International Tennis Federation

COACHING & SPORT SCIENCE REVIEW

The Official Coaching and Sport Science Publication of the International Tennis Federation

Editorial

Welcome to issue 45 of the ITF Coaching & Sport Science Review.

This is a monographic issue of the ITF Coaching & Sport Science Review, which is devoted to Technology in tennis. In preparing this issue we have collated articles from coaches and experts with more than 40 years experience and who are at the forefront of the sport science research in applied technology in tennis. The tennis experts who have contributed to Issue 45 include:

- Paul Lubbers (Director of Coach Education and Sports Science, USTA).
- Peter O'Donoghue (Cardiff School of Sport - Performance Analysis Department).
- Machar Reid (Sport Science Manager, Tennis Australia).
- Bruce Elliott (Head of School of Sport Science, Exercise and Health, University of Western Australia).
- Mark Kovacs (Sport Science Manager, USTA).
- Heinz Kleinöder (Professor at the German Sports University of Cologne).
- Alexander Ferrauti (Professor in applied training science, Bochum University).
- Brenden Sharp (New Media Expert).
- Crawford Lindsey (Tennis warehouse).
- Vicente Calvo (Conditioning Coach of Fernando Verdasco).
- Roberto Forzoni (National Performance Psychologist, LTA).
- Plus ITF staff, including Luca Santilli (Manager, Juniors & Seniors Tennis), Stuart Miller and Jamie Capel-Davies (Technical department) and Scott Over (Assistant Research Officer).

We would like to extend our gratitude to them for their help with this issue. The articles cover tennis technological advances in many areas related to tennis including education, psychology, court surface testing, performance and technique analysis, physiological testing and conditioning, and we believe that this information can help coaches in developing themselves and their players.

The programmes for the five 2008 Regional Coaches Conferences, commencing with the first in San Salvador in September, can all be found on the ITF coaching weblet as well information on how to attend. The ITF are pleased to announce that the keynote speakers include Bruce Elliott, Machar Reid, Doug MacCurdy, Gustavo Luza, Paul Roetert, Carl Maes, Bernard Pestre, Antoni Girod, Kenneth Bastiaens, Mike Barrell and Sandi Procter. For your information presentations from previous regional workshops can be found on www.tennisicoach.com .

Tennis...Play and Stay continues to evolve and in November a Play and Stay seminar will take place in London for invited national federations to attend. The seminar will focus on examples of best practice highlighting how the campaign has progressed since it's launch and how national associations can further enhance their programmes. In addition the campaign's website, www.tennisplayandstay.com has recently been updated with a wealth of new articles and videos to help coaches and federations in more effectively introducing tennis to starter players. More information related to the seminar can be found on the website.

Finally, we hope you continue to take advantage of this and other resources provided on the weblet (http://www.itftennis.com/coaching/) and that you enjoy the 45th issue of the ITF Coaching Sport Science Review.

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The Use of Technology in Tennis Biomechanics

Bruce Elliott (University of Western Australia) and Machar Reid (Tennis Australia)

ITF Coaching and Sport Science Review 2008; 15 (45): 2 - 4

ABSTRACT

This paper highlights the importance of biomechanics and related technology within tennis. The clear difference between descriptive and objective technologies are discussed, along with a comparison of the individual functions of different technologies. In addition the article provides an insight into the variety of computer programs, cameras and equipment available and used by coaches, and sport scientists to develop effective stroke production.

Key Words: Technology, biomechanics, tennis, mechanics.

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INTRODUCTION

Success in tennis is greatly affected by the technique that a player employs. Biomechanics underpins technique and so is integral to this aspect of play. Technique analysis, and ensuing intervention, is the primary responsibility of the coach and requires the allocation of greater or lesser time depending on the player or his/her stage of development. The use of technology in achieving the most effective player performance is nonetheless important from beginners to professionals, yet the specific technologies used likely vary with the individual player's stage of development.

Technology may assist in better describing movement, or it may provide a quantification of movement, both of which can play a part in performance enhancement. However, coaches need to remember that stroke or movement analysis must still follow the process advanced by Elliott and Knudson (2003), where recommendations for change should be based on a comprehensive performance assessment (e.g. physiological - make-up;physiological-fitness/flexibility; pedagogical - stage of learning) in combination with the tactical style of play being developed by the player. Technologies typically used in biomechanics will be presented, with their application to player development discussed.

DESCRIPTIVE TECHNOLOGIES

1. Standard (typically 25 pictures/s) / high-speed =100 pictures/s) digital video linked to the 'eyes'

The human eye needs assistance with capturing all the elements of high-speed stroke production. Feedback based on standard digital videography, while effective with young players may not service the needs of the professional. These players generate comparatively higher racquet speeds so to best analyse and understand the related stroke mechanics; video that captures higher speed footage is required. The ability to present individual images or image sequences and discuss observed features of stroke production, if a correct analysis format is followed, can be a great assistance to all players.

Standard digital video may also be used with graphic software packages (e.g. Flash) to present sequences of images, with a voice overlay that graphically highlight selected aspects of performance. These greatly enhance a player's understanding of stroke production. An article in the New York Times demonstrates this very effectively for recent French Open Winner Anna Ivanovic's service action.
(http://www.nytimes.com/interactive/2008/05/26/sports/playmagazine/200805227_IVANOVIC_GRAPHIC.html)

2. Performance analysis technologies

a. TimeWARP: This system typically allows you to watch delayed video playback of a movement immediately after it is performed. While feedback is being provided for one player, the videoing continues of other aspects of player performance. These programs permit selected sequences to be saved and exported for future reference.

b. SportsCode and Snapper: These are performance analysis packages that permit video to be coded, such that selected shots or shot sequences can be identified and then recalled for inspection. The effectiveness of forehands hit down-the-line from a cross court return may be identified and reviewed.

c. Hawk-eye tracking: The introduction of 'hawk-eye' at Grand Slam and Masters Series Tournaments has provided a unique opportunity to better understand a number of aspects of stroke production, in addition to acting as a very precise method of determining line calls. The tracking of any data linked to the ball may be collected so that temporal and spatial information of interest, including the height of impact, ball velocity and rally duration over an entire match can be provided to the coach.

3. Standard/high speed digital video linked with 2D software package

Feedback has certainly improved from simple viewing of albeit slowed down motion presented above, when coaches were able to link video to a computer loaded with sport analysis software (e.g. Siliconcoach, Dartfish, Swinger, NEAT and Quintic). These programs permit video to be slowed in presentation, create linked image sequences, highlight important aspects of performance and enable 2D data (first stage of quantification process) to be measured from the video. The ability to import files allows comparisons of your player with others, who may display a stroke characteristic that you wish to emphasise - as shown in images below (courtesy of Siliconcoach).

OBJECTIVE TECHNOLOGIES

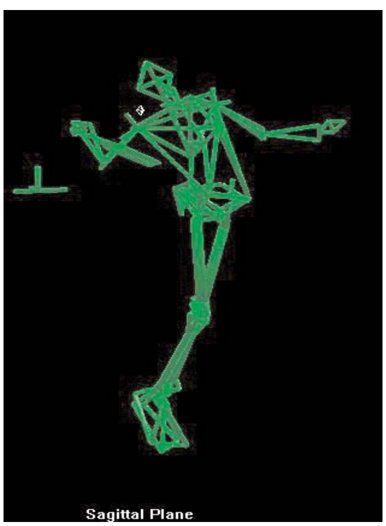
1. 3D motion analysis

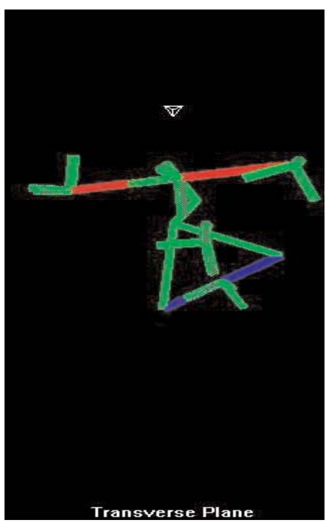
The majority of tennis research in biomechanics has been carried out with multiple high speed cameras (need at least 2 cameras but 3 preferable), linked to a computer to produce 3D displacement data from the digitizing of markers attached to the body, or from visually identifiable joint centres. The majority of data from research labs and from tournament play (2000 Olympics) up until recently were collected in this manner. This technology computes displacement data (describing segment and joint angle velocities) associated with stroke production, which in turn, has been used to calculate contributions to racquet speed of various body movements like wrist flexion. Joint loading such as forces at the shoulder during serving or the hip during a forehand may also then be calculated.

2. Opto-reflective motion analysis

More advanced motion analysis tools such as the Vicon opto-reflective system linked to computer software should be used where movements integral to performance (e.g. shoulder internal rotation in the service action) need to be quantified rather than merely observed. This approach has a much lower error than the above video-based systems, but recording generally must occur in the lab environment. The beauties of these types of systems are that long axis rotation (e.g. shoulder internal rotation, elbow pronation) can be accurately measured, although placement of the marker triads on the various segments is still a research challenge.

These systems, however, may also be used in a descriptive manner to aid player feedback. In the Figure below an anatomical structure of the body from the attached markers is formed, with player attention directed toward the highlighted alignments on the right of the figure: the hip alignment in blue and the shoulder alignment in red - representing a separation angle, during the backswing phase of the serve. An avi video file can also be produced (and synchronised) to permit continuous viewing of this angle, over the entire service action.





3. Dynamometry

a. Force Platforms: Typically used in the research setting to provide data describing the forces that characterise the 'leg drive' in various types of service actions, and as performed by players of various playing levels. These types of data aid the coach in determining when to emphasise 'leg drive' in the development of a mature service action.

b. Force transducers/pressure measurement systems: Individual transducers have been placed on racquets to assess the vibration and forces associated with ball impact. Pressure measuring foil has also been placed on the handle of the racquet to ascertain the distribution of forces to the racquet-hand during stroke production.

c. Dynamometers (e.g. Biodex): This technology, while limited by speed of rotation of the measuring arm, has been employed by many sports scientists and physiotherapists to gauge the amount of torque (rotational force) capable of being applied about various joint of the body. A relevant example would be to measure a player's peak concentric torque at the shoulder during internal rotation relative to the peak eccentric torque of the external rotators at the same joint. These measures are particularly important during rehabilitation and so data collected as a part of athlete profiling is extremely important.

4. Electromyography (EMG)

Muscle activation may fall into the descriptive or quantification domains depending on how one views the output. To merely determine whether a muscle is active or not is really descriptive, even if it does permit the coach to better plan a training program. If the type of muscle activation (concentric or eccentric) is linked to 3D motion analysis then causal mechanisms (quantification) are involved. For instance from the analysis of the service action we know that an eccentric contraction of the external rotators at the shoulder is needed to slow the joint's rapid internal rotation still present in the early follow through. The coach can now plan a program that includes exercises that eccentrically load the joint's external rotators so that this musculature is best prepared to tolerate those loads when serving.

5. Inertial sensors/gyroscopes

The emergence of very small inertial sensor units, made up of a combination of inertial sensors (such as gyroscopes and accelerometers) provides a look to the future of motion analysis. Using evaluation of elbow joint motion as a case in point, instead of 3 markers being positioned on each of the adjoining segments (upper arm and forearm); an inertial sensor unit is stationed on each segment to compute segment and joint movement. The heightened portability of these units may see more research able to be conducted on a court and even possibly in tournaments. Unfortunately, in the immediate future, limitations remain inherent in the technology's ability to reference information in the anatomical frameworks typical of traditional motion analysis, as well as in its capacity to accurately account for the impact of the ball with the racquet. Nevertheless, the prospects of its integration can only be enhanced through work like that currently being undertaken in Australia to develop and validate platforms that allow synchronous acquisition of 3D acceleration data from multiple sensor nodes attached to the racquet and upper limb segments.

CONCLUSION

Technology is synonymous with biomechanics and coaches must be able to utilise specific aspects discussed above, while at the same time understanding how to incorporate other forms of data into their coaching regimes. The Table on next page may be used as a guide, illustrating the common use of these technologies in athlete performance assessment, clinical servicing and research in tennis. However, it should be remembered that biomechanics is only one part of the Sport Science and Sports Medicine Model as presented in this series of articles.

References

Elliott, B. & Knudson, D. (2003). Analysis of advanced stroke production, in Biomechanics of Advanced Tennis, (B. Elliott, M. Reid & M. Crespo Eds), ITF Publication.

Technology	Athlete Performance Assessment	Clinical Servicing	Research
2D standard & high-speed video	√	√	X
GPS/Performance analysis programs	√	X	√
3D video	X	√	√
Opto-reflective motion analysis	√	√	√
Dynamometers	√	√	√
Force platforms	√	√	√
EMG	X	√	√
Inertial sensors	X	X	√

Table 1. Technology types and uses.

"LET THE FORCE BE WITH YOU"
The Use of Technology in the Training of Tennis Athletes

Mark Kovacs (United States Tennis Association)

ITF Coaching and Sport Science Review 2008; 15 (45): 5 - 6

ABSTRACT

This article provides information on great tools and devices available for coaches and conditioners to use for the training and monitoring of tennis players. Four devices were selected because they are all reasonably priced, accurate and have been tested in the scientific literature. The devices discussed in this article are the Heart rate monitor, 3D accelerometers, equipment for hydration testing and a radar gun.

Key Words: Heart rate monitor, hydration testing, radar gun, 3D accelerometers, conditioning.

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INTRODUCTION

As originated in the first Star Wars movie, having the "force" with you as a coach can give your players a major advantage in their tennis development. The "force" in the 21st century is the use of technology in the training, testing and monitoring of athletes. Some tennis coaches and support staff (medical, strength and conditioning and physical therapy) have embraced new technology and the use of tools to help them in optimizing tennis performance and reducing the likelihood of injury.

Improved technology has resulted in thousands of possible devices that are now marketed throughout the world - some which may aid the tennis coach. However, many coaches have not been exposed to, and therefore are unaware, of some of the latest devices that are available. The purpose of this article is to summarize some of the different tools that are available for coaches and a practical description of how they work. The goal is to help the coach decide whether these devices may be appropriate in each individual coaching environment. The four devices listed in the article have all shown positive results both in research settings as well as on the court or in the gym.

HEART RATE MONITORS (HRM)

Most coaches have probably seen or even used HRM before.However, the latest technology has really improved and now they are able to record more training variables and have greater capabilities as a tool for the coaches. The HRM comes with a strap that the athlete wears around his or her chest that uses electric signals to measure the electrical activity of the heart. This information is then sent to a receiver which traditionally has been a watch that the athlete wears (i.e. watch).

However, with the latest wireless technology, the newest HRM can send the signal directly to a computer where a coach, trainer or medical support staff can monitor the athlete in real-time. This is a major advance as it allows a coach to have multiple athletes playing or training on a set of courts while instantly monitoring the workrate of each athlete. Along with being able to monitor individual athletes in real-time, the HRM can store information from an entire training session and can then be downloaded to a computer for analysis. This allows each training session to be recorded and stored for future analysis. This can be a major tool if you are interested in seeing if athletes have improved over the course of weeks or months and can be a helpful observational tool when determining training volumes and intensities. Studying past weeks' work, an analysis of how they responded to a certain drill can provide the coach some great objective feedback of whether the athlete has performed at a higher level with similar workrate. This information can be helpful in a number of ways. It allows the coach to monitor the intensity of training from an objective measure. Each athlete responds differently to the same physiological stress and using HRM allows the coach to tailor workouts, making each drill or session specific to the athlete.

Figure 1 Heart Rate Monitor and Strap

Another area that many elite level coaches and trainers are utilizing the latest HRMs is in the area of heart rate variability. This looks at heart rate over a period of time, typically during rest (or sleep) to monitor changes in the heart rate response. This is starting to be used to monitor symptoms of overtraining and is something that will become more prevalent in the years to come. Although the accuracy of HRMs is very high, the estimated heart rate maximum pre-programmed on these devises is usually 220-athletes age. The research is clear that this estimated formula may be a good starting point, but it has a standard deviation (error rating) of 10-20 beats per minute. This means that the data may not be appropriate to compare different athletes to each other, as two athletes who are both 20 years of age may have actual maximum heart rates of between 180-220 beats per minute. This large variability makes it nearly impossible to compare individual athletes to each other. This being said, HRMs are a great tool to monitor individual athletes against themselves.

The reliability of HRM is high and if used appropriately is one of the most practical and useful technological advances to aid the tennis coach. Typical costs for HRM range between $50 for a simple receiver that can display heat rate, but lacks any of the new technology to store data for downloading or wireless capabilities to have the data relayed directly to the coaches computer in real-time. If you are interested in the top of the line models that allow both multiple athletes real-time monitoring and the capacity to store and download the data for future analysis, it will cost between $300-$500 per athlete.

3D ACCELEROMETERS

Some of the latest training tools available are products that can quickly and easily measure an athlete's power, force and velocity of movement. This is a great tool to help coaches who want objective measures of an athlete's physical performance over time. This new technology is a three-dimensional accelerometer with a sensor that measures the acceleration (the change in speed over time) of the athlete during movements. By multiplying the mass of the body weight or object being moved with the acceleration, the device automatically can calculate the force produced in Newton (N). The integration of acceleration is used to calculate the velocity in centimeters per second [cm/s]. Power can then be displayed in watts [W]. These tools are a great way to monitor an athlete over a period of time to see if the training program on and off court is having the desired result and monitor if the athletes you work with are actually getting stronger, faster and more powerful. The other great benefit of these devices is that they can estimate maximum lifting ability without the need for athletes to perform maximal lifts (i.e. 1RM). This is a great asset when designing strength training programs for athletes, especially younger athletes. The other area where this device is useful is during the rehabilitation from injury. It allows the coach to monitor the athlete regaining strength and power from day to day. This daily practical monitoring can help ascertain when and how much to keep increasing the workouts before there is a drop-off in performance.

Once the data has been obtained it can be viewed immediately, or can be downloaded to an analysis software that allows for extensive review and comparison. This function is effective to make day-to-day or month-to-month comparisons or to compare unilateral sides of the body. These three-dimensional accelerometers have no wires and can easily be attached to the athlete directly for body weight exercises (i.e. jumps, hops and other plyometric exercises) or can be attached to a barbell to measure traditional resistance training exercises such as a squat or bench press. The cost of these devices range between $1000-$3000, and typically include the desktop/laptop analysis software.

HYDRATION TESTING

As dehydration has been shown to be a major limiting factor in tennis performance and also a safety concern when athletes become severely dehydrated, coaches have the option to measure an athlete's level of hydration quickly and easily. An athlete's urine specific gravity (USG) is a measure of the density (or concentration) of urine. Urine color is commonly used to determine hydration levels; however, urine color can be influenced by the ingestion of dietary supplements and also the subjective opinion of the person monitoring the urine color. An example would be an athlete that consumes a vitamin B supplement would have a bright yellow urine, irrespective of whether they are hydrated or not. Therefore, measuring hydration via urine specific gravity is more accurate and is not influenced by dietary supplements.

To measure an athlete's USG, the coach will need a refractometer, which is the measurement device, and a small sample of the athlete's urine. All that is required is one or two drops and the refractometer will calculate the USG. The range of a refractometer is between 1.000 (equivalent to water) to 1.035 (severely dehydrated). It is highly recommended that athletes come into practice or matches below 1.010.

The benefits of using a USG device are the speed, relative accuracy and price. Refractometeres range between $100 to $600 and for most coaches the low-end of the price range will have all the features they will need. This is easy to use and provides the coach and athlete a solid picture of an athlete's hydration status before and after training and competition.

RADAR GUN

The traditional radar gun has been around for a number of years, but like most electronic products the size the devices has been reduced along with the price. It used to be that an accurate radar gun would cost a coach a few thousand dollars. Today it is possible to purchase accurate and reliable radar guns for a few hundred dollars. This reduction in price makes it more accessible to the majority of coaches. Some of the new radar gun models can store data as well, which can allow a coach to monitor an athlete over the course of a practice or match session to see if the average ball velocity may decrease over time. This type of information can be very helpful for a coach when prioritizing areas of training. An example may be that the average ball velocity drops from the first 30 minutes of practice to the last 30 minutes of practice by 15%. This information should be very helpful to the coach to outline the need to focus more on muscular endurance for that specific athlete.

CONCLUSION

Although there are many other great tools and devices available for coaches to use for the training and monitoring of tennis players, these four that have been discussed are all reasonably priced, accurate and have been tested in the scientific literature. It is important to understand the products that you are interested in purchasing as there are many companies that make products appearing to be appropriate and useful, but some of the imitation companies do not produce the same accuracy in product which can lead to results that are not valid. Therefore, it is important to perform diligent research on the brand you are interested in and get recommendations from coaches and trainers that have used that specific product. Hopefully this information has provided you with the necessary "force" to aid your training and monitoring of the current and next generation of great players.

LET THE FORCE BE WITH YOU...

Best Practices for Using Video with your Players

Paul Lubbers (United States Tennis Association)

ITF Coaching and Sport Science Review 2008; 15 (45): 7 - 8

ABSTRACT

This article highlights important guidelines to follow when collecting information and analysis from a camera. It is a collection of interviews which ask current experts from three discipline areas, player development, academia and a founder of a tennis analysis website to comment on best practices, common problems and issues they have when filming tennis.

Key words: Video, analysis, camera, tennis
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INTRODUCTION

Technical, Tactical, Physical and Mental skills can all be impacted in a positive manner by taking advantage of the many different video and software applications that are readily available to the coach. With the advent of inexpensive, easy to use digital cameras and computers, it is now common place for the coach to regularly use video as a teaching coaching tool on a daily basis rather than a once off special session. In addition, websites such as the tennisicoach.com, tennisplayer.net and playerdevelopment.usta.com all provide access to video images of today's best players for players and coaches to view and study.

These advances in video technology can definitely improve the quality and level of coaching and instruction that coaches can provide to the player. There is however some helpful guidelines that should be followed when using video to enhance you're coaching. One of the most important things prior to entering into a video session with a player is to know why you are going to video the player. Do you have a developmental plan for the player where the goals for the player are clear in the areas of technical, tactical, physical and mental development? The goals set in the plan should link directly to the expectations of the video session. Goals for the session should also be developmentally appropriate. Many times coaches use video clips of mature professional players as a model to compare the young player's performance against. Professional players possess skills, abilities, and strengths that younger, less mature players do not possess. Just because you see the best players in the world executing a shot in a certain way, does not mean that a 10 or 12 year old player has the strength or ability to do what the top players in the world can do.

In writing this article, I thought that it would be good to provide you with some guidelines for video practice by interviewing some leading experts in the field and find out how they go about using video technology to help the players that they work with. To do this I have asked by Bobby Bernstein; USTA Player Development, Larry Lauer, Ph.D.; Institute for the Study of Youth Sports at Michigan State University and John Yandell; Editor and Founder of Tennisplayer.net to share with us a few of their best practices on working with video help improve on court skills.

BOBBY BERNSTEIN; UNITED STATES TENNIS ASSOCIATION PLAYER DEVELOPMENT

Question:

Bobby, You have helped hundreds of coaches and player using the Dartfish Video software to improve their understanding and development of tactics and technique. What are some suggestions you have for coaches who are beginning to use video in their coaching and teaching?

Answer:

The use of video is for the benefit of both the player and the coach. I have first hand experience where the coach just purchased a new video application and was really excited to use it with their best player. The coach and the player were not in agreement to the use of the video nor where the in agreement on what needed to be looked at. Let's just say that the coach was much more excited to use it than the player and the session was a failure. The bottom line is that if the player is hesitant to examine the video or does not agree with the context of the analysis it can't work well. Along the same line, the coach needs to be able to focus the player on one or two aspects of their game that needs to be addressed. There exists the temptation to point out every error or flaw and this could lead to a situation where the player is overwhelmed with information and feels frustrated. One of the most important things to do is to use video as a way to show a student what they are doing right.

LARRY LAUER PH.D.; DIRECTOR OF COACHING EDUCATION, INSTITUTE FOR THE STUDY OF YOUTH SPORT, MICHIGAN STATE UNIVERSITY

Question:

What recommendations do you have for coaches who would like to use video to help players improve their Mental Skills?

Answer:

Identify Key times and responses - It's most helpful to look at emotional reactions to important situations during a match such as being down a break point. Have a plan for what you want to capture when shooting video. What are indicators of mental skills effectiveness you are looking for in these key situations? Body language, facial expressions, the eyes and where they are focused between points, routines - pace of play.

Keep video sessions short and focused - do your homework before meeting with the player; review the video. What frames are most important to review? Attempt to keep video review less than 30 minutes with a player.

Stimulate recall - you can make certain inferences when observing a player and how he or she is thinking, but the video only provides a stimulus to get the player talking. Use the video to set up important questions - such as what were you thinking and feeling prior to this service game?

Recognize what they are doing right - so often video sessions become a review of mistakes, and players are usually a bit uncomfortable watching themselves on video. They will immediately look for things they are doing wrong or how bad they look. Instead, start by pointing out the strengths they are exhibiting. Reinforce what you want to happen. This will also make the constructive criticism you are about to give them easier to accept.

Set goals based on video review - video is very helpful in building awareness of body language, for example. How video sessions are only as beneficial as what the player takes from it. So, at the end set goals to maintain 1-2 things the player is doing to perform with mental toughness, and 1-2 things to work in practice.

JOHN YANDELL, FOUNDER OF TENNISPLAYER.NET

Question:
What are the best practices you follow when using video to correct technique with a player?

Answer:
I believe that when using video of professional players as a learning model that it is very important to use players that match the technical style of the player you are filming. For example, if you are coaching a player with a conservative forehand grip structure, you don't want to compare him to Nadal, who uses a more extreme grip. I also believe that as coaches we need to have clear ideas of the key positions of each stroke and at the same time understand the underling sequences of the stroke. For example, a player may make late contact with the ball, but if the initial unit turn with the body and feet aren't timely or sound, the other problems that happen later in the sequence of the motion will be impossible to correct.

Question:
John, can you discuss the process you use to film and analyze?

Answer:
Personally the way I work on court is to allow the player to initially hit a fairly large number of balls--maybe 50 groundstrokes or more, or 20 serves, get relaxed, and hit some which will be better, and some which will show the tendencies that need improvement. I film all of this and then proceed to do the comparative analysis, first alone and then with the player. After examining the video, we set goals about what needs to change in the stroke and then go back to the court with the camera to re-film and repeat the process. As the player moves toward the goals you have set, you can take a quick look at the progress on court using the lcd screen on the camera. One important technical reminder is that when you film at 30 frames a second with a conventional mini DV camera, you won't have the ball on the racket in the large majority of examples. If you're using a camera with a higher frame rate you will capture the ball more times.

On - Court Tennis Training: IT Control Methodology

Vicente Calvo (Physical Conditioning Coach of Fernando Verdasco, Spain)

ITF Coaching and Sport Science Review 2008; 15 (45): 9 - 10

ABSTRACT

This article presents an IT programme designed to control and systematize tennis training on court. The different variables affected by training are defined together with a way of analyzing them. The concepts of tasks, technical units and exercises that help in this monitoring process are also defined.

Key Words: Training, control, I.T.

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INTRODUCTION

The purpose of this article is to present an IT application specifically designed for tennis called Set-tennis court. This programme is, first of all, a didactic tool, a method to organize training on-court. It provides a way of organizing exercises that develop technique, while training physiologically those physical skills that are necessary for competition.

The goal is to optimize player's performance by the use of an integrated training of movement and basic strokes, while increasing player's efficiency and favouring an economy of effort. A Task Control Model is used in order to identify the player's effort on-court and to provide guidelines as to how to develop the necessary physical qualities for top performance.

Finally, the programme organises the tasks according to the previously planned physical training objectives and sets those tasks in different zones of the court, thus achieving the desired technical objectives.

Set-tenis software

The Set-tenis court Software in its Maker, Professional and Analyzer versions is used to facilitate the visualization of the training process.

This innovative programme has been designed to work with players of any level (beginners, intermediate or advanced). It consists of different versions according to the prospective users and their needs. It is the first IT application that organizes tasks on the court, and provides variables of load control (i.e. volume, intensity and density). Due to its dynamic features and to the point replay capability it helps to elaborate tactical thinking in players.

ON-COURT TRAINING ZONES	1	2	3	4	5
NAME	Light Aerobic	Medium Aerobic	Mixed: VO2 max Aerobic-Anaerobic	Anaerobic Lactic: Extensive and Intensive	Anaerobic Alactic
LEVELS	-Regenerative (<1h) -Extensive (40’-2h)	Aerobic Efficiency (12-40’) -Aerobic capacity submax (4-12’)	-Aerobic capacity (2-4’) Aerobic power(VO2) 1’20” to 2’15”	Glycolytic capacity 45” to 1’20” Glycolytic power 20” to 45”	-Alactic capacity <20” Alactic power <10”
LH	-1 -1-2	-2-3 -3-4	-4-6 -6-8	-8-10 -10-12	-variable -variable
HR	<120 (120-155)	(155-170) (170-175)	(175-180) (180-183)	(183-188) (>188)	-variable -variable
Total duration of effort (in intervals)	<1h >1h	<1h (30 to 60”) from 10’ to 30	<12’ <8’	<5’ <3’	<2’ <1’
Intervals of application	Series of 10’-20’-40’-1h	(10’-40’) (2’-3’-4’-6’-8’-10’-12’)	(1’-2’-3’-4’) (45’-1’-1’15”-1’30”-1’45”-2’)	30-40”-1’-1’15” (15”-20”-30”-40”)	10-15-20” from 0.5”-10”
W/R Relationship	1/0.1-0.2	1/0.2-0.3 1/0.3-0.5	1/0.5 1/0.5-1	1/1-5 1/3-8	1/10-15
%VO_2 Max	60-80	80-95	95-100	>100	>100
IMax %	<40%	<50% <55%	<70% <85%	85-90% 90-95%	95-100% 100%
Type of force applied	Resistance F. -aerobic -acyclic	Resistance F. -aerobic -acyclic	Resistance F. -mixed -acyclic	Resistance-F. - lactic -acyclic	Resistance F. -alactic -acyclic
Tasks on-court	-ANNEX -Filing cards	-ANNEX -Filing cards	-ANNEX Filing cards	-ANNEX Filing cards	-ANNEX -Filing cards

Table 1. Shows the different training zones, their names, their level, and the different varialbes influenced by training.

METHOD FOR ON-COURT TRAINING CONTROL AND SYSTEMATIZATION

The explanation of the information on table 1 is as follows:

Names and levels: Distinguish conditioning capacities that players need to develop, considering the physiological models used to obtain energy.

Training Zones: Concentrate on the intensity scale of the rhythm of energy production.

Variables influenced by training:

1. **Lactate concentration (LH)**: It sets the relationships between oxygen consumption and speed of movement. According to the values of lactic acid, there will be different energy sources of energy acquisition.
2. **Heart rate (HR)**: Closely related to VO2 max values and to the accumulation of LH. Cardiovascular response produced by the different efforts. Measure quite valid for zones 1, 2 and 3; although not so relevant for zones 4 and 5.
3. **Total duration of the effort:** Time during which it is possible to perform actions keeping the intensity of the zone at intervals.
4. **Intervals of effort application:** Help with the possible combinations in the duration of the active phases for training sessions that will develop the objectives of each zone together with the methodology of work.
5. **Relationship work/rest (W/R):** Shows work density; the relationship between time spent in the movement and recovery time between series and repetitions.
6. **Percentage according to the VO2 max.** Percentage of oxygen consumption per ml and per kg of body weight related to the maximum each player can use. Closely related to the metabolic route and to the prevailing energy source in the intensity scale of the zone.
7. **Percentage according to the maximum intensity (Imax):** As time increases, the ability to keep up such speed decreases and, consequently, we move to another training zone. It tries to provide more information when assessing the tasks that go beyond the VO2 max%. This variable helps defining training rhythms more efficiently than the VO2, max., mainly in those zones of greater intensity, Zones 4 and 5. It is based on a set of field tests for each zone.
8. **Indicators related to the % of Imax:** The intensity of movement or the speed of acceleration-deceleration of the legs in movement that precedes and follows the stroke, i.e. in each unit of movement that will be defined later. The intensity of the stroke or the fexp % of the stroke (this variable affects the entire kinetic chain at work during the stroke: legs, hips, core and arms). Ltotal= lmovement+ lstroke.
9. **Relationship between volume and intensity of each zone**

EXERCISES AND TASKS

Training zones	Volume of movement	Intensity of movement / stroke	
Zones 1 and 2	highV/mov	lowI/disp	medium-lowI/stroke
Zone 3	medV/ mov	medI/disp	high-medium-low/Istroke
Zones 4 and 5	low/V/mov	highI/disp	high-medium-low/Istroke

The technical unit: Concept

We define exercises as the amount of motor actions used to solve a concrete motor problem or to optimize its results. These exercises which specifically develop the necessary qualities to play tennis, combining movements and strokes, are labelled Technical Units. When we provide load indicators to these Technical Units, we refer to Tasks, i.e. on-court exercises with an assigned duration, recovery and intensity. Their execution will have certain physiological implications.

The technical unit: Acyclic characteristics

By using exercises and designing tasks we will standardize movements and gestures, to facilitate recovery of balance after a shot or to increase co-ordination, thus, showing more fluidity and economy of motion. The exercises used will be acyclic. As much as possible, we should consider the situations of imbalance in movements, and the constant change of spatial /temporal patterns. So, they will be differentiated according to their nature:

Basic preparation exercises

These are those exercises that use separate technical units of movement or strokes, using methods that allow assimilation and learning of the different acyclic gestures. We would also include here exercises and tasks that, through of repetition and with appropriate volumes, influence on the player's functional development, creating a solid foundation. Examples: zig-zagging between separated cones stressing the work of the external foot, doing the same exercise but pretending to use a forehand or a backhand groundstroke.

Special preparation exercises

These are the most frequently used on-court. They try to develop the technique with overload conditions. Repetition is used to strengthen tactical objectives that need considerable technical accuracy, thus building a reserve that will help during fatigue. They employ stroke actions and movements that occur during matches. Exercises with a partner and basket directed by the coach using fraction methods will be frequently used. Unlike the previous exercises these are on-court exercises with balls and rackets.

Competition exercises

They intend to reproduce competitive conditions by setting modelled tasks or points played with certain conditions set by the coach. They try to create real match play situations.

PROGRAMME SUMMARY

The season should be planned with its macrocycles and mesocycles. The microcycle has to be selected together with the main objectives for each day and for each session. The on-court contents should be introduced and made compatible with the off-court physical training. The files, which reproduce exercises with load indicators, should be looked at. The on-court tasks should meet their objectives. The duration of the tasks has to be checked using a watch and the basket of balls. The intensity should be controlled with a heart rate monitor always keeping the type of drill in mind. At the end of the session, the collected data need to be loaded into the computer and the relevant information has to be written down for the adequate follow up.

CONCLUSION: OBJECTIVES OF THE PLANNING PROCESS

We want to get highly efficient players in their actions: precision + economy of efforts. It is this search that will force us to plan, organize the training sessions and optimize resources. All tennis programmes and academies want to be efficient; they want to teach their players something useful to compete. There are different ways to apply teaching points which differentiate one programme from another. It is through the tasks and exercises that we will be able to provide guidelines for an adequate design of the training sessions.

For those readers who are interested in this programme, the methodological basis of this application can be found in the book "Set-tenis Court. El entrenamiento en pista del jugador de Tenis", ("Set-tennis Court. Tennis player's training on the court").

Court Pace Rating

Stuart Miller and Jamie Capel-Davies (International Tennis Federation)

ITF Coaching and Sport Science Review 2008; 15 (45): 11 - 12

ABSTRACT

This article gives an insight into pace and the assessment of tennis court surfaces. The measure and perception of pace is discussed as well the ITF's Court Pace Rating Programme (CPRP). Different equipment and methods used in surface analysis, and the five pace court rating categories are described. In addition the use of CPR on the international tennis tour, and in particular the Davis Cup, are summarised to aid in coaches understanding of these fairly recent changes to the game.

Key Words: Pace, bounce, court pace rating, tennis.
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1. WHAT IS THE 'PACE' OF A TENNIS COURT? HOW IS PACE PERCEIVED BY PLAYERS?

Pace is a descriptor of a playing property of a court, and describes the way in which the ball bounces off the court. Tennis is played on a range of different court surface types, and their respective 'paces' are very different. In general, clay courts are 'slow', grass courts are 'fast' and other types (such as acrylic and carpet) are somewhere in between. The pace of synthetic surfaces, such as acrylic and carpet, can be varied, depending on the composition and construction of the surface. The pace of 'natural' surfaces can also be altered, for instance watering a clay court (which makes the surface even slower). Players perceive pace through experience of playing on a variety of courts, and building up a mental 'database' of their relative characteristics. This experience allows them to predict how the ball will bounce for any given shot.

Despite its name, 'pace' is not solely to do with the speed of the court, and is actually a combination of speed and time. That is, a ball which loses less speed as a result of impact with the court is faster than one which slows down more. This is a function of the friction forces exerted between the ball and court while they are in contact, and which differs for any pair of materials in contact. That is, for any incident speed and angle, the felt on a ball will generate a different frictional force depending on the surface of which the court is made, and this will result in a different outbound speed.

Court pace can be summarised as the amount of time a player has to play a shot. This has two components:

a. The horizontal speed of the ball.

When a ball and court make contact, a frictional force is generated at their interface. This force acts in the opposite direction to the direction of relative movement of the ball (i.e. acts to slow it down). The greater the friction, the more the ball slows down and the more time is available to the receiver to reach the ball. Courts which generate more friction are perceived as 'slower'.

b. The vertical component of the bounce of the ball.

A tennis ball that conforms to the Rules of Tennis must bounce to a height of 1.35-1.47 m when dropped from a height of 2.54 m onto a rigid surface. This happens because tennis balls have elastic properties and return some of the energy stored in their elastic structures following impact with the surface. Tennis courts are not perfectly rigid, and so they also store (and return) some energy. Following impact, the speed a ball leaves a surface in the vertical direction is determined by the vertical speed prior to impact and the energy returned in the vertical direction. A greater energy return will produce a higher bounce, which will give a player more time to reach it before it hits the court again. Higher-bouncing courts will be perceived as 'slower' by players.

2. QUANTIFICATION OF COURT PACE, AND DEVELOPMENT OF THE 'COURT PACE RATING' (CPR) SYSTEM

The quantification of court pace is based on theoretical work by Howard Brody, which models ball/surface interaction based on physical laws. Brody found that the pace of a court could be expressed as a direct function of its coefficient of friction, which was converted into a pace rating on a scale of 0-100 (where higher numbers represent faster surfaces) known as Surface Pace Rating (SPR). Measurements of pace are made using a device known as a Sestée (Figure 1). The Sestée measures the inbound and outbound velocity of a ball fired at a surface. The Sestée consists of two boxes, which are placed on the surface to be measured. At both ends of each box is an array of laser-receiver pairs. When a ball passes into a box, it interrupts a number of laser-receiver pairs (and the time of the internal clock is recorded). As the relative position of the laser-receiver arrays is known, both the speed and angle can be calculated.

Studies by the ITF showed that measurements of pace from the Sestée did not always agree with player perceptions. This was particularly true for clay and grass, which are the surfaces with the highest and lowest bounces respectively. This suggested that including bounce information into the calculation of pace would enhance the agreement. With bounce information included, the revised measure - known as Court Pace Rating (CPR) - was introduced in January 2008, and subsequent comparisons between CPR and anecdotal comments of players suggests that the new measure is much closer to player perception on all playing surfaces.

3. MEASUREMENT OF COURT PACE RATING IN THE COURT PACE CLASSIFICATION PROGRAMME

The ITF operates a Court Pace Classification Programme (CPCP), which classifies tennis surfaces into one of five categories (slow, medium-slow, medium, medium-fast, fast). Products are categorised according to their CPR, and listed on the ITF web site and in its Approved Balls and Classified Court Surfaces booklet, which is produced every year. Typically, several 0.5 × 0.5 m samples of the surface are submitted for classification. However, surfaces can also be classified in-situ, through on-site testing. To date, over 130 surfaces have been classified.

Classifications are made using the Sestée, but ITF is also developing a predictive device to carry out more on-site testing. This device, named the SPRite (Figure 2), is designed to provide a more economic and portable means of measuring CPR.

4. INCORPORATION OF COURT PACE RATING INTO THE DAVIS CUP RULES

In January 2008, a rule limiting CPR for surfaces used in the competition (excluding clay and grass) was introduced. This rule, which aims to control the extent to which home nations can take advantage of selecting a surface that suits the strengths of their players, places limits on CPR of 24-50. To establish these limits, many different types of surfaces have been tested by the ITF, from clay courts with a CPR of less than 20 to carpets measuring nearly 60 CPR. The results were then compared against players' perceptions of how fast that particular court played. The limits of 24-50 were established on the basis of all the available information.

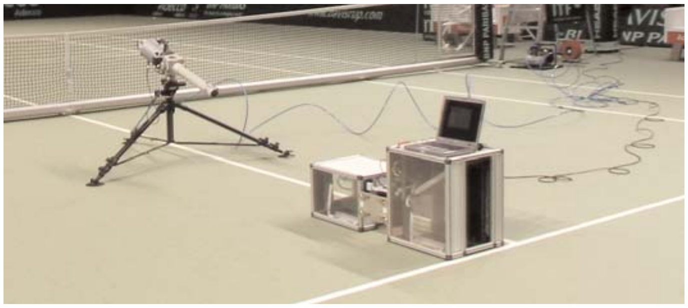

Figure 1. On-site testing.

Figure 2. SPRite.

New Technologies and Racquet Power

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ABSTRACT

This article identifies the key factors in racket technology and what players and coaches should look for when purchasing. It describes mass distribution, frame and stringbed stiffness as well as their important relationship with performance. Additionally the article explains the notable difference between racket specifications and the perception and reception of the player to the different rackets.

Key Words: Technology, frame stiffness, racket performance.

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INTRODUCTION

With all the new racquet and string technologies that come out each year, how is a player or coach to assess the consequences of these on one's performance? Every technology claims to improve some combination of power, control, spin, comfort, maneuverability or stability. There are so many ways offered to do each. And if they do improve any of these, the obvious question is, "Improvement compared to what?" But the primary concern for most players is technology that increases power. This article will concentrate on that.

The usual way players assess the likely performance of a racquet is by analyzing the specs of a racquet. The usual ones are weight, balance, swingweight, length, headsize, and flex. And for strings and stringbeds, players look at the material, gauge, tension, and pattern of the strings. These are the factors players look to, no matter what technology is added "on top."

There is a good reason for this. Most new technologies alter performance because they in some way influence one or more of the factors listed above. And we can generalize further. All the listed racquet characteristics are in one way or another dependent on the distribution of mass and its stiffness and all those of the stringbed have to do with the stiffness of the string and stringbed system. In essence, you can analyze any technology in terms of how it will affect mass distribution and frame and stringbed stiffness. Together, mass and stiffness account for virtually all the racquet's role in producing shot velocity.

The reason is this: At impact the racquet bends, recoils, twists, and flips and the ball squashes. Almost all the energy used in these motions and deformations becomes unavailable for returning the ball. Bending is primarily a function of frame stiffness; motion is primarily a function of mass; ball squashing is a function of string stiffness. So, more frame stiffness limits bending, more mass limits motion, and lower stringbed stiffness (i.e., soft) limits ball deformation. The two questions to ask of any technology are these: Does the frame innovation increase the effective mass or stiffness at the hitting point, and is the energy returned from a stringbed system greater than the same racquet design without it? The essential procedure for analyzing a technology is to determine how much and where energy becomes unavailable for ball return.

Mass Distribution and Frame Stiffness in Performance

Wood racquets were heavy, soft, even balanced, and had a small headsize. This was due to one thing-the strength-to-weight ratio of wood. It took a certain amount of material along each section of the racquet just to maintain structural integrity.

Then, along came graphite. It was much stiffer and stronger per unit of weight than wood. Consequently, racquets could be made stiffer and stronger yet weigh much less. But today's racquets are already so incredibly strong and stiff that to make a racquet stronger or stiffer as a whole would be an exercise in diminishing returns with little discernable effect on performance. If a material is two times stronger or stiffer than another, that fact does not necessarily mean the racquet as a whole will be twice as stiff due to its incorporation in the frame. Stiffness depends on what kind of material is used, how much is used, where it is used, and how it is used. But if a material is stronger and stiffer by weight, then less can be used in one area so more material (of any kind) can be used somewhere else. For that reason, with the advent of graphite, super-light racquets became possible, as well as radically head-light and head-heavy designs. Most importantly, mass could now be spread out over a larger circumference, making oversize racquets possible. The ability to move mass around made possible the production of truly differentiated frames that could then be targeted to particular player segments of the market. It also signaled the beginning of the era of the power game.

It might appear we are now at a stage where we have already reached the limits of mass-location combinations such that at any given location we can make a racquet with "too much" or "too little" mass and/or stiffness. On the other hand, it could be asserted that we haven't come close to trying all possible combinations of mass and location. Either way, the ball's rebound from the racquet all comes down to how heavy and how stiff a particular impact location behaves. The ball does not care what technology produced this end result, it just knows that it is flying at x miles per hour. (However, as discussed below, different ways of achieving the same amount of power may feel very different to the player, who does care.)

There is one measurement that is most telling about the power of the racquet. It is known as ACOR or "Power Potential." It is a measure of the speed of the ball after impacting a stationary racquet compared to its speed before impact. The rebound speed is the ultimate consequence of all the components of racquet design. No matter what space-age materials or innovative designs go into the racquet, the end result is simply a ball being ejected at a certain speed, spin and angle. The racquet with the highest ACOR rebounds the ball fastest, period. (Racquet power potentials can be found and compared at the Tennis Warehouse University website: www.twu.tennis-warehouse.com.)

The graph (Figure 1) shows the measured power potentials for 80 27-inch racquets for impacts along the center line. There is a direct relationship of power to swingweight at each hitting location. This is not true of the graph of any other variable. The spread around the trend line is primarily due to local frame stiffness at the impact point. For an impact 25 inches from the butt, there is more scatter around the trend line. The frame is not as stiff here and more energy is lost to frame bending. As impacts occur closer to 21 inches (near the sweetspot where the racquet does not bend upon impact), the frame bends less and the power is more completely determined by the mass distribution (swingweight) and less scatter is evident. Racquets that scatter above the trend line are most likely stiff, those below, soft.

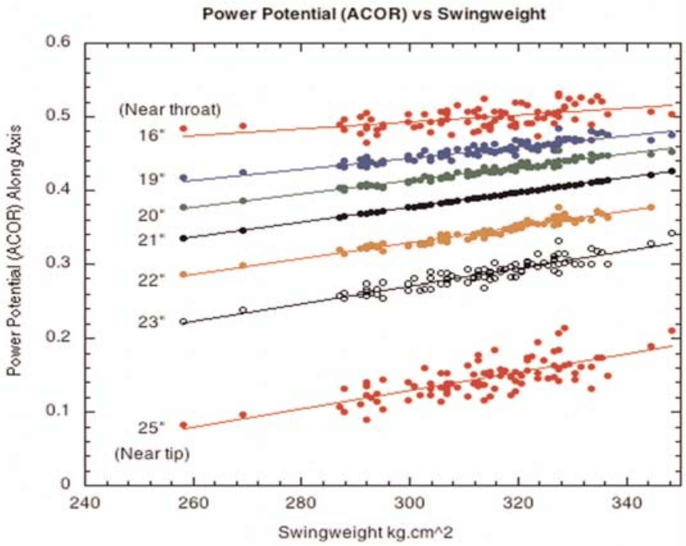

Figure 1. Power Potential vs Swingweight.

Either way, if we consider the trend line itself as the contribution of mass distribution to power, and if the range on either side of the trend line as the contribution of stiffness to power, then we see that there is not much room for increasing power by increasing stiffness because the power potential added over and above that produced by mass distribution is small. Of course you can always add power by adding mass, but this too is a course of diminishing returns, not only because you can't swing the racquet, but because after a point, adding weight is simply superfluous. The ball won't move a 100-pound racquet much less than a 50-pound one.

Stringbed Stiffness and Performance

It is the same story with string-there is not much room for improvement in energy return. All strings return about 95% of the energy that goes into them. That looks like you could still get 5% more power? Not quite. In a serve, for example, only about one third of the racquet's energy of motion as measured at the impact point gets converted into elastic energy (stored energy in the stretched and compressed colliding objects). Only about half of that is directed into the strings. Thus, the strings only get 50% of 30% of the energy, or in other words, they take in 15% of the total energy. Of that they lose 5%, or about 0.7% of the total energy. It's safe to say that no technological advancement in string is going to produce much in terms of shot speed due simply to improvements in energy return.

Improvements in the energy return of string are not likely to be something you would notice. What you do notice is anything that changes how much energy goes into the strings in the first place. The more elastic energy that goes into the strings instead of going somewhere else (ball deformation and frame bending), the more energy that will be returned to the ball. The way you get more energy into the strings is by any method that softens the stringbed. This is accomplished by changing string tension, gauge, material, and construction. It is also accomplished by altering the stringbed suspension system, which includes any structure that supports the strings like grommets, power pads, and any structure that accentuates string deflection such as moveable or compressible support structures. It does not matter to the ball how you make the stringbed softer. A stringbed of a given stiffness value will return the same ball speed whether it is accomplished with a softer material, lower tension, or different stringbed suspension system. However, one caveat is necessary with respect to suspension systems designed to soften the stringbed. These must be as efficient in energy return as the string, or if not, they must increase the elastic energy in the stringbed by more than the amount of energy they lose in the process over and above what the strings alone lose (5%). If they don't, it might simply be more efficient to lower the string tension to achieve a softer stringbed.

Perception and Reception

Ultimately, for the player, it all comes down to perception and reception. No matter the physical characteristics of the racquet there is no telling how the player will perceive it, and in the end, perception rules. There are a million things you can do to influence perception. Most new technologies affect perception more than measured physical differences in racquet performance, especially as measured by Power Potential (ACOR). A player ultimately judges a racquet on what he/she feels, thinks, perceives is its performance, which in turn has real effects on player's performance with the racquet. In that sense, all technologies are equal, necessary, and good for the sport. They provide the player with choice, and every player comes to a racquet with different needs, goals, desires, skills, and proclivities.

A racquet and ball collision can be divided into two phases-what happens to the ball and what happens to the player. Almost all of what happens to the ball occurs before anything happens to the player. News of the impact of the ball only gets to the player's hand about halfway through the impact time. Nothing the player does at this point will affect the ball. News about how stiff, heavy, or anything else about the handle-end of the racquet will not arrive back to the ball in time to influence the ball's rebound either. Ball impact and player impact are separated in time, materials and construction. There is a different "racquet" hitting the player's hand than is hitting the ball. The racquet between the impact point and the handle influences what the player feels and thus how the player interprets the hit. Many new technologies affect what the player feels. In other words, they affect the magnitude and duration of impact force (shock) at the hand as well as the magnitude and duration of the vibration aftermath. That is one reason new technologies have a great impact on the player's perception of what is happening to the ball, even if nothing significantly different is occurring.

CONCLUSION-THE PLAYER AS INVENTOR

In sum, mass and stiffness (frame and stringbed) predominate in a racquet's performance as measured by the ball's rebound speed. Other factors contribute, but their effects are marginal. Further, alterations to both mass and stiffness have reached the boundary of increasingly diminished returns. More racquet power is not going to come in quantum leaps. Increases in power will come in small increments such that they will hardly be noticed. Perhaps 10 years from now, if we compared racquet power, we would think we are in the Stone Age today. But the change will come gradually, and we will barely notice it. But along the way, racquets will continue to feel different and look different. As such, quantum leaps in perception might occur, even if they do not as far as racquet power is concerned.

That is not to say that players will not continue to develop new techniques that used in conjunction with the new technologies will increase ball speed. The oversize racquet also made possible more spin, which in turn allowed players to hit harder. But even here, the extra ball speed comes from greater swing speed, not from a more powerful racquet. It comes from a different use of the racquet. And it is the same with strings. Ironically, players get faster shots from strings with less power (e.g., polyester) because it allows them to swing even faster, creating a vicious circle of ever more spin and ever more speed. In this way, the player remains the greatest inventor.

ITF Junior Tennis School Programme

Luca Santilli (International Tennis Federation)

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ABSTRACT

This article highlights the ITF Junior Tennis School project which provides an internet based educational resources for up and coming players, coaches and tennis officials in the world of international tennis.

Key Words: Junior, education, internet, school.

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It is quite remarkable how technology can help nowadays. Take for example the recently launched online ITF Junior Tennis School and its E-learning website:

A new world has been opened to junior tennis players from every continent as well as to national associations, parents, coaches and tennis officials.

As we believe at the ITF that junior tennis is mainly about LEARNING, we wished to contribute to the education of young international athletes on tennis related topics affecting their career and thus help the National Associations, Coaches and Parents in the important task of raising awareness and preparing the players for the pro-circuit.

Therefore, the online ITF Junior Tennis School was conceived in order to educate and provide practical assistance and guidance to young players starting to play at international level. We wanted to help junior tennis players in their education through a better understanding of their involvement in international tennis as an important part of their lives.

The ITF launched the online JTS at the end of February 2008 and in only 4 months more than 1400 users from 100 countries have registered and enrolled. Seventeen (17) e-learning modules set in a graduation pathway have been designed to help players both on and off court.

Players follow a power point presentation (approx. 20 slides) with voice over and take an on-line test featuring 10 true/false and 10 multiple choice answers questions, and need to answer 80% of them correctly in order to be able to access the next module. Upon completion of all 17 educational modules the young athletes become graduates of the ITF Junior Tennis School and receive a certificate. The modules are also available in PDF and audio format.

These modules cover topics such as how to train and eat properly, the mental game, anti-doping, player protection, the role of the agents, tennis history etc. They also cover some other areas such as how to choose a coach and a training environment, and provide information for parents as well as players. These modules have been written to be easily understood by non-native English speakers.

The School is currently available in English, French and Spanish with other languages such as Chinese, Arabic, Russian and others to be added in future.

The ITF e-learning website www.itfjuniortennisschool.com does provide also videos taken at ITF educational forums, hence, providing young players with the possibility of following presentations on topics such as player protection, anti-doping, injury prevention as well as to the possibility of listening to interviews from former top professional players such as Jiri Novak.

The ITF goal for the future is to continue to improve the E-learning website and its content making it more interactive through the use of available technology and allowing for users and players to exchange views and opinion on any of the topics and presentations offered by the modules as well as rating them.

The full list of modules is as follows:

Anti-doping
Career Management
Choosing a Training Environment
Code of Conduct
Diet, Nutrition and Dehydration
How to Choose a Coach
Injury Prevention
ITF Junior Circuit Regulations
Media Training
The Mental Aspect
Parents
Periodization
Physical Training on the Junior Tour
Player Protection
The Role of the Agent
Tennis History
Travelling to ITF Tournaments

The Hit & Turn Tennis Test

Alexander Ferrauti (Ruhr University of Bochum, Faculty of Sports)

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ABSTRACT

Internationally no unique endurance testing procedure for tennis players exists. Thus we developed a practical test procedure which can be easily applied on different performance levels. This "Hit and Turn Tennis Test" is a tennis specific adaptation of the "Multistage 20 m Shuttle Run for Aerobic Fitness" on the dimensions of a tennis court. The objective of the Hit and Turn Tennis Test is to move for as long as possible from the backhand to forehand corner and hit a forehand or backhand simultaneously to the sound signals coming from a DVD. The Hit and Turn Tennis Test is a pro-gressive test and consists of 20 Levels. Measurements are the maximum achieved test level and the number of strokes on this level as well as the estimated maximum oxygen uptake (VO$_2$max). Additionally blood lactate measurements allow the calculation of submaximal blood lactate thresholds. This paper gives detailed informations about the testing procedure and the data analysis.

Key Words: Endurance, maximum oxygen consumption, multistage 20m shuttle run.

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INTRODUCTION

On international level no unique endurance testing procedure for tennis players exists. Usually a multistage running test with a linearly increased running velocity is applied. The underlying testing criteria such as the surroundings (field test or laboratory treadmill test), the starting velocity (e.g. 2,5 m/s or 10 km/h), the height of the steps (e.g. 0,4 or 0,5 m/s or 2 km/h), the step duration (2-10 min) and the submaximum (different lactate thresholds) and maximum performance parameters (e.g. O$_2$max)differ completely between the multiple scientific schools (1). In consequence, no international comparable data of the worldwide best tennis players are existing.

Generally it is questionable if a one directional running test is sufficiently valid in respect to the tennis specific profile of demands. In a pilot study of our working group we found that the energetic demands in tennis are clearly limited by stroke econ-omy, body mass and the specific running coordination. Thus, it is not surprising that in the past several ideas for a specific endurance testing by the use of a ball machine had been published (2). The insufficient testing economy of these tests and the multiple degrees of freedom in the individual solution of the testing demands (e.g. stroke velocity, running technique) are the main reasons why ball machine tests did not yet found a worldwide acceptance.

Based on these problems one game specific testing procedure was established in the last 15 years in the international surrounding. This "Multistage 20 m Shuttle Run for Aerobic Fitness" has a clearly defined protocol and includes the sport game specific changes of direction (3). The athletes have to run up to 40-60 20 m runs and to make a 180° turn exactly when an acoustic "beep" comes from a CD Player. The MFT is normed for different age groups and validated by the O$_2$max and could be interesting for the tennis players endurance testing. On the other hand, tennis players have to run shorter distances by using a specific foot work. Thus our aim was to develop a tennis adapted MFT and to transfer it on the dimensions of a tennis court.

THE HIT & TURN TENNIS TEST

General Test informations

The Hit and Turn Tennis Test is a progressive fitness test for tennis players. The test takes place on a tennis court with a racket and can be performed by one or more players simultaneously. The objective of the Hit and Turn Tennis Test is to move for as long as possible following the rhythm indicated by acoustic signals in regular intervals. During this time the player has to follow the prescribed footwork patterns and stroke activity. The person should stop running when she or he cannot keep up any longer with the signals. Then the maximum achievement level will be registered and recorded.

Footwork and Stroke Activity

During the test the players have to run along the baseline and hit a ball pendulum (Figure 1) with their forehand or backhand simultaneously to the sound signals. The ball pendulums are located on each double court sideline. Players have to hit the ball pendulum by using their respective competition techniques (e.g. only one or two handed backhand). The stroke has to be strong enough so that the top of the ball pendulum hits the ground. Instead of a ball pendulum you can also use a pylon for stroke simulation.

The ball pendulums or the pylons are located on each double court sideline. The distance between the two ball pendulums amounts exactly 11.0 m. Thus it is also possible to perform the test without a tennis court, if you measure a straight running track of 11.0 m. Two players can be tested simultaneously with one pair of ball pendulums. Up to 8 players can be tested at the same time on one court (Figure 2).

Figure 1. Ball pendulum for stroke simulation.

The illustrated test design shows two right or left handed players standing face to face in the middle of the baseline. The running direction of both is directly opposite since the audio advice to play forehand or backhand at first is predetermined by the DVD. So it is impossible for the players to clash with each other during stroke simula-tion. As a matter of course one player can do the test on his own with one pair of ball pendulums. The footwork before and after the stroke simulation is exactly prescribed. The test supervisor or the coach has to control the quality of the footwork and the stroke activity.

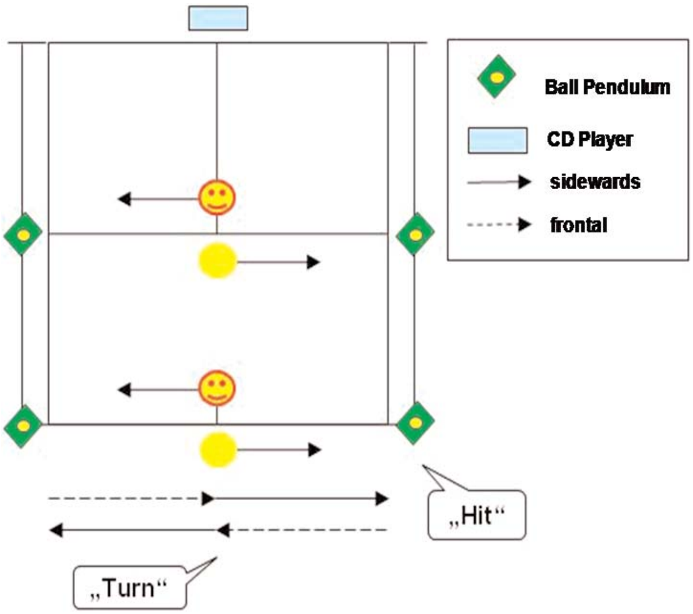

Figure 2. Test Design and Running Direction.

At the beginning of each test level the player stands in a frontal position in the middle of the baseline. After the starting signal he turns sideward and runs to the prescribed backhand or forehand corner. After striking the ball pendulum the player returns to the middle of court by using side steps or cross steps in a frontal direction. When passing the middle of the baseline again he turns sideward and continues to run to the opponent corner (Figure 2).

Progressive Test Design

The Hit and Turn Tennis Test is a progressive test and consists of 20 Levels. The test starts off slowly, but progressively increases in intensity. On level one the running speed will be very slow but on each following level signals will increase the running speed. On level one the span of time between forehand and backhand strokes amounts about five seconds and is reduced by 0.1 seconds on each subsequent level until three seconds at level 20. The duration of all levels is around 55 seconds. This duration simulates the longest points observed in a tennis match.

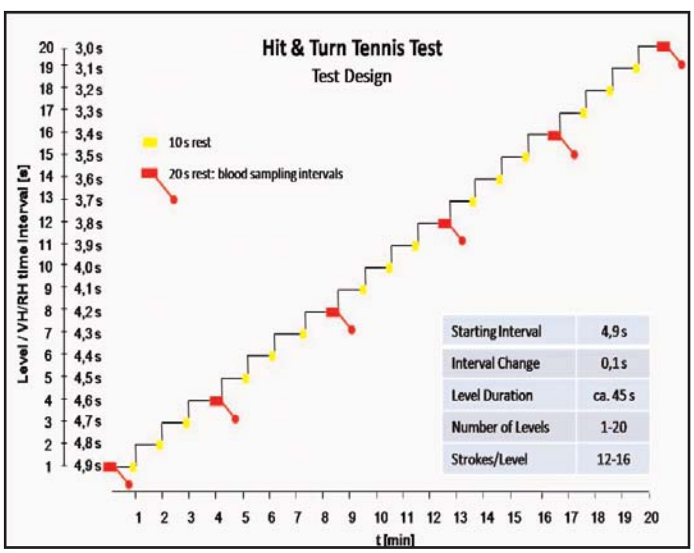

Figure 3. Progressive Test Design

All levels are interrupted by a rest period of ten seconds. The player has to return to the middle of the baseline. After level 4, 8, 12 and 16 there is a longer break of 20 seconds that can be used to take blood lactate samples. The measurement of blood lactate is optional and should be done only by qualified staff (Figure 3).

The advantage of the accompanying measurements of blood lactate is that beside of the maximum performance level (which is strongly dependent on the motivation) you can estimate a submaximal performance threshold. If you want to test a group of players simultaneously you can omit the measurement of blood lactate because during simultaneous performance, pressure of competition will sufficiently increase the motivation of each player. In this case the only measured variable is the maximum achieved level.

Signals

Each level starts with a countdown of three seconds and a randomly chosen advice "back" or "for". The test person has to follow this advice for his or her first run into the forehand or backhand corner. Each triple bleep signals the end of the level. The advice "Lactate" indicates the start of the longer 20 second rest periods in which samples can be taken.

Test Preparation

Before starting the test it is advisable that all test persons watch the video instructions on the DVD. Then place the ball pendulums on the doubles court sideline and carry out an operational check. Mark the middle of the baseline, if it is not already the case. If you perform the test outside of a tennis court you have to place the ball pendulums at the end of an 11 metre distance line and mark the middle. It is important to check that your DVD player and the DVD are working properly.

Once settled and ready the players have to line up with their rackets in the middle of the baseline. The progressive test can be selected on your DVD. The test starts with a countdown of three seconds and the advice "back" or "for". From there on the test participants run slowly in their respective direction.

TEST INTERPRETATION

Maximal Performance

The most important measurements are the maximum achieved test level and the number of strokes on this level. A table has been produced and validated, which enables scores on the test to be converted into general performance categories and into estimated values for the maximum oxygen uptake (VO2max). At present the graphs only includes norm values for men and juniors older 15 years (Table 1 and Figure 4).

Submaximal performance

After the levels 4, 8, 12 and 16 as well as after completing the whole test (level 20) blood samples can be taken to determine the blood lactate concentrations. These values allow the calculation of submaximal blood lactate thresholds. The assessment of the submaximal performance has two considerable advantages: (1.) It is independent from the motivation and the effort of the test person and (2.) the player can stop the test before being completely exhausted.

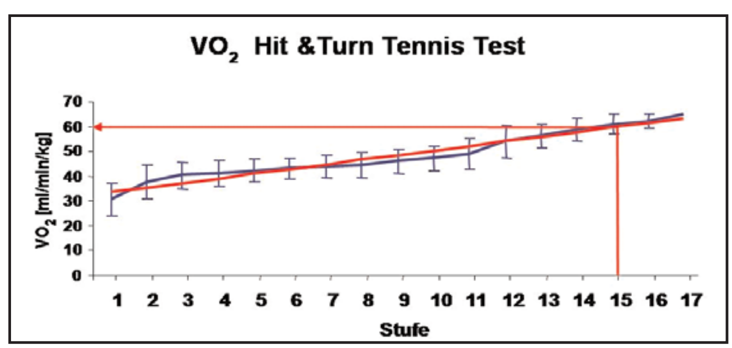

Figure 4. Test level and relative oxygen uptake for male tennis players (n=26).

VO_{2est} [ml/min/kg]		Strokes																Category
Level	Interval [s]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
1	4,9																	
2	4,8																	
3	4,7																	
4	4,6																	
5	4,5																	bad
6	4,4																	
7	4,3																	
8	4,2																	
9	4,1	46,0	46,0	46,1	46,2	46,3	46,4	46,6	46,8	47,0	47,2	47,4	47,6	47,8	48,0			
10	4,0	48,0	48,0	48,1	48,2	48,3	48,4	48,6	48,8	49,0	49,2	49,4	49,6	49,8	50,0			
11	3,9	50,0	50,0	50,1	50,2	50,3	50,4	50,6	50,8	51,0	51,2	51,4	51,6	51,8	52,0			average
12	3,8	52,0	52,0	52,1	52,2	52,3	52,4	52,6	52,8	53,0	53,2	53,4	53,6	53,8	54,0			
13	3,7	54,0	54,0	54,1	54,2	54,3	54,4	54,5	54,6	54,8	55,0	55,2	55,4	55,6	55,8	56,0		
14	3,6	56,0	56,0	56,1	56,2	56,3	56,4	56,5	56,6	56,8	57,0	57,2	57,4	57,6	57,8	58,0		good
15	3,5	58,0	58,0	58,1	58,2	58,3	58,4	58,5	58,6	58,8	59,0	59,2	59,4	59,6	59,8	60,0		
16	3,4	60,0	60,0	60,1	60,2	60,3	60,4	60,5	60,6	60,8	61,0	61,2	61,4	61,6	61,8	62,0		
17	3,3	62,0	62,0	62,1	62,2	62,3	62,4	62,5	62,6	62,7	62,8	63,0	63,2	63,4	63,6	63,8	64,0	excellent
18	3,2	64,0	64,0	64,1	64,2	64,3	64,4	64,5	64,6	64,7	64,8	65,0	65,2	65,4	65,6	65,8	66,0	
19	3,1	66,0	66,0	66,1	66,2	66,3	66,4	66,5	66,6	66,7	66,8	67,0	67,2	67,4	67,6	67,8	68,0	International
20	3,0	68,0	68,0	68,1	68,2	68,3	68,4	68,5	68,6	68,7	68,8	69,0	69,2	69,4	69,6	69,8	70,0	champion

Table 1. Performance assessment and estimation of the maximum oxygen uptake (VO2est) according to the maximum achieved test level. These values are valid only for male players older than 15 years. * According to the functional equation f (x) = 2 x + 30, Level {8;20}*

THE ASSESSMENT OF THE BLOOD LACTATE MEASUREMENTS CAN BE EFFECTED IN TWO DIFFERENT WAYS.

Simple tabulation

The test level on which the participant first supplies a blood lactate concentration of more than 4 mmol/l is recorded (and/or more than 6mmol/l). Using this table an easy estimation of the tennis-specific aerobic fitness can be obtained. These values are valid only for male players older than 15 years.

Level	> 4 mmol/l	> 6 mmol/l
0-4	Bad	very bad
5-8	Average	Bad
9-12	Good	average
13-16	Excellent	Good
17-20	international champion	Excellent

Table 2. Simple tabulation of aerobic fitness on the basis of blood lactate concentra-tions after Level 4, 8, 12, 16 and 20.2.

Calculation of lactate thresholds by means of Linear Interpolation:

To calculate the level on which a player reaches a defined blood lactate concentration (e.g. 4mmol), you can use the following equation:

$$4 \text{ mmol Level} = f_0 + \frac{f_1 - f_0}{x_1 - x_0}(x - x_0)$$

Example:

Level 4: 3 mmol/l $(x_0, f_0) = (4, 3)$

Level 8: 6 mmol/l $(x_1, f_1) = (8, 6)$

$$4 \text{ mmol Level} = 3 + \frac{6 - 3}{8 - 4}(x - 4)$$

$$4 \text{ mmol Level} = 5.1$$

Result: During the Hit and Turn Tennis Test the player reaches his 4mmol blood lactate threshold immediately after level 5.

INDIVIDUAL EXAMPLES FOR TEST INTERPRETATION

Figure 5 shows the individual results of two male players with a different tennis per-formance. Player R.G. is ATP ranked on position 576. He finished the test exhausted after level 17. His VO2max is clearly higher and the respective submaximal blood lac-tate concentrations on level 4, 8 and 12 clearly lower compared to Player R.Z. The application of the both tables 1 and 2 qualified both players as being "excellent" (player R.G.) or "average" (player R.Z.) in respect to their tennis specific endurance capacity.

Player R.G. (ATP 576)
Test break-off: Level 17 (finished) Evaluation: excellent
VO2max: measured: 67.0 ml/min/kg
According to table 1: 64.0 ml/min/kg
4 mmol/l: interpolated: level 14.2
according to table 2: 13-16 Evaluation: excellent

Player R.Z. (4th division)
Test break-off: Level 12 (finished) Evaluation: average
VO2max: measured: 51.0 ml/min/kg
According to table 1: 54.0 ml/min/kg
4 mmol/l: interpolated: level 10.3
according to table 2: 8-12 Evaluation: good

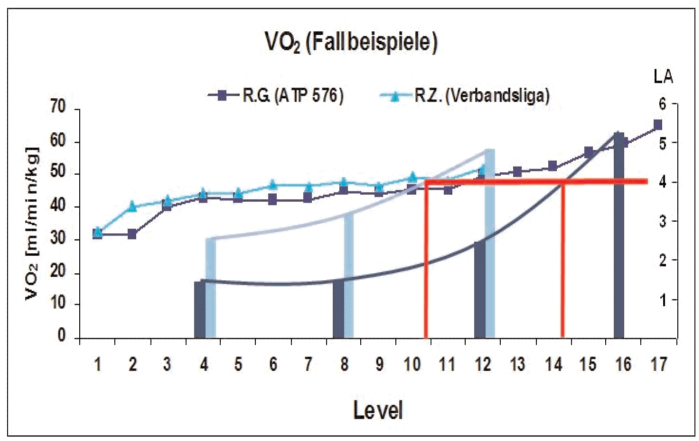

Figure 5. Illustration of the test results from selected players.

BEEP TRAINING

It is possible to use special files of the DVD for an on-court endurance training ("Beep Training"). Therefore the DVD contains sequences of three minute duration for selected levels. The training intensity can be continuous or variable. The respective Beep Training Levels should be dependant on the test results (Fig. 5).

Intensive continuous method

4 x 3 min
Level 10 (anaerobic threshold training)
2 min rest

Variable continuous method

3 min level 7
3 min level 12
3 min level 8
3 min level 13
3 min level 5

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Whats the Point - Tennis Analysis and Why

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ABSTRACT

This article is a review of information and tennis analysis gathered through technology and notation to give a broader picture of the norms and trends within the modern game. The article focuses on professional tennis findings but can be used by coaches and players to specify their training and adapt strategy for competition.

Key Words: Tennis analysis, match statstics, performance notation.
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INTRODUCTION

Notational Analysis systems have been traced back to the time of the Egyptians. They used symbols and Hieroglyphs that represented dance patterns and moves. Notation has come a long way since the times of the Egyptians and today analysists in many sports use customised computers and cameras, ball tracking devices and automated statistical packages to describe the intracacies of a game.

At the top level many teams have full time analysists as an extra objective tool for the coach. They examine their players and opponents patterns, tactics, norms and traits without bias, all in an attempt to identify ways to win. This analysis can take place pre, post and during a match. In tennis it is not usual to have a personal analysist that understands a player's game, that can use analysis equipment and programs, or that can provide objective reliable feedback. It is the coach pre and post game and the player during a match which will have to be the analyst. But is this sufficient or could tennis benefit from more feedback for players?

However, analysis of tennis does take place and can provide valuable generalised information to make training for matches more specific to the given scenario. For most coaches an easy way is to use the trends found by other experts so that training can be more specific than current. Not everyone has the time (or expertise) to analyse 1000 hours of Grand Slam footage and figure out tactical differences, but some people do, so why not use the information for your own benefit?

Objective data should be recorded during a live event and recalled after the performance, to provide feedback on the causes of faults and their consequences, but also to provide positive technical and tactical response to aid in performance enhancement (Hughes and Franks, 1997; Hughes and Franks, 2004).

PERIODISATION ACCORDING TO COURT SURFACE

The results of research studies highlight the differences between games played on different surfaces allowing players and coaches to prepare for matches with a much better understanding of the nature of the game on the specific court surface. Players can plan their year based on the main tournaments they are targetting, the surfaces of those tournaments and select build up tournaments appropriately. The year can be periodised around different sub-seasons like the clay court season, the grass court season and the hard court season varying the training to be specific to the surface.

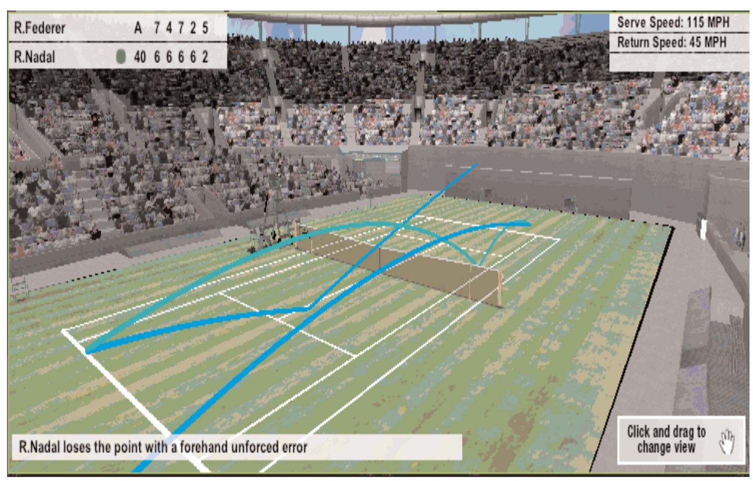
For example players use different serve placement strategies at different Grand Slam tournaments (Unierzyski and Wieczorek, 2004); players serve wide more often at the French Open and to the middle zone more at Wimbledon. More serves are returned into court in the Australian Open than at Wimbledon (Hughes and Clarke, 1995). In addition the percentage of points played from the baseline differ with surface with 51 % during Roland Garros, 46% at the Australian, 35% at the US and only 19% on the grass at Wimbledon. This type of information helps coaches know what are the typical tactics and trends used when on different surface.

STRATEGY AND TACTICS ACCORDING TO THE SCORELINE

Some interesting observations have been made relating to player strategy and scoreline. O'Donoghue and Scully (1999) analysed Grand Slam men's singles matches where both players had been level, ahead and behind on service breaks at some point during the match. The indicator of strategy used was the proportion of points the player went to the net. Those players who won these matches had a consistent strategy irrespective of the scoreline. However, the players who lost these matches tended to go to the net less when they were ahead on service breaks. Abandoning a strategy that had been successful in getting the player a service break was concluded to be a major factor in the player losing the match.

A similar observation was that players are more likely to go to the net when serving than when receiving (O'Donoghue and Ingram, 2001) and this knowledge can be used to help players prepare and make tactical decisions relating to service games and in receiving games focusing on passing or angled returns.

O'Donoghue (2007) analysed the proportion of points where players went to the net when they had game points, faced break points against them and during normal points within a game. Strategy was uneffected in women's singles, but in service games male players went to the net more when facing a game point against than when playing normal points.



RALLY TIMES

Rally times and the recovery times in between rallies give an indication of the demands of different levels of competition in tennis (Collinson and Hughes, 2002). O'Donoghue and Ingram (2001) measured rally times in Grand Slam tournaments between 1997 and 1999 and Brown and O'Donoghue (2008) determined mean rally lengths for men's and women's singles in 2007; the results of these two studies are shown in Figure 1. These studies revealed that rallies were longer in women's singles than men's singles. Furthermore, there were differences between the rally lengths at different tournaments indicating a surface effect on rally length. However, the variability between tournaments has reduced since the late 1990s., especially when we examine the difference in rally duration between the French Open and Wimbledon in both women's and men's singles.

The rally duration alone does not give a complete indication of the nature of work within rallies. For example, some matches with short rallies have more shots played per second than matches with long rallies. Matches with the shortest mean rally duration have the most shots played per second (O'Donoghue, 2008). Therefore, rallies at Wimbledon could be considered to be played at a higher intensity than those in the other tournaments, while rallies at the French Open might be considered to be played at a lower intensity than those at the other 3 tournaments. There are also more shots played per second in men's singles than in women's singles. Therefore, a higher intensity of play within rallies could be leading to rallies breaking down earlier.

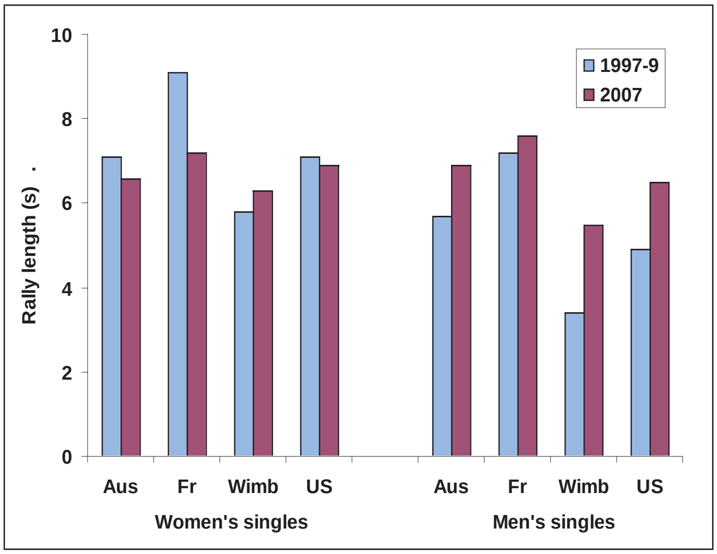


Figure 1. Rally Length for different Singles Games (1990s and 2007).

The duration of a rally has also been measured using number of shots per rally. Table 1 shows a comparison of rally lengths between previous studies. Findings of both Unierzyski and Wierzorek (2004) and Verlinden et al (2004) found rally length to be significantly greater at the French Open than at Wimbledon. From this table coaches can see that it is likely regardless of other factors (intensity and time duration) that players will hit around 2-3 more balls per rally at the French Open than at Wimbledon.

	Wimbledon	French Open
Verlinden *et al* (2004)	2.6	4.5
Unierzyski and Wierzorek (2004)	2.6	6.0

Table 1. Average Number of Shots in a Rally for Men's Singles.

WORK TO REST

Table 2 shows the similarities and differences a coach need to take into account when prescribing or periodising training for grass or clay and the change in the duration of rallies between male and female tennis. It shows a mark difference in match characteristics and should be used to achieve tennis specific training. The style of game would vary considerably for a typical female player at Roland Garros where the rally time is 8s and the percentage of the match playing rallies is 20.5% if compared with 3.5s and 11.5% for the average male competing at Wimbledon. It suggests therefore that a female has a 1 to 4 ratio of work to rest at Roland Garros compared to the 1 to 9 ratio for a male at wimbledon which alone may require a considerable change in a coaches specificity of their programme.

	French Ladies'	Wimbledon Ladies'	French Men's	Wimbledon Men's
Rally Times (s)	8	6	5.5	3.5
Inter-serve time (s)	10.5	10.5	10	10.5
Inter Point Times (s)	19.5	19	20	18.5
Inter Game- same ends (s)	28	27.5	28	27
Inter Game- change ends (s)	100	94	103	84
% Match playing rallies	20.5%	17%	15%	11.5%

Table 2. Male and Female time factors at Wimbledon and Roland Garros (O'Donoughue and Liddle, 1998).

DISTANCE COVERED AND MOVEMENT

Methods of investigating the activity of players within rallies include determining distance covered (Underwood and McHeath, 1977) and examining footstep movements (Richers, 1995). Since 1977, there have been great technological advances including automatic player tracking which have been used by broadcast media services during the coverage of tennis matches. Such technology does not only allow distances covered to be determined but also the speed of movement and acceleration and deceleration. Richers (1995) analysed footsteps made by players within rallies. She defined a continuous footstep movement as being a series of steps without changing direction. The study revealed that the number of footsteps within continuous footstep movements was similar between surfaces (5.4 on hard courts compared with 5.7 on clay and grass courts). However, there were fewer continuous footstep movements made within rallies on grass than on the other surfaces leading to shorter rallies being played on grass.

Ferrauti and Weber (2001) found that on clay 80% of all strokes played at the baseline are played within 2.5 metres and the player would hit the shot in a standing position. In addition they found that around 10% were between 2.5 and 4.5 metres away requiring a slide from the player and only 5% of shots were further than 4.5 metres away requiring a full run. Only a small amount of balls were deemed out of reach. These findings although specific to clay court tennis give an overview of the proportions of movement types and distances covered during match play and that should be guidelines for a coach during training.

Speed agility quickness training is now common in elite sport, but is often done without complete knowledge of the agility demands of those sports. In tennis, Robinson and O'Donoghue (2008) found that there were more turns or path changes per rally at Wimbledon than at Roland Garros. Another difference that Robinson and O'Donoghue found that the players were able to stop at the middle of the baseline between shots more at the French Open than at Wimbledon. This led to a greater number of breaking movements and accelerations per rally at the French Open than at Wimbledon. These results are useful in understanding injury risk of tennis at different levels and the increased demand for direction changing agility whilst playing on grass and a larger demand for breaking and acceleration movements on clay.

INDIVIDUAL STYLES OF PLAY

O'Donoghue (2004) related performance indicators in typical performances to common trends for the population of tennis players of the same ability. The approach also showed how consistent or inconsistent the players performances were. Figure 2 is a performance profile for Pete Sampras that tells a potential opponent that Sampras serves consistently fast on first and second serve, wins a consistently high percentage of points on first serve and goes to the net on a relatively high number of points compared to others. It also shows that the percentage of points won when a second serve is required is inconsistent as are the number of double faults served. For coaches to analyse an opponent in this way can give your player confidence and help identify clear goals for victory.

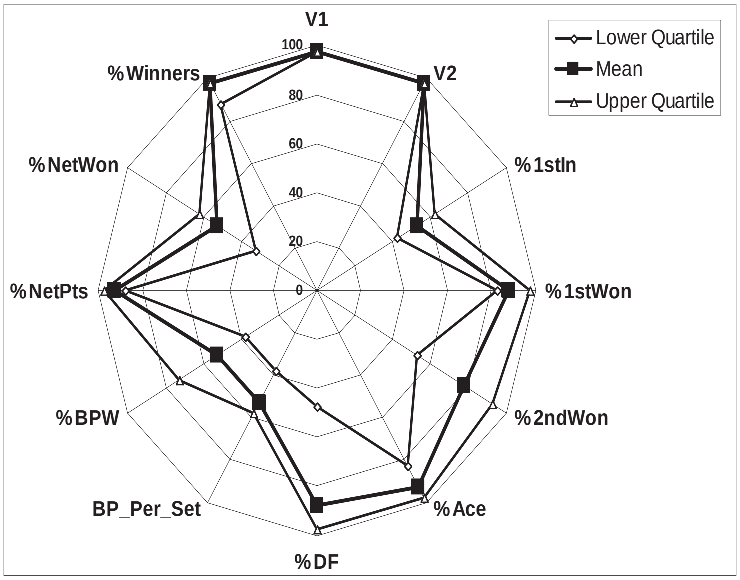


Figure 4. Normative Performance Profile for Pete Sampras (14 matches).

CONCLUSION - LINKING NOTATION WITH APPLICATION

To conclude, it is essential that coaches receive and relay to players knowledge of the appropriate trends norms and differences from this type of research and are not detered by over complicated analysis. Combining a practical approach from analysists with an increase in awareness of information by coaches will generate a greater understanding of tennis and its common characteristics through this type of technology.

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The Use of Rebound Training in Tennis Conditioning

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ABSTRACT

This article describes the use of rebound training and its application to tennis. It describes why rebound training is important and how it benefits a tennis player specifically. It looks into when it is appropriate to prescribe rebound training and gives some practical examples of how to train effectively.

Key Words: Rebound training, plyometrics, stretch shortening cycle.

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INTRODUCTION

Rebound training is a training method with many expressions in sport. In general, it means training forms with bouncing effects such as jumping or fast strokes. These movements are often called plyometrics or reactivity. Its main characteristic is a muscle stretch immediately followed by a muscle contraction. From the physiological perspective, the underlying physiological mechanism is the stretch-shortening cycle. Also general activities such as running and hopping, are strongly influenced by stretch reflexes (Komi, 2005). In tennis specific leg work and stroke production they play an important role for speed strength and high velocities. This becomes evident in the fast change from eccentric to concentric muscle work e.g. during ground strokes or side steps which takes place in a small time pattern of approx. 100 ms respectively 200ms (Kleinöder and Mester, 1996).

FORMS AND EFFECTS OF REBOUND TRAINING

In the spectrum of strength training, rebound training mainly improves muscle quality and less muscle size. This can be explained by a better neuromuscular coordination expressed in a higher recruitment of muscle fibres and a higher firing rate of motor units (frequency). Moreover, the stretch reflex and the storage of elastic energy within muscle structure and tendon also play an important role (Komi 2005). Additionally, mean power output for rebound motion is considerably higher than concentric only motion (approx. 12%). Other effects of rebound are the production of greater peak accelerations (up to approx. 40%) and greater initial force and peak forces (approx. 14%, cp. Cronin; McNair and Marshall, 2001).

This shows that rebound training can be used in many forms of strength training. Of high importance is the interval of change from eccentric to concentric work which should have a short duration. This is of general importance no matter whether the wrist or the leg extensor muscles are involved. A longer pause interval can be effective for other objectives such as muscle hypertrophy, but can be interpreted as an indirect method to improve movement velocity.

Quite often, the border between rebound and maximal force training is not strict as can be seen in the various forms of jumping. Dependant on the condition of ground, different aspects of force production are important for a good jumping result. So there is a shift from reactivity to maximal force when the ground is soft as is the case in beach volleyball e.g. or when using a mat or when training on grass court. Maximal force becomes much more important under these circumstances and the contact time on the floor increases. Therefore training of jumping performance is often combined with conventional strength training and vibration training. Vibration training means a high frequency stimulation (20-50 Hz) of the trained muscles within a small amplitude of 1-5 mm. This kind of rebound training has been proven successful for the improvement of jumping performance esp. (Mester, Kleinöder and Yue, 2006).

There are other special conditions of rebound training such as EMS (electromyostimulation) training. In modern forms, electrodes in form of belts are placed directly on the muscles to be stimulated. When performing static or isometric training, EMS intensifies the muscle contraction and allows to reach fast muscle fibres easily (Komi, 2005). Another special condition of rebound training is trampoline jumping. It helps to improve the stability of the torso and balance in general which is a fundamental condition for successful rebound training.

DIAGNOSTICS OF REBOUND TRAINING IN TENNIS

Rebound training encloses many different tasks in tennis. Leg work consists of different forms of side steps, fast steps forwards and backwards, jumping for a volley or smash, changes of direction in variable order etc. Thus plyometrics is trained daily on the court itself in form of long endurance reactivity with continuously differing intensities. This includes stroke production as well, esp. fast ground strokes. In detail, around 100 ms before hitting the ball there is a pre-stretch of the forearm muscles which is released in a high acceleration towards the impact with the ball (Kleinöder, 1996). Dependant on the compromise between velocity and precision in each situation the stretch shortening cycle plays an important role esp. for velocity production. In order to prepare players diligently with reference to health and performance a differentiate diagnostics of static and dynamic force is needed.

In practice this is quite often tried with simple tests of sport performance, e.g. jump-and-reach, the physiotherapeutic interpretation of special tests or simple video analysis. This, of course, delivers general information about the training status and performance. In order to offer detailed individual training programmes, however, the testing should also include a deeper analysis of jumping performance with force-time-curves of each leg or other muscle groups. This gives important information about specific coordination during the actual task. Classic diagnostics consists of three tests of jumping performance, i.e. the squat jump (SJ), the counter movement jump (CMJ) and the drop jump (DJ). The squat jump tests dynamic power production and maximal force without rebound, whereas rebound qualities and speed strength are measured with the CMJ and esp. the DJ.

In addition to that, a selective and combined understanding of the muscles involved in the movement is important for training consequences. This approach includes the testing of force, speed strength and power of functional muscle groups thus revealing individual weaknesses. Moreover, it also gives information about balances of agonists and antagonists involved. Based on this sophisticated knowledge and consequently a deep understanding about the athlete´s condition, trainers are able to deduce the individually most effective training mix of methods. Another advantage of this approach is the transferability to the different conditions of plyometrics.

Figure 1. Jumping performance.

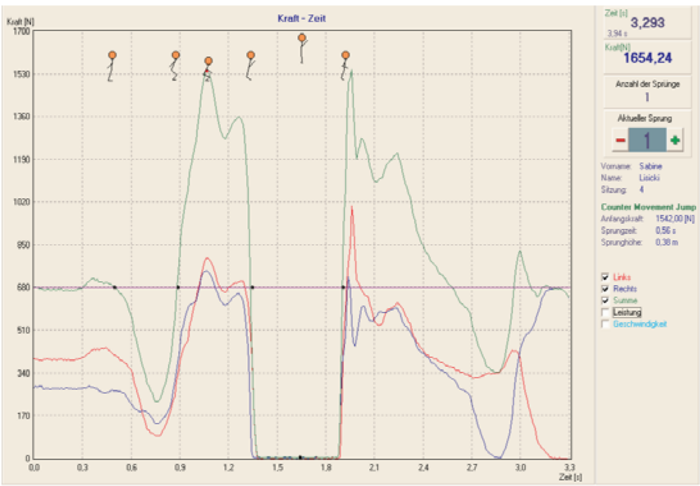

Figure 2. Example of Strength diagnostics.

TRAINING METHODS

A good performance in tennis depends considerably on rebound abilities. These occur in various forms with low (e.g. side steps) and high intensities (e.g. explosive jump for a volley). Also the time pattern of the stretch shortening cycle varies considerably with long (e.g. powerful change of direction) and short expression (e.g. fast strokes). This is also true for the different courts, e.g. clay, hard or grass court.

Accordingly different and variable training methods are needed. Therefore plyometric training should be supported by conventional strength training early since both forms complement each other. So children start early with easy forms of plyometrics such as skipping or jumps on mats for the leg work in order to avoid high impacts. Skipping can be combined with tennis specific leg work such as sidesteps etc. Since depth jumps place high stress on muscles and joints as well as single-leg work (Baechle, 2000) they should be carefully prepared by an additional strength training next to coordination and technique training. For the upper body and the arms medicine ball training with varying tasks can be performed. These enclose tosses with and without stretch shortening cycle. Again, resistance training with weights is also helpful because it improves stability of the torso and supports speed strength of the arms.

The additional strength training should follow medical guidelines. The American Academy of Pediatrics, the National Strength and Conditioning Association, the American College of Sports Medicine and the American Orthopaedic Society for Sport Medicine recommend early strength training. The approach should be suitable for children following functional movement technique and a progressive loading. Moreover, at least 6 repetitions should be done during training in order to avoid maximum loads (Fleck and Kraemer 2004). Later special forms of strength training such as vibration and EMS training should be included in order to intensify rebound and strength training. These methods have the advantage that training units are short and at the same time effective (Mester, Kleinöder and Yue, 2006).

CONCLUSION

Rebound is an important factor in tennis performance with different forms of low and very high intensity. Plyometrics is both influenced by maximal strength and the coordination of the SSC depending on the task on court. This is true for the leg work as well as the velocity production of fast strokes. Because of the complexity it is recommended to start early with the improvement of all components. A differentiated diagnostics helps to find out individual weaknesses and saves time to organise the training accordingly.

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Information Technology in Tennis

Scott Over (International Tennis Federation) and Brenden Sharp (Australia)

ITF Coaching and Sport Science Review 2008; 15 (45): 24 - 25

ABSTRACT

This article discusses current advances within information technology and computers that are available to coaches and players. Why information technology aids with education in the coaching world and possible future plans to make these resources more available and effective.

Key Words: Information technology, distance learning, coaches education.

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INTRODUCTION

As tennis is a truly global sport played in just about every nation in the world it was one of the first sports to take full advantage of the internet to share information. Before the internet tennis enthusiasts wanting to get information on tennis had to rely on either their television, newspaper or their local tennis magazine which all had limited space and time they could allocate specifically to tennis.

The internet has had a profound effect on just about every industry, and tennis is no exception. The internet enabled Tennis coaches and players to gain access to tennis experts and information from every corner of the planet. In the early years of the internet this information was primarily in the form of text and photos due to the fact that most users gained access to the internet via slow dial up accounts. Over the past few years the speed at which users are connecting to the internet have increased dramatically due to the rapid adoption of broadband as the preferred way to access the internet. Coinciding with this was the rise of digital still and movie cameras which have enabled the virtual explosion of video content being published to the worldwide web.

If you type Tennis Coach as the search term on Google's search page you get 2,200,000 results returned. Now that you can gain access to all this information it is very important that you can separate the truly valuable information from the huge amount of content now available.

TENNIS ICOACH

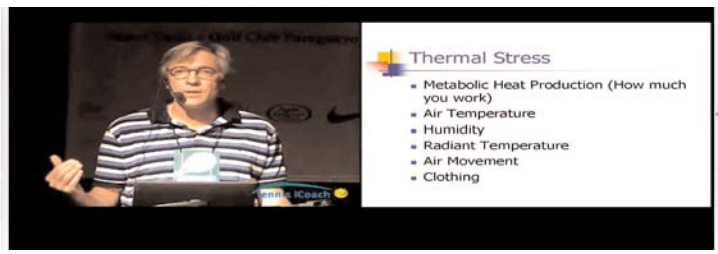
An example of best uses of the internet in Tennis Coach Education is how the ITF are now video recording their regional and worldwide coaches conferences and publishing them to the internet. The ITF have been conducting these events in different regions around the world where a select number of coaches attending have had access to world class experts. Now anybody who has internet access is also able to have access to these experts by watching the videos online.

The ITF believe that they can play a crucial role in helping to grow the sport worldwide by distributing information via the internet. On July 1 2007 the ITF launched their all new Tennis iCoach website. Tennis iCoach uses the latest online techniques to further engage and educate the tennis coaching and playing population around the world. These videos are both on court and in the lecture room presentations from experts from all over the world. Up until now only a select few coach were able to attend these coaching conferences. By publishing these videos to the internet the ITF are now able to dramatically increase the number of coaches who can gain access to the valuable information.

Currently available on the web is a large amount of information on tennis and sports science. Tennis iCoach is an extensive bank of information however in addition it contains e-learning modules that contain a mixture of text, audio narration and video. These eLearning modules are presented by the experts that have worked with the ITF to produce these exclusive modules. Many of the modules link directly to the content of ITF level 1 and 2 courses and assess with quizzes providing feedback and future progressions. This we believe emphasises the approach of the ITF to not only provide up to date information but continuous education for coaches' worldwide.

What is currently available for a tennis coach?

- All the resources are **categorised** to aid finding specific information. This includes tactics, biomechanics, psychology, technique, conditioning, coach development, strokes, teaching methodology and much more.
- Made all resources readily **searchable** and accessible.
- **Lecture Room Presentations** - which combines PowerPoint presentation with video and audio.



- **On court presentations** - Taken from ITF coaching conferences.
- **Drills and Exercise videos** - Using current professionals and top coaches.
- **Biomechanical stroke analysis from Dartfish with video** (Various Speeds)
- **Sequenced photos of various professional's strokes**
- **E-learnings** - 50+ PowerPoint with audio and quiz assessment.

- **Articles Archive** - 100's from players, coaches and experts.
- Added choice to search for exact subject areas or specific words of interest.
- **Interviews** with experts and players.
- Coaches are able to add their own **feedback** to each and every article and video presentation to become interactively involved in the ongoing evolution of this global tennis resource.

Tennis iCoach is the only truly global based tennis website on the internet with expert contributions from leading coaches from every corner of the world. The resources provided are not provided by one national association but by many. Not providing just one style, ethos or technique but from international courses and world conferences, Davis and Fed cup captains, professional players and world renowned sport science experts with years of experience in tennis from countries such as Argentina, Australia, Belgium, Brazil, Britain, Canada, France, Germany, Italy, South Africa, Spain and USA.

WHAT COULD BE DONE FOR THE FUTURE

Future possible plans for internet based education could include live feeds from the ITF conferences and the possibility of a monthly live expert who can arrange a time to give a lecture on an agreed topic, and answer any questions in the form of a live consultation. In addition the possibility of developing a customised coaches education platform which analyses information and assess the competence of a coach to determine what is required to further long term coach development using existing resources.

In addition to the constant update to the current resources, a diversity into Spanish resources is planned for the near future as well as adapted tennis resources including information on Wheelchair tennis, tennis for the blind and tennis for people hard of hearing.

CONCLUSION

The accessibility of these resources and the advance in technology allows the ITF to educate people in areas and lifestyles that previously were not being exposed to this quality of information with relatively low cost to both the coach and the federation. These examples of distance learning tools provide a resource which can increase a courses education hours without the rental of a room or tutor and that enables a coach to study in their own time. These resources make a flexible alternative for those people who work long hours and have other commitments, those that wish to assist but do not wish to take a full 5 day course, or for people living in countries where coaches education is poor or doesn't exist.

Psychology & the Use of Technology

Roberto Forzoni (National Performance Psychologist. Lawn Tennis Association)

ITF Coaching and Sport Science Review 2008; 15 (45): 26- 27

ABSTRACT

This article looks into the current techniques and technologies used in sport and tennis by psychologists. It describes how psychologists and coaches can link physiological feedback such as heart rates and ECG's to aid with psychological support to an athlete.

Key Words: Technology, electrocardiogram, anxiety, stress.

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PSYCHOLOGY & TECHNOLOGY: AN INTRODUCTION

Unlike other sport sciences, psychology can suffer from the lack of objectively measurable parameters. The fitness coach can show improvements made from a training programme quite easily using numbers; the athlete will be running faster (seconds), jumping higher (cm) or lifting more weights (Kg). For the psychologist, measuring success can be more difficult. What real changes are going on inside the players mind? Has our intervention really managed to reduce levels of anxiety, for example, and if so by how much? With technological advances, decreasing costs and equipment size, along with the ease of use of bio-feedback and neuro-feedback devices make the accurate assessment of the effectiveness of specific mental skills strategies easier to measure and monitor over time.

So how can technology help sport psychologists?

As an applied consultant, I value the use of technology to help the athletes with whom I work. We live in an MTV world, and young athletes are surrounded by technology. The use of ipods, mobile phones and PCs is not only common, technology is now very much an integral part of an athlete's life (how did we survive without MySpace/ Facebook/YouTube, etc.?). Initially, using 'technology' can help consultants sell psychology, and ongoing it can help athletes gain more acceptance and enjoyment in 'using' psychology.

A product example: Heart Math - Freeze Framer

One way I have used technology to support and enhance my work with athletes has been with the use of bio-feedback software to monitor levels of stress and measure the effectiveness of various interventions to reduce anxiety; specifically, by measuring an athlete's heart coherence (see below), the effective development and use of relaxation techniques can be assessed.

One of the many products available is the Heart Math / Freeze Framer package which measures heart coherence. This is a real value for money and easy to use programme. Once loaded onto your PC, the athlete is 'connected' by means of a finger or ear sensor, and immediate graphical feedback is displayed on screen. What I like about this software is that it offers three 'game-like' programmes whereby images change on screen in accordance with how coherent your hear rate is; an example is a black and white image changing to colour the more coherent your heart rate becomes. By practicing various relaxation techniques (including controlled breathing and visualising positive images) you can actually effect and, once trained, control your heart coherence, and consequently your emotional control. The 'game' can become quite competitive by having players try and achieve more improvement than others. This can further enhance its use by practicing relaxation techniques in competitive situations! By practicing over a period of time (e.g. once a week for 4 weeks), athletes can start to develop skills to not only lower their heart rate, but more importantly increase their heart coherence and thus their feelings of well being. Scores are recorded and progress can be easily and objectively monitored. This training is a great way to get players to understand how much control they actually have over their emotional responses. The standard game images can be replaced with actual player performances (good and not so good) in order to train players to deal better (whilst in a more controlled and relaxed state) with a variety of real match situations.

STRESS, ANXIETY, HEART RATE VARIABILITY AND HEART COHERENCE

Stress and anxiety are the body and mind's response to any pressure that disrupts its normal balance; they are often cited as the number one block to successful performance. Stress occurs when our perception of events doesn't meet our expectations and we are unable to manage our reaction. As a response, stress expresses itself in a number of ways; in tennis this can be by getting tight, frustrated and angry. One way of looking at anxiety is that it throws off our physiological and psychological equilibrium, keeping us out of sync. If our equilibrium is disturbed for long, the stress can become disabling, seriously impeding performance. In the long term it can even create numerous health problems. It's worth remembering that stress is caused by our emotional reactions to events rather than the event itself. So learning to control reactions is key.

Emotions, or feelings, have a powerful impact on the human body. Emotions like frustration, insecurity and depressing feelings are stressful and inhibit optimal health and relief from stress. Positive emotions like appreciation, care, and love not only feel good, they promote health, performance and well-being. Research has shown that when you learn how to intentionally shift to a positive emotion, heart rhythms immediately change. A shift in heart rhythms may not seem important but in fact it creates a favourable cascade of neural, hormonal and biochemical events that benefit the entire body. The stress relief effects are both immediate and long lasting.

Heart rate variability (HRV) is a measure of the naturally occurring beat-to-beat changes in heart rate. The analysis of HRV, or heart rhythms, is a powerful, non-invasive measure of neuro-cardiac function that reflects heart-brain interactions and autonomic nervous system dynamics. HRV can be derived either from the electrocardiogram (ECG), using electrodes placed on the chest, or from pulse wave recordings, using a plethysmographic optical sensor placed at the fingertip or earlobe. Whilst ECG recordings offer some advantages, pulse wave recording devices provide data suitable for most applications, and, as they require no electrode hook-up, are more easily adaptable for use in a much wider variety of settings.

A promising advancement in biofeedback technology is the recent development of HRV feedback systems. In relation to other types of biofeedback, HRV feedback offers several unique advantages. First, HRV feedback reflects the activity of both the sympathetic and parasympathetic branches of the autonomic nervous system and the synchronization between them. Compared to EEG feedback, HRV feedback is also considerably simpler and more straightforward to learn and use, which facilitates rapid improvement. Further, because the instrumentation utilizes only a simple pulse sensor requiring no electrode hook-up, it is extremely versatile and can be used easily and effectively as an educational tool not only in clinical settings but also in the home, in the workplace, in schools, or even while travelling. Its cost-effectiveness also makes it accessible to a greater number of people and in a wide range of applications. In relation to other biofeedback modalities, HRV feedback is also more reflective of changes in emotional/ psychological state, and thus is particularly powerful in applications where reducing stress and increasing emotional stability are critical.

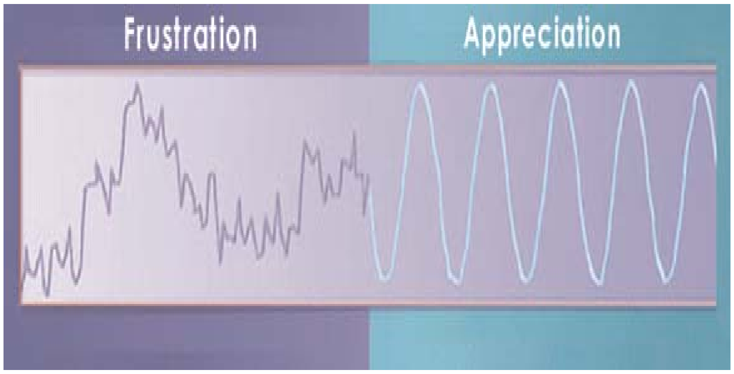


Figure 1. Shift to coherence. Real-time heart rate variability (heart rhythm) pattern of an individual making an intentional shift from a self-induced state of frustration to a genuine feeling of appreciation by using a positive emotion refocusing technique. Note the distinct change in the pattern of the heart rhythm from an erratic, disordered heart rhythm pattern associated with frustration to a smooth, harmonious, sine wavelike (coherent) pattern as the individual uses the positive emotion refocusing technique and self-generates a heartfelt feeling of appreciation.

HOW COHERENCE AFFECTS STRESS, WELL BEING AND PERFORMANCE

Some of the devices and programmes now available have been designed to help athletes learn to activate and sustain the coherence state. Research has shown that shifting into coherence is an effective and powerful strategy for reducing and transforming stress and anxiety. When we are faced with a stressful situation, making a shift into coherence prevents or minimises the body's normal stress response and its negative repercussions on the brain and body. It also facilitates thought and emotional regulation abilities that are normally compromised during stress and negative emotional states, thus enabling athletes to deal with stressful situations more effectively.

Because the body's systems function more efficiently during coherence, generating this state can save significant amounts of energy. Regularly using coherence building tools can lead to higher energy levels and improved sleep.

Generating coherence shifts the body into a state of optimal functioning and is thus a natural performance enhancer. Claims of increased clarity, more effective decision making, improved work flow, enhanced creativity are also made.

PERSONAL PERSPECTIVE

I used the Heart Math Freeze Framer product over the course of two years at one of the LTA's High Performance Tennis Centres and it proved a huge success with young (12-16yr old) players, keen to show their ability to control their emotions, and relax in varying situations. I understand that the Italian world cup squad employed a bio-feedback device prior to the 2004 World Cup finals, with players watching stressful penalty shot outs and learning how to stay calm and relaxed. Italy won the world Cup on penalties, all 5 players scoring.

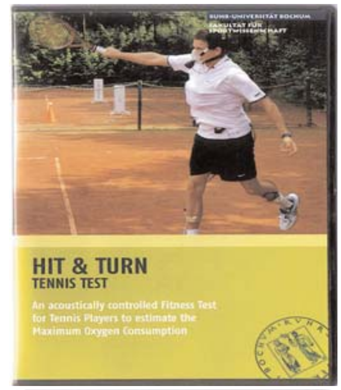
The power of this type of heart coherence training lies in the fact that this approach not only produces immediate feedback, but also facilitates sustained changes in health, well being and performance. Itis also a really fun way to train your own emotional control.

CONCLUSION

As the cost, ease of use, and practicality of bio-feedback machines continue to become more affordable, sport psychology consultants will find an array of computer generated software to use in the future which will enable them to accurately measure the effectiveness of various interventions. With technology being an integral part of athletes lives, the consultant of the future would be wise to invest time and money into learning about the feedback systems available.

Research and notes on heart rate variability and coherence from: Heartmath LLC: www.midmodulations.com

Recommended Books and DVDs

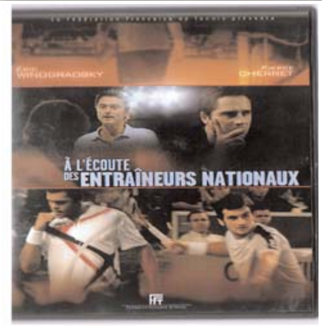


HIT AND TURN TENNIS TEST

Author: Dr. Alexander Ferrauti **Year:** 2008 **Language:** English **Type:** 15 page manual and DVD **Level:** All levels

The Hit and Turn tennis test is an acoustically controlled and progressive fitness test for tennis players. The test can be easily carried out with a racket on a tennis court by one or more players at the same time. The objective of the test is to follow as long as possible the audible signals and to keep up the required footwork. The player has to run along the baseline and hit a forehand or a backhand shot in the respective corners in time with the audio signals. The maximum achieved test level is assessed and can be used to estimate the maximum oxygen uptake. The DVD includes instructions as well as the training exercises and the test audio.

For more information contact: alexander.ferrauti@rub.de



A L'ÉCOUTE DES ENTRAÎNEURS NATIONAUX (LISTENING TO WHAT NATIONAL COACHES HAVE TO SAY)

Author: French Tennis Federation **Year:** 2008 **Language:** French **Type:** DVD **Level:** Advanced

National coaches are privileged observers of the evolution of the game at the highest level. Eric Winogradsky and Pierre Cherret, both coaches at the National Training Centre of Roland Garros, answer questions on a variety of topics, offering their views on male and female player development at the professional level. Their comments will no doubt be of interest to both coaches and tennis fanatics.

For more information visit www.fft.fr

LES NOUVEAUX TESTS DES BALLES ET LA CHRONOLOGIE DE L'APPRENTISSAGE (THE NEW BALL TESTS AND THE STAGES OF LEARNING)

Author: French Tennis Federation **Year:** 2007 **Language:** French **Pages:** 39 **Level:** Beginner / Intermediate **ISBN:** 2-916131-08-6

The new ball tests are part of the progressive tennis approach which uses formats on 12 metre, 18 metre and 24 metre courts. The suggested stages of learning help coaches plan their sessions and prepare players for the tests in order to improve their playing skills.

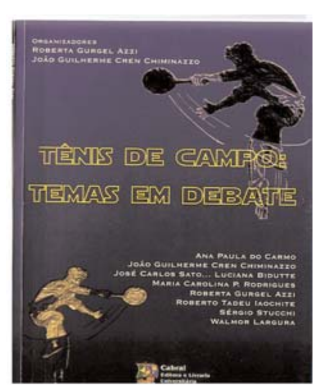
For more information visit www.fft.fr

HOW TO OBTAIN A SPORTS SCHOLARSHIP IN A US UNIVERSITY

Author: Thomas E. Anderson **Year:** 2006 **Language:** Spanish **Resource Type:** 350 page book **Level:** Intermediate/ Advanced

This is an extensive guide to obtaining sporting scholarships to Universities in the United States of America. It describes the level of academics, level of performance and standard of English required for acceptance. The universities and sporting structure is discussed as well as how they vary by comparing different types of division universities and sports available in America. The guide has a step by step approach to the application process discussing overseas applications and typical forms, visas and paperwork necessary for a successful acceptance to a desired university.

For more information visit www.becasusa.com



(TENIS DE CAMPOS: TEMAS EM DEBATE) TENNIS: TOPICS AND DEBATES

Editors: Roberta Gurgel Azzi and Joao Guilherme Cren Chiminazzo **Year:** 2005
Language: Portuguese **Resource Type:** 120 page book **Level:** All Levels **ISBN:** 85-89550-61-3
This is a collection of Portuguese articles which focus on typical problems in physical education and discusses psychological theory of how some of these can be overcome. The compilation combines theories and practice from University professors, players, coaches and experts with various backgrounds and knowledge in tennis to attempt to bridge the gap between academic knowledge and practical application.

For more information visit www.editoracabral.com.br

General Guidelines for Submitting Articles to ITF Coaching & Sport Science Review

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TOPICS

ITF Coaching and Sport Science Review considers for publication original research, review papers, opinion pieces, short reports, technical notes, topical lectures and letters in the disciplines of medicine, physiotherapy, anthropometry, biomechanics and technique, conditioning, methodology, management and marketing, motor performance, nutrition, psychology, physiology, sociology, statistics, tactics, training systems, and others, having specific and practical applications to tennis coaching.

FORMAT

Articles should be word-processed preferably using Microsoft Word, but other Microsoft compatible formats are accepted. The length of the article should be no more than 1,500 words, with a maximum of 4 photographs to be attached. Manuscripts should be typed, double spaced with wide margins for A4-size paper. All pages should be numbered.

Papers should usually follow the conventional form: abstract, introduction, main part (methods and procedures, results, discussion / review of the literature, proposals-drills-exercises), conclusions and references. Diagrams should be done using Microsoft Power Point or any other Microsoft compatible software. Tables, figures and photos should be relevant to the paper and should have self explanatory captions. They should be inserted in the text. Papers should include between 5 and 15 references that should be included (author/s, year) where they occur in the text. At the end of the paper the whole reference should be listed alphabetically under the heading 'References' using the APA citation norms. Headings should be typed in bold and upper case. Acknowledgement should be made of any research grant source. Up to four keywords should also be given and the corresponding author contact details.

STYLE AND LANGUAGES OF SUBMISSION

Clarity of expression should be an objective of all authors. The whole emphasis of the paper should be on communication with a wide international coaching readership. Papers can be submitted in English, French and Spanish.

AUTHOR(S)

When submitting articles authors should indicate their name(s), nationality, academic qualification(s) and representation of an institution or organisation that they wish to appear in the paper.

SUBMISSION

Articles may be submitted at any time of the year for consideration for future publication. Articles should be sent by e-mail to Miguel Crespo ITF Development Research Officer to the following e-mail address: coaching@itftennis.com.
In calling for papers, the Editors ask that contributors adhere strictly to the guidelines. Views expressed by contributors are their own and not necessarily those of the Editors or publisher.

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