ASPECTS TO CONSIDER WHEN BUYING A RACQUET

Rubén A. Báez (1)

The article discusses the most relevant topics when purchasing a racquet, technical issues, economic, cosmetic, different types of strings, etc. I hope this article will be useful to those players eager to learn more about this topic.

www.TennisTop10.com

(1) Tennis Instructor (Argentine School of Tennis Instructors, Buenos Aires), Bachelor in Business Administration, Public Accountant, Post grade's degree in Finance Management and Capital Markets, MBA (IAE Business School, Austral University, Argentina).

INDEX

TECHNOLOGY

STRINGS

ASPECTS TO CONSIDER WHEN BUYING A RACQUET

Choosing a Racquet

When we go to buy a racquet there are a number of aspects that we must consider. It is not about buying the most attractive racquet or that it is using this or that player or the star of the club. First, whom has the decision must be aware the technical level of tennis that the player has, beginner, intermediate or advanced. Usually, when someone comes to buying his or her first racquet is usually a beginner so he or she does not have enough knowledge about the brand, size, weight, etc.

There are different models within each brand that could confusing the buyer. The first racqutet should not be very expensive as even the individual does not know his or her style of play and the parameters to consider in choosing the right racquet. If this person discovers that likes to play tennis and continues to progress in his/her knowledge and technique then the second time he or her acquire another tennis racquet will be much more aware of the characteristics of the product, either because his or her friends, colleagues or tennis teachers comment him or her practical aspects of the racquets or because the player is experiencing for himself or herself the feelings of the game. The player and the tennis instructor should discovering which playing style has the tennist, if someone performs better from the baseline, if he or she is good with volleys, if he or she is a strong player and hits very flat or with a lot of spin, etc.

All these aspects going to determine the profile of the amateurs and going to prepare them to purchase the second racquet. This article is aimed at those kinds of fans, intermediate and advanced, who have already knowledge which racquet is more suited to their style of play. Anyway, if you are a beginner tennist, these concepts will be useful for you to better understand the emphasis on the acquisition of the right racquet for each individual. As we move forward we will discussed these issues again.

Types of racquets

The racquets are made for beginners, intermediate and advanced players. Within these categories there is a wide variety of intermediate configurations. There is a racquet for each player, just trying to figure out the racquet that best fits his/her game and not choose the racquet that he/she likes due to it external cosmetic. You might like the racquet that is using Roger Federer for instance, but for your gamer profile could be convenient to use the model that is using Rafael Nadal. In addition, within each brand and model you can combine the string tension, string type, balance, weight, etc., and will have different configurations in this model since the same racquet with a certain balance has a different configuration as the same racquet with another balance, you can assemble your own racquet making it to control or concentrate more weight in the head and get a more powerful hit at the expense of more control.

There is a vast range of possibilities and you can choose one of them, that one that best suits your game or the stage of your learning curve.

Four types of racquets:
1) Power and Game Improvement Racquets
2) Control Racquets
3) Tweener Racquets
4) Junior Racquets

1) Power and Improved Game Racquets

Manufacturers use this name of racquet whose design is to generate power. These racquets are for the social tennist and there are a variety of them on the market. The head sizes are usually "oversize or super oversize" (106-135 square inches), they are very light racquets (226-284 grams), are longer than the standard of 27-inch (68.58 cm.) measuring between 27 and 29 inches (69 to 73.66 cm.)

These racquets are very stiff and their profile is quite wide (from 26 mm. to 30 mm.), this allows it to generate more power when hitting the ball. Another important aspect is the balance, the weight of the racquet is distributed mostly to the impact area for that reason they are called "head-heavy". Eventually, his balance is usually balanced with the head and the handle. They are designed for

players with slow and short swings (especially the drive) and they want to generate more power with less effort.

2) Control Racquets
Such racquets are used by professionals and amateurs with a high level of tennis. They are characterized to be heavy (311 grams to +368 grams), have small heads (85-95 square inches), frameworks with narrow profile (17-22 mm) making them more flexible. They are balanced for greater maneuverability and control so the weight is distributed mostly to the handle and are called HL (Head Light). The result is a racquet that has low power or bit bounce of the ball when it hits the strings. They are designed for players who are not interested in a racquet that generates great power, but in a racquet that allows greater control because the power is generated by the player himself/herself. This type of racquets are not recommended for beginners and even less for children or very young tennis players as they could cause serious injuries in the elbow, wrist and shoulders. There is an adequate racquet for each age, tennis level and body development. Do not be swayed by marketing and not buy a racquet that can cause injuries, besides the price of this kind of racquets is more expensive. If you are a parent who has a child less than 12 years old competing in tennis does not buy him/her a professional racquet yet. Otherwise, the child could suffer seriously injuries.

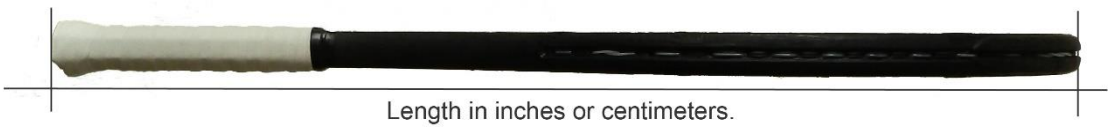
3) Tweener Racquets
They are generally lighter racquets (from 255 grams to 310 grams), balanced in a spectrum from head light to slightly head heavy, midplus size (93-105 square inches) and are usually longer than the standard of 27 inches (27.5 - 28 inches). The output power that offer these racquets is from medium-low to medium-high. These racquets are used by tennis players who are in a category between beginners and advanced level. They are advanced intermediate players without becoming professionals or very advanced in their game. These players look for better maneuverability and ball control.

4) Junior Racquets
The junior racquets have less than 27 inches (68.58 cm.). Usually they measure 21, 23 or 25 inches long. The head size is great for providing power to the young player whose age varies between 5 and 10 years old. These racquets are inexpensive and generally made of aluminum or titanium. Instead the racquets, designed for children whose age varies between 11 and 14 years old, the ranges of length are between 25 and 26 inches, are more expensive and they are made with the same components as the adult models. In this case the weight of the racquet should not exceed 290-300 grams as maximum with stringing included.

Figure 1
Parts of the racquet

Lenght
It is the length of the racquet measured in inches or centimeters.

Figure 2
Lenght of the racquet



Weight
The amount of grams or ounces it weighs a racquet.

Stiffness
The stiffness of the framework is the flexibility that it has. There are coefficients that measures this aspect.

Figure 3
Stiffness

Head size
It is the internal surface of the head of the racquet which holds the strings measured in squared inches or squared centimeters according to Table 1 sorted from minor to largest.

Table 1
Head size

Head Size	Squared Inches	Squared Centimeters
Midsize (Mid)	85 - 92	548 - 594
Midplus (MP)	93 - 105	600 - 677
Oversize (OS)	106 - 115	684 - 742
Super Ovesize (SOS)	116+	748+

BALANCE

Is the static measure of the weight distribution of a strung or unstrung racquet (Depends on the manufacturer's specifications). The balance is measured from the end of the handle in points, inches or centimeters. Commonly referred to as "points" HL (Head Light) or "points" HH (Head Heavy). A point equals 1/8 inch or the equivalent of 3.18 mm.

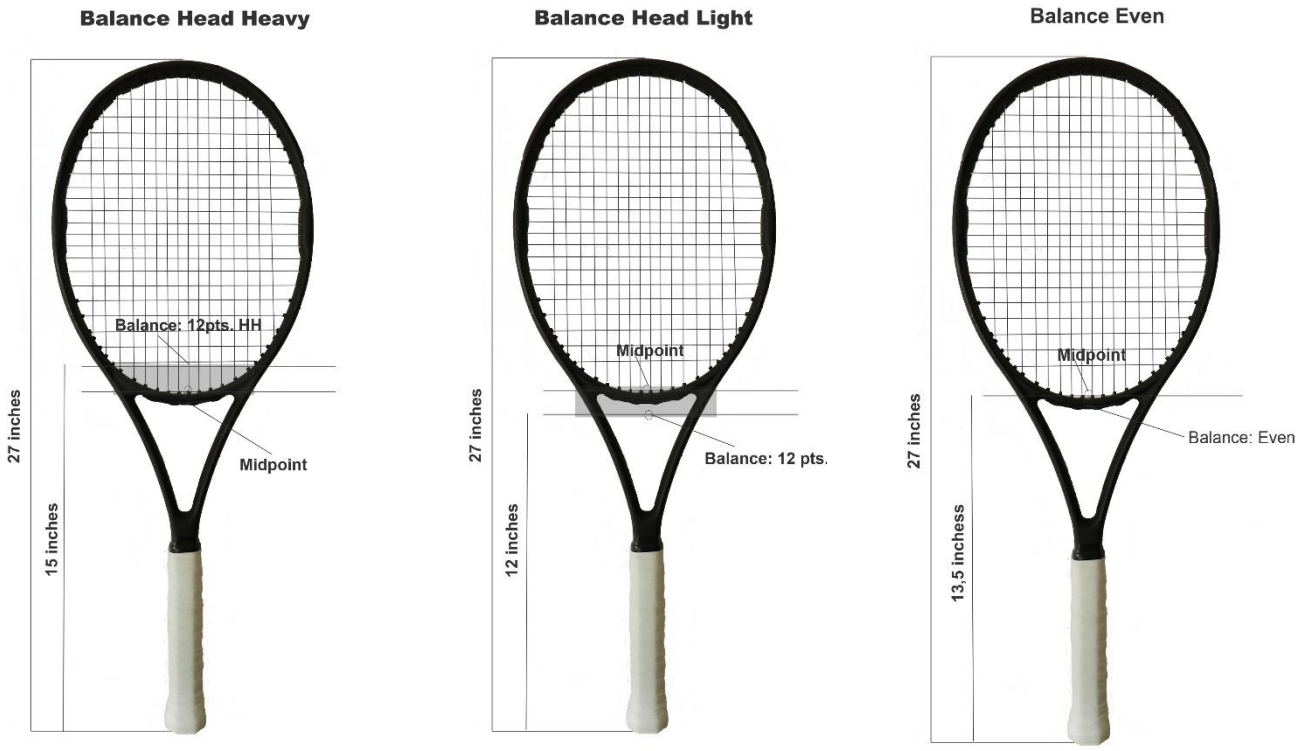
It must consider two measures to calculate the balance:

a) Measurement of the geometric center point of the racquet or midpoint. If the racquet measures 27 inches or 68.58 centimeters, the central point is 13.50 inches or 34.29 centimeters.

b) The other measure is the *static balance* or *point of balance* that affects swingweight, that is to say, the weight feeling of the racquet when we carry it forward or backward simulating a drive (See swingweight). It is measured by placing the racquet on a circular support that enables balancing the racquet until it is perfectly balanced, for example might be a circular bar of a pencil diameter. Two racquets can weigh the same but one of them can seem heavier than the other simply because the weight is distributed more towards the area of impact of the ball, for instance towards the head.

Generally racquets with heavy head (HH) its weight distribution is more concentrated in the head to give it more mass and power to the area of impact. On the other hand, in the racquets that prioritize control over the power of the impact are the head light (HL) relatively speaking and the distribution of weight is more concentrated toward the handle which gives you better control of the maneuverability of the racquet and the power is in charge of who executes the shot.

Figure 4
Balance



Generally, control or HL racquets are suitable for more experienced or advanced players because this type of racquet have heads with smaller impact surfaces that vary between 88 inches and 95 inches. It required a well-trained physical as they may arise injuries on the wrists, elbows and shoulders. As we will see below the output power of the ball depends on several factors including: the size of the head, the design and the length of the racquet, the strings tension, the gauge of the strings, the type of strings, string pattern, the weight of the racquet, the biotype of the player and his technique and the racquet balance, among the most prominent factors.

Now that we have explained these pair of concepts remains for us to know how the "balance" of a racquet is calculated. The measure of the midpoint in a) is easy, as we measure the length of the racquet and divide by two the result, that's a fact. The other datum is calculated as the measure of the static balance or *balance point*, this is measured from the end of the handle to the point measured in b) which is when the racquet is balanced on a support (pencil, circular stick). Once we have these two measurements simply we should calculate the difference between the two and the result is the racquet balance. Namely,

If the **balance point** is greater than the **midpoint** = **HH** (Head Heavy)
If the **balance point** is minor than the **midpoint** = **HL** (Head Light)
If the **balance point** is equal to the **midpoint** = **Even**

Here's an example:

- Balance HH (Head Heavy):
  - Lenght of the racquet: 27 inches
  - Midpoint: 13.5 inches
  - Point of balance: 15 inches
  - Balance: 1.5 inches or 12 points HH

- Balance HL (Head Light):
  - Lenght of the racquet: 27 inches
  - Midpoint: 13.5 inches
  - Point of balance: 12 inches
  - Balance: 1.5 inches or 12 points HL

- Balance Even:
  - Lenght of the racquet: 27 inches
  - Midpoint: 13.5 inches
  - Point of balance: 13.5 inches
  - Balance: Even

Remember that the balance can be specified with strung or unstrung racquet according to the specifications of each particular racquet. Generally, the racquet balance from factory is unstrung.

Head Heavy Racquets
As we mentioned in the previous point, the HH racquets are those whose weight is distributed towards the head. Generally, are racquets whose head is greater than 100 inches, are more light relatively speaking and whose purpose is that the greater amount of mass is concentrated in the impact zone or sweetspot. In the tennis parlance it says that such racquets have "more bounce".

Head Light Racquets
Are those racquets whose weight distribution is oriented toward the handle for the purpose of giving greater control when someone hits the ball. This type of HL racquets are more heavier and their heads are between 85 and 98 inches, for the other hand, the smaller surface of the head gives a "lower rebound" than a HH racquet. In this case, given a certain string tension, the power that it need to transfer to the impact of a HL racquet for the ball to comes out at the same speed as a HH racquet must be greater, this action is in charge of the player. Of course there are other factors that influence the speed of the ball, these concepts will be seen later.

Swingweight
Is a measure of the feeling of how heavy feels a racquet when it rotated, that is to say, its ability to maneuver. This aspect is also known as Second Moment of Inertia. The swingweight depends on several factors, including the weight of the racquet, length, balance, and head size. As a general rule, a racquet with a heavier swingweight than other with a lighter one will be more powerful, but will be less maneuverable. The swingweight can be increased by adding weight above the balance point or increasing the length. The swingweight cannot be reduced unless the added weight is eliminated it or decreasing the length of the racquet.

The swingweight is measured by a number (calculated by the manufacturer). While greater is this number greater the stability of the racquet. On the other hand, while lower this number, the greater the maneuverability of the racquet. In general, when the higher is the swingweight more powerful will be the racquet.

Another way to analyze the swingweight is like a measure of the resistance that the racquet opposes when is rotated around an imaginary axis passing through the palm. A low swingweight allows for better maneuverability to the player to swing the racquet. But it also makes it easier to move the racquet by the ball impact, resulting in a loss of power. The movement of the racquet is the major cause of the loss of power in the impact. The swingweight is determined both by the amount of mass as by its distribution on the racket (the distribution is more important). The more amount of mass is concentrated at the head, the greater the stability of the racquet.

Summary:
A lesser swingweight + maneuverability - power impact - stability
A greater swingweight - maneuverability + power impact + stability ➔ Hammer Effect

Grip size
Measure of the grip circumferenceip. Standard sizes of grips vary in a range between 4 1/8 and 4 5/8 inches (Table 2). The most accepted method to measure the appropriate size of the grip is hold the handle with Eastern grip, also known as "Shake hands", which is the same side of the handle that is on the same plane of strings (Figure 5). The optimal size of the grip allows to fit the index finger of the left hand (or right if left handed) between the ring finger and the palm of the right hand that is holding the racquet. If the index finger does not find enough space means that the grip is too small. Conversely, if the index finger has much space between the ring finger and the palm of the hand the grip is too big. A too small grip will require more muscle strength to avoid the racquet spin in the hand after the impact (see Figure 6).

Prolonged use both a very small grip as one too large may cause injury to the elbow (tennis elbow).

Another way to measure the correct grip is with a ruler with an open hand and fingers extended together, place the ruler resting on the lower side of palm (area above the thumb) aligned with the ring finger (see Figure 7). Obviously, the preference of each player allows exceptions to this rule. The diameter of the handle can increase but can not decrease, so it is advisable to start with a smaller handle and increasing it to go to the most comfortable position for each player.

Figure 5
"Shake Hands" grip

Figure 6
Optimal grip size

Figure 7

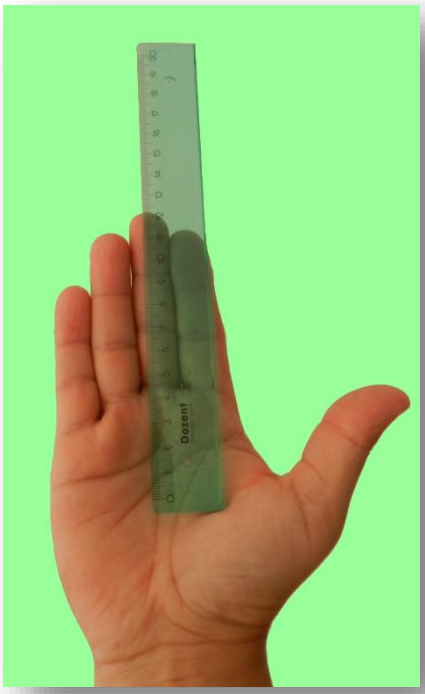


Table 2
Grip sizes (inches)

U.S.A.	Europe
4	0
4 1/8	L1
4 1/4	L2
4 3/8	L3
4 1/2	L4
4 5/8	L5
4 3/4	L6

FRAME

Frame/Cross section

There are different types of profiles racquets that give them different characteristics. These features relate to both the cross section as the height of the frame profile. The profile is what shapes the frame to where the extremes are joined at the handle. Basically there are two types of profiles:

a) *Constant cross section.* The cross section is of constant height, uniform and thin cross section too, leading to greater flexibility in its frame and its strings pattern. This aspect allows that the time of contact of the ball with the strings is greater and this improving control and sensitivity.

   Racquets with this type of framework, generally, are designed to the competition because they favor speed and acceleration and have more mass than average.

b) *Variable cross section*. Frameworks that have different heights in their thickness.

Generally, racquets with a narrower frame, for instance 21 mm. offer less power but have greater control. By contrast, a racquet with wider frame, for example of 26 mm. possesses greater potency but less control. In turn, if the thickness of the frame is variable exists a variety of configurations of power and control (Figure 8).

The flexion of the frame at the time of impact with the ball dramatically affects the power level of the racquet. A frame with increased rigidity absorbs less energy of the ball which results in a greater bounce for it because it must add the energy that the player hits the ball plus the energy that is not absorbed by the racquet, besides this kind of frames offer a lower degree of control on the ball.

It would be appropriate to clarify an aspect that seems a contradiction. People often think that a racquet with a relatively more flexible framework, when to bend it over backwards in contact with the ball would impart greater power output for a catapult effect.

This is wrong , as the ball, according to field observations, remains between 3-5 milliseconds in the stringing and this time is smaller than the time that the frame takes to recover its original position. The instant that the frame reaches the maximum flexibility on the impact, the ball has already left from the stringing. This leads to the conclusion that the frame of a racquet does not give energy to the ball, so that it absorbs greater or smaller energy that the ball brings depending on the ratio of the stiffness of the framework. To have even clearer idea, imagine when you are practicing in the fronton. The ball bounces off the wall which absorbs a certain amount of energy and returns the ball at a certain speed. If the wall

of the fronton would be of a soft or flexible material, the wall could absorb more amount of energy from the ball bouncing at a lower speed than in the first case. The wall of the fronton does not return energy to the ball, only absorbs energy from the ball that will be higher or lower depending on the stiffness of it.

Figure 8
Flexibility of the framework

In addition, the stiffness of the framework not only has an impact on power, but also affects the control and the feeling of comfort. Generally, a racquet with more powerful impact provides a lesser degree of control. Another factor to consider is the type of player that hold the racquet, depending on his or her skill level, if he or she is an advanced level player may prefer a more flexible racquet (which generates less power at impact) because he or she will be responsible for generating more power with his swing and technique. A racquet with too much power (stiffer frame) for these players could cause too many unforced errors as long or wide balls. If the player is a beginner or intermediate level, a racquet with a stiffer frame it may be more appropriate because the player does not need to generate too much power, is the same racquet that generates the extra power to the out of the ball. Also some advanced level player could want to use this type of racquet with greater stiffness, but surely his or her back swing should be shorter and compact. This would apply to an advanced player but with little muscular power, in this case he/she need a powerful racquet.

Rigid racquets are less comfortable than racquets with more flexible framework. Thus, what we have mentioned, a stiffer frame absorbs less energy on impact with the ball, thus more energy is transmitted to the wrist, elbow and shoulder that a racquet with a more flexible framework. Regarding the feeling of comfort depends on each particular player, because each one has a different feel.

Finally, another aspect is the amount of effects that can be generated. Generally one could say that the stiffest racquets provide fewer effects than the more flexible ones because the ball remains less time in the stringing. Of course, there are other aspects to consider, such as the string tension, the type of strings, player skill, but leaving constant all these aspects and circumscribing only stiffness, it is true that a more rigid frame gives more power, less control and therefore less effects on the ball.

General information on the frames

- A heavier frame generates more power.
- A heavier frame vibrates less.
- A heavier frame has a larger sweet spot.
- A stiffer frame generates more power.
- A stiffer frame has a larger sweet spot.
- A stiffer frame transmits more of the shock load to the arm than a more flexible frame.
- A stiffer frame provides more uniform response through the entire stringing.
- A larger frame generates more power.
- A larger frame is more resistant to twisting.
- A longer frame generates more speed and therefore more power.

Torque

Is a flexure that affects the framework from one side to side when the impact is outside the sweet spot (see "Polar Moment of Inertia").

Swing Speed

It is the speed that usually someone hits the ball from the baseline, which is an important factor when choosing the power of the acquired racquet. If the player has a short backswing is more likely to need a framework of great power. On the other hand, if the backswing is wider a racquet that bounces too much on the impacts it may not be advisable, also a racquet with much power adversely affects the control of the ball impact. An alternative would reduce the power of the racquet with an increase tension of the stringing, but the risk here in this case is that the vibrations of impacts are totally transmitted to the arm. You must find the right racquet for each biotype of player and skill level.

Polar Moment of Inertia or Swing Weight (Twist Rate)

It is also known as "oscillation of weight" or "swingweight". How stable is a racquet on off-center impacts, including his resistance to twisting. A racquet with a large polar moment of inertia will be more resistant to twisting on off-center hits. The larger the size of the racquet head, the greater the polar moment of inertia. The oversize racquets usually have a large polar moment of inertia and better resist the torsion than racquets with smaller heads. The polar moment of inertia can be increased by adding weight to the 3 and 9 (Figure 9) or increasing the size of the grip or handle to a point that become comfortable. Remember that adding extra weight will change the configuration of the racquet, not only in weight but will also affect its balance and swingweight.

Figure 9
Additional weight at 3 and at 9

Coefficient of Restitution
It is the relationship between the rebound velocity of the ball (post-impact) and the velocity of incidence of the ball (pre-impact) on the racquet. The area of the sweet spot is the point of greatest coefficient of restitution where the ball will bounce faster The coefficient of restitution is between 0 to 1, while closer to 1 the larger the bounce of the ball. It stands to reason that the same racquet, with the same balance and the same type of strings can have different coefficients of restitution varying the stringing tension. For example, some professional players typically use two racquets, one for receiving the serve and the other to kick, supposedly the difference between the two is the coefficient of restitution. This coefficient is measured by fixing the racquet with some device. If the racquet is held by a player, the coefficient of restitution is close to the top of the throat. When the ball hits the racquet this is flexed and part of its force is absorbed. When further from the handle hits the ball, greater is the flexion on the structure of the racquet and a greater amount of energy is dissipated, therefore, less energy is transferred to ball rebound. That is the reason why the coefficient of restitution is close to the top of the throat of the racquet.

Vibration Frame
This is the oscillation of low frequency experienced by the player after the racquet has impacted the ball. Stiffer racquets least dampen vibrations than flexible racquets. Do not confuse this type of vibration with the vibration of strings, because the vibrations of the frame are of shorter duration and can not be reduced by using anti-vibrators placed in the stringing. The impacts on the "sweet spot" have the lowest rate of

vibration than anywhere else in the stringing. To reduce such vibrations one should adding weight and strung with a medium tension, but in any case, the vibrations can be reduced by using rubber devices.
The manufacturers, as the racquets are becoming lighter, try to improve comfort without increasing the weight significantly. Today is incorporated inside the handle of the racquet a system vibration damping and shock.

Shock Frame (Impact with the frame)
This is the initial high amplitude oscillation (shake) that a racquet experiences during or immediately after impact with the ball. Not to be confused with the vibration of the frame. The impact with the framework contributes to cause more injuries in the wrist, elbow or shoulder that vibrations of the framework. The magnitude of the oscillation will depend on the size of the racquet, the head size, the frame stiffness and string tension basically. Larger racquets with flexible frames and less tension in the stringing tend to lessen the effect of impact with the frame. Therefore, the impact transferred to the hand and arm due to decentered hits is less than with smaller racquets, more rigid and greater relative tension in the stringing. Some racquets models have technology to reduce these impacts before being transferred to the hand. If the impact is made in the area of the "center of percussion" or "sweet spot", this type of vibration does not affect the player.
One way to lessen the impact with the frame, once you have acquired a racquet, is adding weight to the frame, lower the strings tension using a thinner gauge for strings and increase the handle size adding another overgrip without sacrificing comfort, in order to eliminate or reduce the torque. Remember that anti-vibrators have no effect in reducing or absorbing the impact with the frame.

Shock
Force that is transmitted from the hand and arm to the ball impact.

Butt Cap
This is the lid of the end of the handle that is usually made of plastic. Often include the brand logo of the racquet and is often used to determine the order of serve doing spin the racquet. It usually has a notch to remove and add weight to the handle.

Figure 10
Butt Cap and handle

Constant Taper Beam
It is when the profile of the racquet frame remains constant the tapered thickness along it (From the head down by the shoulders until the beginning of the handle).

Contoured Beam
Frameworks that have a constant profile, double cone, or different thicknesses designed to optimize the balance between power, cushioning and control.

Dual Taper Beam
It is the variable width of a racquet that is viewed transversally. In this case, the racquet frame is thin (head) - width (shoulder) - thin (throat + shaft). This tapered design maintains the stiffness of the racquet in the main area where it bends during ball impact.

Racquet Head
It is the part of the racquet that contains the stringing and ends at the top of the throat.

Shoulders
Part of the racquet that goes from the top of the throat to the lower part of the head.

Shaft
The handle portion between the throat and the grip and is very short.

Throat
It is the part of the frame structure that joins the head with the racquet handle. It is the triangular part where often are placed, on the inner side, the technical specifications of the racquets such as: weight, balance, head size, recommended tension, string pattern, recommended strings, etc.

Comfort
The racquet's overall effectiveness at protecting your arm from the forces of the ball's impact, including shock, vibration, and the turning forces that are diminished with greater stability.

Forgiving Racquet
A racquet is often called forgiving if, on off-center hits, it transmits less shock to the arm or produces less unpredictability in the direction of the rebound of the ball. A flexible racquet is more forgiving to the arm, whereas a stiffer one is more forgiving to the shots, so the term is sometimes used in contradictory ways. A racquet with more stability, however, is more forgiving in both senses.

Maneuverability
This term refers to the speed and ease with which a racquet adjusts its position during the game. This is particularly important in the area of the net, where the racquet movements are essentially fast.

Stability
The stability of a racquet can be measured as its polar moment of inertia, which is its resistance to torsion or twist on off-center hits. A more stable racquet imposes less strain on the arm and sent the ball toward a more predictable direction. Generally, a wider impact area and a heavier head contributes to greater stability. The weight added to the head positions of 3 and 9 (at the tip is at 12) is most important, but a head that is heavier in general, will also be heavier in these positions.

Damping
It is the ability to reduce the impact and vibration of the frame before they reach the hand and elbow. This can be achieved by some kind of device that reduces the vibration, which is typically located in the handle. The weight of the racquet influences the decrease of ball impact and vibration. The degree of stiffness of the racquet also has influence in reducing the impact on the frame and vibration.

Drill Flash
It is the residue of material left on the inside of the frame as a result of drilling thereof, friction or deterioration of the holes. Many racquets have a cap at the end of the handle to facilitate removal of these residues. If the racquet does not have this cap should remove the stringing and grommets strip to remove waste through the holes of the frame. Generally, racquets come without drill flash, manufacturers have already taken this into account.

Resilience
This term is related to the "elasticity" of the stringing and is applied to measure the response of the same. A stringing has greater elasticity when providing greater speed and power to the ball. With the passage of time, the stringing gradually lose elasticity and each time print less power and speed. This aspect of loss of elasticity causes the stringing lost its original effectiveness.
That is, the elasticity is the speed at which a stringing is returned to its rest position after the impact with the ball. This term refers to the stretch of the strings. This will depend on certain factors, namely the thickness or gauge of the strings, the material they are constructed (natural gut, nylon, kevlar, aluminum, polyester, etc.), the design of the strings (multifilament, monofilament, composite, textured, etc.) and the strings tension. The stringing when diminishes its tension and elasticity over time and use, involves the player to experience a greater effort to get similar results on the impact of the ball. In addition, there is a decrease in the control of the shots because the stringing is gradually being "lax" and "less elastic" so the racquet bouncing "more" with which one could lose that feeling of comfort in the impacts that has a new stringing.

First Moment of Inertia
Also known as "weight to lift racquet" (I am not sure if it is the correct translation). It is the feeling that you feel when lifting the racquet by the handle. It is a rough static measure of the racquet maneuverability depending on its weight and balance. There is a formula to calculate the first moment of inertia: Weight (grams) x Balance (in centimeters measured from the end of the handle) divided by 100. For example: 339 grams (12 ounces) x 30.5 cm (12 pts HL.) /100 = 103.4 grams/meter. For this particular racquet the first moment of inertia is 103.4 g/m.

TECHNOLOGY

Titanium
Titanium is a metal used for racquet frames, offering high ratio stiffness/weight with multi-directional force. Often mixed with graphite, whose strength is dependent on the orientation of its fibers. The racquets built with titanium have a market price set in a range from low to medium.

Graphite
The graphite used in the racquet frames is not the true graphite that you might find in a pencil for example, but this carbon fiber adds stiffness and resistance to plastic resin when is mixed to form a frame. Due to its high ratio stiffness/weight, the graphite is the material more used for racquet frames between a range from medium prices to high prices. When a racquet is made only of resin and graphite, is said to be 100% graphite, although the plastic resin represents at least 40%. If other materials are used, the frame is called a compound.

Composite
It is the combination of materials used for the construction of frameworks, more commonly from graphite and fiberglass, sometimes also with other materials such as titanium and Kevlar, mixed with plastic resin. The rigidity and cost of framework components depend on the exact mix of materials.

Fiber Glass
Fiberglass is one of the materials that are used for the construction of racquets, but rarely a racquet will be built only fiberglass, it is very flexible material for most players.

Ceramic
Ceramic materials are used in some composite frames, together with graphite. They provide stiffness, but its weight and fragility have limited their use.

These are the compounds most commonly used in building frames racquets.

STRINGS

Tension

The tension of a strung racquet is almost always less than the tension indicating the stringing machine. This is because the strings are stretched in most cases. Therefore, a strung racquet with a certain tension (as measured by the stringing machine) can actually get from 5 to 10% less tension, for example, depending on the size of the racquet, the strings and the type of machine used.
Another important aspect to consider is the influence that has the string tension in controlling the impact with the ball. In general,

Lower tension => less control at impact => higher power output of the ball
Higher tension => greater control at impact => lower power output of the ball

Sweet Spot

It is the area of the racquet stringing that offering the highest power and precision of ball impact with the least amount of vibration of the racquet. There are three (3) types of sweet spots,

a) *Center of Percussion:* offers the least amount of initial hit to the hand that hits. The initial shock or impact is considered potentially more damaging cause to the player's arm.
b) *Nodal Point:* The area of the stringing that produces the least amount of vibration at the time of impact with the ball. The vibration of the frame is what the players feel after impact with the ball (oscillation of low level) in certain racquets (usually more flexible). This type of vibration do not have the same risk of injury as referred to in point a), in fact there are technologies that can effectively reduce this type of vibration.
c) *Maximum Coefficient of Restitution:* Also known as the Power of the Racquet, is what produces less vibration of the three.

The sweetspot location is determined by several factors, the weight of the racquet, balance, head size and stringing tension.

Elasticity

It is a term often used to describe the ability of the stringing to return to its initial position after hit the ball. Factors that influence this aspect are the material of the strings (polyester, natural gut, titanium, etc.), construction (monofilament, multifilament, etc.), the gauge of the strings and the tension among the main factors. With the passage of time the stringing loses tension and elasticity so it will require more effort from the player to hit the ball.

Hitting Area

It is the measure, in squared inches or squared centimeters, of the area corresponding to the stringing, that is, the entire area occupied by the strings in the racquet head. Within this area there are three different "sweetspots" (see Sweetspot) to obtain maximum power, less impact and less vibration.

Bumper Guard

It is a piece of plastic, usually attached to the eyelet strip that protects the outside of the frame in the upper half of the racquet head from bumps and scratches in that area.

Main strings

The main strings are those located longitudinally in the racquet head. In general, are the strings that suffer most from the impacts and they break more often because they have the greatest displacement or friction.

Cross Strings

The cross strings are those that are located horizontally on the racket head.

String pattern

The string pattern is an aspect that some players pay little attention to when choosing a racquet. Each racquet has its own string pattern, ie, the amount of vertical and horizontal strings that comprise it. The

size of the spaces formed by the main strings and the horizontal is what is known as density of string pattern. The greater are the spaces of the stringing more "open" is the string pattern. While smaller the spaces of the stringing more "dense" or "closed" is the string pattern.
An open string pattern will print with a more power to the ball when it will be impacted and also will allow it to sink deeper in the stringing contributing to increase the topspin effect. Conversely, a denser string pattern will allow greater control over the ball than a more open string pattern and the strings will move least during the shocks providing a minor output power to the ball. This is important to keep in mind for those players who like to hit the ball with great topspin effect, in this case the life of the strings depends of the stringing pattern, tension, type and gauge of strings between the most relevant aspects.
A racquet with a string pattern more "open" will cut the strings more often, because they suffer more friction or movement during its lifetime. The opposite happens with a racquet with a "closed" string pattern, the strings have less friction and therefore last a relatively longer period of time.

In general:
Dense or closed string pattern: 18 (mains) x 20 (crosses)
Moderately closed string pattern: 16 (mains) x 19 (crosses)
Moderately open string pattern: 16 (mains) x 18 (crosses)
Open string pattern: 16 (mains) x 15 (crosses)

Gauge
Thinner gauges offer more capacity of recovery (often associated with the "feel"). Thicker strings have longer life. Strings gauge 15 are usually used in racquets for beginners and some intermediate. Most players do not like frequently stringing used gauges 16, 17 and 18 that are for those who can afford an expensive stringing. Each gauge has a tolerance that is a little thinner.

Table 3

GAUGE CONVERSION

U.S.A.	Europe	Inches	Millimeters
13	12	.065 - .071	1.65 - 1.80
14	11	.059 - .065	1.50 - 1.65
15	9.5	.056 - .059	1.41 - 1.49
15L	9	.052 - .056	1.33 - 1.41
16	8.5	.050 - .053	1.26 - 1.34
16L	8	.048 - .051	1.22 - 1.30
17	7.5	.046 - .049	1.16 - 1.24
18	7	.042 - .046	1.06 - 1.16
19	4	.035 - .042	0.90 -1.06
20	3.5	.031 - .035	0.80 - 0.90
21	3	.028 - .031	0.70 -0.80
22	2.5	.024 - .028	0.60 - 0.70

There are currently three types of measurements for the string gauge, the standard of USA, European and measurement in generic millimeters. In the standard measure USA while higher is the number assigned to the string thinner is its gauge. Most tennis strings are 15-17 gauge, although some are less frequent like 18-20 gauge. The higher the gauge number, the thinner is the string and is usually measured in millimeters and is represented by the letter "L" (Light). A gauge 15L is between 15 and 16. A thinner string contributes to better sensitivity, power and rotation effects for the ball that a heavier gauge string of the same material and construction. Although the industry has attempted to standardize the specifications of the gauges, there has been no explicit agreement between manufacturers, at least globally. This means that strings of 16 gauge, for example, are not made equal for the different brands. The string 16 gauge of a certain manufacturer can measure 1.28 mm, while the same gauge and type of string manufactured by other may have a significantly difference with regard the first. Each type of gauge has ranges of tolerance in the manufacturing. In the case of a 16 gauge string the tolerance range is set between 1.26 mm and 1.34 mm (see table 3).

Hybrid Strings
Hybrid stringing are those that combine different types in the main strings and the cross strings. A hybrid stringing is used to increase the playability and durability in function of a desired or expected result. A common hybrid is to use an aramid fiber for the main strings combined with a synthetic for the cross strings. A hybrid assembly like this is for those chronic strings breakers. A "softer" hybrid uses polyester

for the main strings and synthetic for the cross strings. Another hybrid configuration could be used natural gut for the main strings and synthetic for the cross strings. Hybrids can also be imagined for any configuration, from the simple use of different gauges for the main and cross strings combined with different hybrids mentioned above. Hybrids offer the player a new world of options.