **Maximum** Linear Velocities of the Hitting Arm in the Tennis Serve (Male and Female subjects)

	Velocity ms^{-1}	Time to impact (s)
Knee	0.8	0.10
Hip	2.2	0.19
Shoulder	3.0	0.14
Elbow	5.8	0.13
Wrist	12.8	0.09
Centre of Racquet	27.2	0.04

Modified from Elliott, et al. (1986)

7. *Racquet Trajectory for Impact* (Figures 8 to 9)

Research has shown that a serve is seldom hit flat at high speeds because the height of the impact above the court for players of average stature is too low to allow the ball to clear the net and land in the service court (Braden and Bruns, 1977; Elliott, 1983; Brody, 1985). Braden and Bruns (1977) stated that to hit the ball hard, on a straight line so that it clears the net by one to six inches and lands one inch inside the service line, the centre of your racquet must be ten feet in the air. Brody (1985) stated that if you serve the ball hard a little topspin can easily double your chances of hitting a good serve. Gravity, air resistance and forward ball rotation then all help to ensure that an appropriate trajectory occurs for a successful service. As gravity and air resistance are always present, forward ball rotation will provide the extra margin for error at tyhe net. The flat power serve in fact appears a misnomer for many highly skilled players. High performance adults hit a fast "flat" serve with a near vertical racquet at impact the tip of which moves in an upward line of approximately 4° from 0.05 sec., prior to until impact and then generally continues through along a horizontal line immediately following impact in an attempt to generate some forward ball rotation (Elliott, 1983). The highest **forward** ball rotation from the players in this study was caused when the racquet was moved with an upward trajectory of 5° prior to impact and continued with a 2° upwardtrajectory from impact to 0.05 sec., following impact (Elliott, 1983).

Principle:

An UP and OUT hitting technique must be emphasised in development of an efficient service action.

8. *Ball Toss*

While it is imperative that the ball toss be fitted into a rhythmical **racquet** action, the height of this toss has led to disagreement within the coaching literature. The height that the ball should be "pushed in the toss has proven a problem for both players and coaches as role models have used a variety of ball heights. Plagenhoef (1970) used high speed photography to show that the great majority of International tennis players filmed **impacted** the ball just after it had begun to drop (Newcombe and Trabert, **0** to 2.5 **cm** drop; **Seixas,** 2.5 to 7.5 cm drop; **Ashe,** 7.5 to 12.5 cm drop; **Gonzales** and Hoad, 15 to 22.5 cm drop). A mean ball drop prior to impact of 53 cm (1.7 feet) was recorded for four male and four female State level adults (Elliott et al., 1986). **Beerman** and Sher (1981) calculated that the ball remains at the peak of its flight when "pushed to the height of the "sweet spot" of the racquet for eight-fold the time it would remain at this point when projected 1.2 m above this point (calculations ignored air resistance). They further calculated that with a ball toss 1.2 m above the "sweet spot", you have to hit a ball moving at approximately 5 ms^{-1}. The servers in the study by Elliott et al. (1986) were required to hit a ball dropping at 2.2 ms^{-1}. The subject is Figure 9 allowed the ball to drop 23 cm prior to impact and was therefore required to hit a ball moving at approximately 2.1 ms^{-1}.

Principle:

The ball should be "pushed to the height of the "sweet spot" or top of the racquet when in the hitting position to impact a near stationary ball. Remember that this position will be higher than that attained by the outstretched racquet while standing on the ground, particularly if the server has a good lower limb drive.

9. ***Impact Height*** (Figure 9)

The optimal hitting height for any individual should be characterised by an extended body with the racquet at 90° to the court. The shoulder joint should be extended (approximately 140°) while the elbow and wrist joints should approximate 180°. Elliott et al. (1986) reported mean values of 138°, 156° and 157° respectively for male and female adults at impact. The Internationally ranked female in Figure 9 demonstrated a near ideal situation with a shoulder joint angle of 132°, and elbow joint of 170°, a wrist angle of 171° and a racquet angle of 90°, which produced a hitting position of 162 per cent of standingheight.

Brody (1985) using computer simulation, showed a strong correlation between the height of impact and success in the serve. At 40 ms^{-1} (90 mph) a ball hit at 2.7 m above the court has twice the chance of success of one hit at 2.2 m from the court. The harder the ball is hit the more important the height of impact is to a successful serve (Brody, 1985). To attain the higher impact position many players, as shown in Figure 9, leave the ground to impact the ball (Groppel, 1984).

Principle:

An off the ground hitting position created by a natural lower limb drive and summation of body segments is of benefit as it creates a higher impact position; however, if a purposeful upset service rhythm and be detrimental to performance.

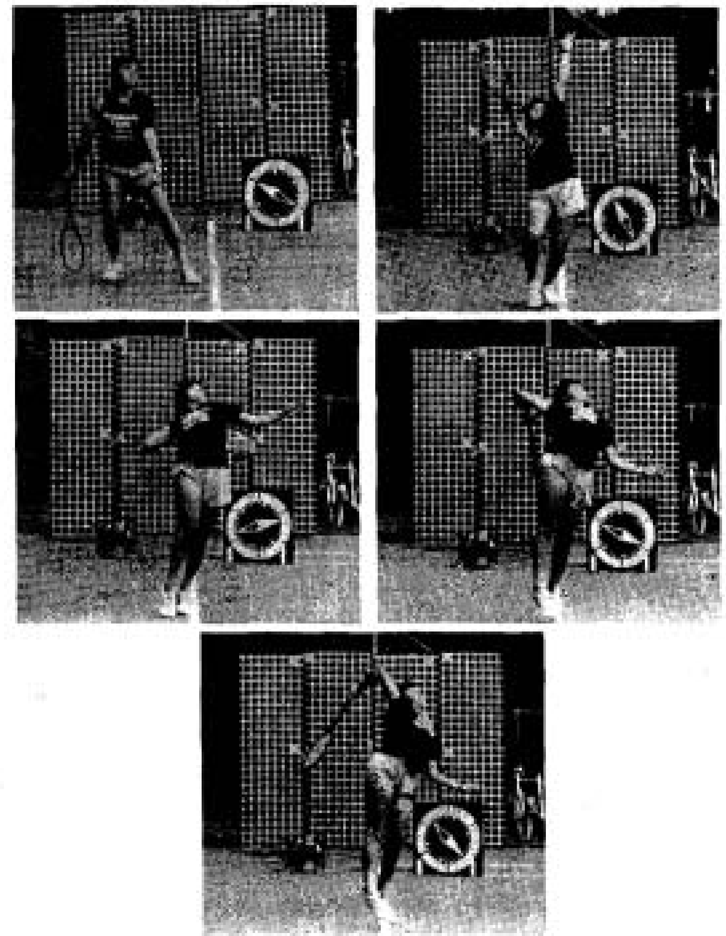
10. ***The Follow-Through***

An effective follow-through is necessary if optimal racquet velocity is to be achieved at impact and the racquet-arm is allowed to slow down gradually without undue risk of injury. Pronation of the forearm continues after impact, although the extent and timing may vary from player to player (Figures 9 to 10). Another question that must be addressed during the follow-through is, which foot should land first after impact? The server in Figure 11 lands on her left foot prior to starting her movements to the net by bringing her rear-foot prior to starting her movements to the net by bringing her rear-foot forward. No research evidence exists that would dictate which foot landing provides more power in the service, nor is any data available to suggest which technique would get the performer to the net faster (Groppel, 1984). The service action is completed with a racquet follow-through across the line of the body and total movement into the playing area.

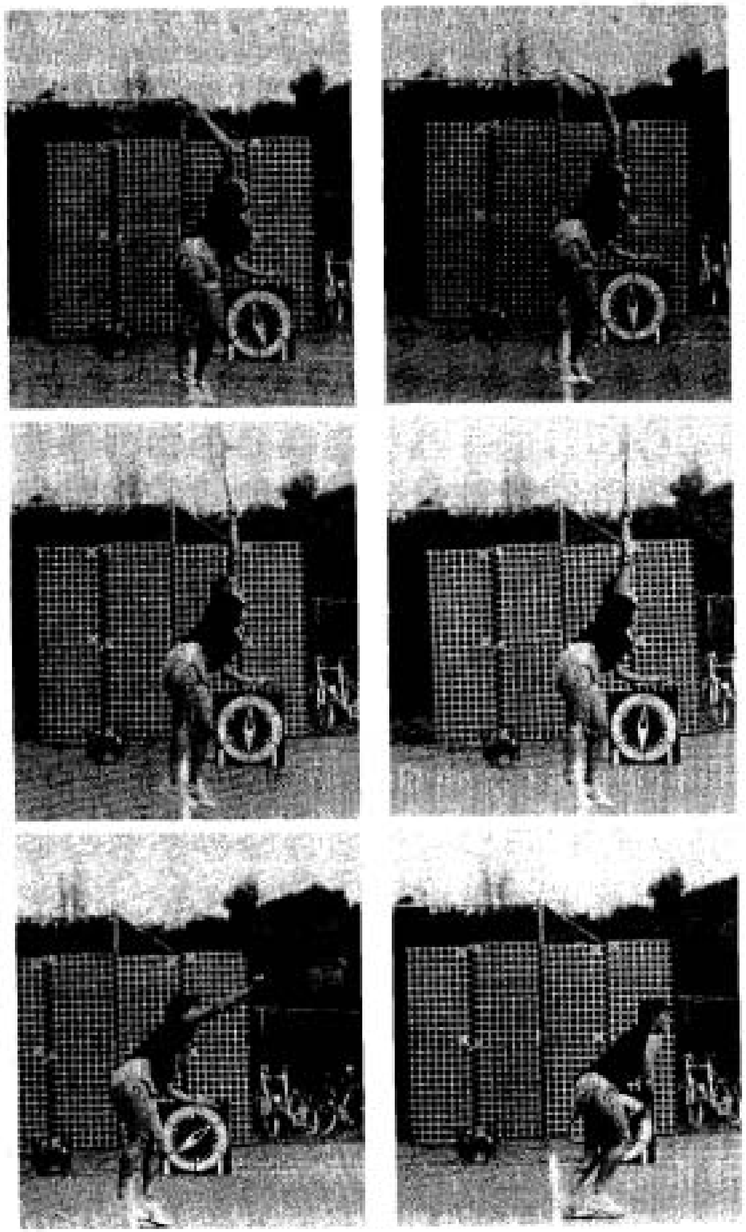
Principle:

A smooth follow-through that incorporates movement towards the net (if serve-volley game required) is an essential ingredient of good service technique.

Coaching of the tennis serve, like any skill, should be based on the individual flair and physical characteristics of the performer and the knowledge of the coach. Improved performance will occur at all levels when the mechanical basis of the skill to be taught are understood and introduced to the learning sequence at the appropriate time.



Figures 1 to 5: Sequence of service actions taken from film



Figures 6 - 11: Sequence of service actions taken from film

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