MEDICINE AND SCIENCE IN TENNIS

Journal of the STMS, the ITF, the ATP and the Sony Ericsson WTA Tour

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Dear Tennis Friends,

Welcome to the April issue of Medicine and Science in Tennis which contains the report and abstracts from the very successful 2006 STMS World Congress held in Melbourne, Australia. Several of the presentations appear as full-text articles and our special congratulations go to Tim Wood for bringing together so many respected and knowledgeable speakers, which in turn led to lively discussion and interesting debate.

I would like to take this opportunity to congratulate the ITF President, Francesco Ricci Bitti, on his election to the IOC during the recent Winter Olympic Games in Turin. This is a great honour for him, and the sport, and will undoubtedly have a very positive effect on the way tennis is perceived in Olympic circles. In this issue, you can review the IOC Consensus Statement on the Female Athlete Triad, which was formulated by an expert group at the IOC headquarters in Lausanne, 7-8 November 2006.

It also gives me great pleasure to announce that the May 2006 edition of the British Journal of Sports Medicine (BJSM) will be devoted totally to tennis and you can find a preview of this issue on page 4. Michael Turner and I were asked to act as guest editors for this issue and contributions come from STMS members, the ITF Sports Science and Medicine Commission, the ATP and the Sony Ericsson WTA Tour. All STMS members who have paid their membership fees for 2006 will receive a free hard copy in May and STMS members will be able to access the articles electronically through the STMS membership website, using their login code and password.

Make sure that you have paid your 2006 membership fee!

The BJSM is published by the BMJ group and is the monthly journal of the largest sports medicine organization in the UK – BASEM (the British Association of Sport and Exercise Medicine). For more information, please visit the BJSM website at www.bjsm.bmjournals.com, the BASEM website at www.basem.co.uk, and Exercise Medicine. For more information, please visit the BJSM website at www.bjsm.bmjournals.com, the BASEM website at www.basem.co.uk, or our website at www.stms.nl or contact Michael Turner directly at STSMmembership@aol.com

As you can see from our 2006 Conference Calendar (page 5x), there are numerous educational opportunities this year, with tennis medicine conferences being held almost every month. I have no doubt that these events will provide an excellent forum for the exchange of ideas and research in the expanding field of tennis medicine and science and I do hope that you will support them whenever you can.

Best wishes,

Babette Pluim, MD, PhD
President STMS
The meeting was a great success, not only because of the number of participants (150 people) but also because of the scientific quality and the interest shown by the participants.

The programme was both theoretical and practical, whereby a lecture on the biomechanics was followed by a review of the bony and tendinous lesions (acute and chronic) that may result from playing tennis. Methods of training were discussed, followed by the rehabilitation and physiotherapy. The end of the first session was dedicated to the indications for and problems with arch supports. Two exhibitions, on arch supports and shoe technology, completed this day.

These meetings are an excellent opportunity for the various team members that take care of athletes to meet (doctors, physiotherapists and coaches), but also for the professionals who come from the various regions in Switzerland and from the neighbouring countries (particularly Germany). We have continued to develop our relationship with Tennis Europe, because we are convinced that the medical team should work more closely with the official organisations concerned with the functioning and development of tennis at international level.

We would like to thank Pfizer AG who have supported us during the last three years with the organisation of this Symposium.

The Symposium in 2006 will be dedicated to back injuries and will be held in Basle on 25 October.

The symposium entrance

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**CONFERENCE ANNOUNCEMENT**

Society for Tennis Medicine and Science

North American Section Meeting

*August 10-12, 2006, Greenbrier Resort, White Sulfur Springs, West Virginia*

**S**TM S will continue its tradition of high levels of scientific presentations, challenging levels of tennis play, enjoyable social programs, and beautiful venues with its next meeting at the Greenbrier resort.

The scientific program will highlight all aspects of the medicine and science of tennis, ranging from injury and prevention in youth to tennis play in the older athlete with arthritis. Topics will include, among others, surgical and non surgical treatments, rehabilitation, biomechanics of tennis, heat issues, core stability, and prevention programs. The format for the sessions will follow the Gordon Conference Format where 1-2 short presentations will be given on specific topics followed by guided discussion sessions. The group will discuss the topic, which will include the reasons for consensus (agreement), difference (disagreement), and future directions. Emphasis will be on specific application of the information to tennis play, but also to athletic participation in general. The preliminary agenda for the meeting includes:

- Opening night reception Thursday night
- Educational meeting 7:30 AM - 12:30 PM Friday and Saturday
- Organized tennis play Friday afternoon
- Bunker tour Saturday afternoon
- Closing dinner Saturday night

The Greenbrier resort is one of the nation’s oldest and most complete resorts. Set in the mountains of West Virginia, it has excellent facilities for all types of athletic activities—indoor and outdoor tennis clinics and individual play, golf, horseback riding, swimming, hiking, and canoeing. In addition it has many other activities—shopping, spa facilities, children’s programs, first run movies, and tours of "the bunker", a cold war facility intended to house members of Congress in the event of a nuclear attack.

We have planned several social activities, including a welcome reception, organised tennis play, a bunker tour, and a closing dinner. The Greenbrier is one of only two facilities in the USA to have received 4 star designation every year for the past 25 years. A group of rooms have been reserved at a special convention rate of $270.00. Each attendee will need to make their own reservation to secure the room. Please contact the Greenbrier resort at +1-800-453-4858 and request the room block for STMS.

For further information please contact:

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BJSM & STMS
serves up a tennis special

Tennis theme issue FREE for STMS members
The May 2006 issue of the British Journal of Sports Medicine (BJSM) will be dedicated to tennis science and medicine. This issue is FREE to members of the STMS, as is access to the online version via the STMS website.
Including contributions from members of the STMS, the ITF Sports Science and Medicine Commission, the ATP and the Sony Ericsson WTA Tour; this edition promises to be a must-read.

Articles include:
• Applied physiology of tennis performance Mark S Kovacs
• Tennis injuries: occurrence, aetiology and prevention Babette M Pluim, Jacobus Bart Staal, et al
• Postero-medial elbow problems in the adult athlete Denise Eygendaal, Marc R Safian
• The Sony Ericsson WTA tour 10 year age eligibility and professional development review Carol L Otis, Miguel Crespo, et al
• Health benefits for veteran (senior) tennis players Bonita L Marks
• Spondylolisthesis in young tennis players Angel Ruiz Cotorro, Ramon Baius Matas et al

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Most singles matches in Grand Slam tennis tournaments are played to completion even if one or both players need medical attention during the match. An indication of a more serious injury is provided by a match score such as 6-4, 4-2 (ret) where one player retires before the match is completed. On average, about 3% of all matches are not completed. For example, 54 out of 1269 (4.3%) matches were not completed at the US Open during the ten-year period from 1995 to 2004. The percentage of incomplete matches at all four Grand Slam tournaments is shown in Table 1 for three selected five- or ten-year periods. All data were obtained simply by examination of the set scores at each event. No attempt was made to determine the type of injury.

The first row in the table includes a five-year period where wood racquets were still in use and where the Australian Open was still being played on grass. The Australian Open switched to hardcourts in 1988. The US Open changed to hardcourts in 1978. The second row includes a ten-year period where modern graphite racquets had completely replaced wood racquets. The third row shows the results for women’s singles matches over a recent five-year period.

One can conclude from this table that (a) grass courts lead to fewer injuries, (b) women have fewer injuries than men, (c) the number of injuries increased when graphite racquets replaced wood racquets and (d) women have more injuries on Australian hardcourts than on other Grand Slam surfaces, while men have more injuries on the US hardcourts. Women have fewer injuries per match in part because they play best of three-set matches while men play best of five sets. However, the injury rate for women is less than 3/5 of that for men. The fact that around 97% of matches are played to completion indicates that the various court surfaces are relatively safe. Nevertheless, a serious injury in just one match can result in a relatively long period where a player is unable to play tennis at all or where the player is more susceptible to additional injuries. Consequently, the results in Table 1 should be regarded with some concern by both players and sports medicine practitioners.

The switch from wood to graphite resulted in the game being played at a faster pace. It also resulted in a change to a Western grip forehand, a double-handed backhand, an open stance, baseline rather than all-court play, the demise of the serve and volley game, and it resulted in more grunt- ing and screaming because the players started hitting the ball harder. Many observers attribute the changes to the fact that modern racquets and players are more powerful. In fact, modern racquets are lighter and less powerful. The main change was due to the increase in racquet width from nine into around 10.5 inches. The result was that players could strike the ball faster without the ball clapping the frame. The faster racquet head speed resulted in more topspin which caused the ball to land shorter in the court. Players could therefore hit the ball even harder which gave them even more topspin, especially when using a Western grip. Today’s players tend to hit the ball as hard as they possibly can. As shown in Table 1, the result has been an increase in injuries on all court surfaces, not just on hardcourts. A more complete explanation of the influence of wider racquets is given in the new book “Technical Tennis” by Crawford Lindsey and myself.

### Table 1: Grand Slam incomplete matches

<table>
<thead>
<tr>
<th>Period</th>
<th>Who</th>
<th>Wimbledon</th>
<th>Australian Open</th>
<th>French Open</th>
<th>US Open</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978-1982</td>
<td>Men</td>
<td>0.3%</td>
<td>0.8%</td>
<td>1.2%</td>
<td>2.2%</td>
</tr>
<tr>
<td>1995-2004</td>
<td>Men</td>
<td>2.0%</td>
<td>3.1%</td>
<td>3.6%</td>
<td>4.3%</td>
</tr>
<tr>
<td>2001-2005</td>
<td>Women</td>
<td>0.6%</td>
<td>1.9%</td>
<td>0.6%</td>
<td>0.8%</td>
</tr>
</tbody>
</table>
The 8th International Congress of the Society for Tennis Medicine and Science was held in Melbourne, Australia on the 14 and 15th January 2006, the weekend preceding the start of the Australian Open. Over 90 delegates and speakers registered and participated in the conference and overall the feedback was extremely positive.

After the conference was opened by Paul McNamee, the Chief Executive Officer of the Australian Open, Professor Tim Noakes, the keynote speaker from South Africa, and Professor Mark Hargreaves gave an overview of the traditional view on the peripheral model of fatigue during exercise as well as the recent central governor model in which the brain has a significant input into exercise performance and tolerance.

David Connell gave a succinct overview on when to undertake a radiological investigation. Sometimes the decision making process can be clouded by a number of other factors. Lorenzo Masci, one of the Australian Open tournament physicians presented his Masters research looking at whether MRI is as sensitive as bone scanning when investigating for lumbar pars stress fractures.

His research showed that of 50 positive SPECT bone scans for these stress fractures, MRI only successfully picked up 40. So even when fine slice MRI is used looking particularly at the pars region, up to 20% of stress fractures could be missed. On the other hand the practitioner should be mindful of the dose of radiation that often teenage tennis players may be exposed to when investigating these stress fractures, both with SPECT bone scan and subsequently CT scan if the bone scan is positive. Some things are never black and white in medicine!

After morning tea, a session was devoted to looking at the technical factors relating to court surface and tennis shoes. Coefficients of friction were explained by Stuart Miller, the ITF technical manager, with further input from Rod Cross. Both Jason Agosta and Cathy Ortega gave some practical tips regarding newer footwear from Nike and in Cathy’s case over ten years on the WTA tour as a primary health care provider.

Local academics Shona Bass and Jill Cook presented some results of research that is ongoing analysing the effect of tennis on bone and tendons. Overall their findings appear to reiterate the importance of exercise during pubertal years and its positive effect on both tendon and bone. This was followed by the Annual General Meeting of the STMS.

The afternoon started with a series of six different workshops run on two occasions. These were typically hands on workshops and presented by number of speakers. Many delegates were able to take home at least two or three practical tips to incorporate into their clinical practice.

The day ended with a review of articular cartilage from an orthopaedic surgeon and radiological point of view and the classification of rim lesions in hip pathology and the critical role of the bony anatomy, particularly with reference to hip dysplasia in the aetiology of a number of hip conditions. Alison Grimaldi, a physiotherapist from Queensland presented her concepts of instability involving muscle groups around the hip that could contribute to hip symptoms and pathology.
The conference dinner was held that night at Kooyong Lawn Tennis Club, the former site of the Australian Open. The delegates were joined at the dinner by a number of staff working at the Australian Open, particularly from the WTA. Sunday morning started early at 7.00am with an on-court workshop conducted by Bruce Elliott and Craig Morris from Tennis Australia. Bruce took us through the biomechanics of the player’s service action and identified some key areas in which technical faults may contribute to injury risk.

Back inside a very topical session of heat strain in tennis took place. John Brotherhood and Sarah Morante presented current research being performed on tennis players of varying standards in which a number of parameters including core temperature, heart rate and performance are being monitored. It is hoped that this will give us a better indication of the physiological responses to varying environmental conditions and guide the formation of suitable guidelines for playing tennis in the heat.

Mike Bergeron gave an excellent overview of his research into appropriate fluid and salt intake during tennis. Tim Noakes then tried to clear up a number of myths surrounding exercise-associated heat injuries. Pre-cooling before exercise in the heat has been shown to be of merit and to allow the individual to exercise for longer before having to stop. Angie Calder presented her views on a number of recovery strategies to be used in tennis. This is particularly pertinent given the significant number of matches which the top players have to play, either on consecutive days or with only 48 hours rest as occurs in Grand Slams. Mark Hargreaves returned to give some practical tips regarding suitable carbohydrate repletion.

Stuart Miller and Rod Cross gave an overview of tennis racquet and ball technical issues in a manner in which the majority of the audience could understand given the obvious complexity of the subject. After lunch five free papers were presented and Daniel Hornery won the award for the best presentation. This was followed by a sessions looking at talent identification in tennis players, their response to injury and further ideas on how tennis players feel when they are in the ‘zone’. Finally Greg Hoy, a Melbourne orthopaedic surgeon, gave an excellent overview of typical shoulder injuries found in tennis and their particular management.

Michael Turner closed the conference with an at times amusing presentation on how the Lawn Tennis Association runs their medical program.

I would like to thank all the speakers for their contribution in making the conference an outstanding success. I would also like to thank all the sponsors including Genzyme, the silver sponsor, for their support. Some of the presentations are now available on the website (www.stms2006.com.au); most of the abstracts can be found in this issue of the journal.
MEET THE EXPERT:
Dr Miguel Crespo, ITF Research Officer, Tennis Development

1 What made you choose a career in tennis?
While I was still playing competitive tennis I used to coach during the weekends in Club Sporting and Club de Tenis Valencia. In summer, I coached the kids at my original club, Club Tenis Las Vegas in La Eliana, Valencia where I spent my holidays. I still remember that my first coaching session as a coach, believe it or not, was when I was 15. Afterwards, when I finished playing professional tennis, I was at the University of Valencia studying Languages. Maria José Pascual, who was at that time Vice-president of the Spanish Federation and Director of Coaching, asked me to join the Federación Valenciana de Tenis and the National Training Centre in Valencia as assistant coach, then I was asked to join the Escuela Nacional de Maestria de Tenis (which is the Royal Spanish Tennis Federation School for Tennis Coaches) as assistant Director together with Pancho Alvarriño, one of the best coaches I have ever met, and under the direction of Alberto Riba. This was already a full time job that I combined with my University studies. When I finished Uni, I felt I could combine my studies with my work in coaches' education, and that is how everything started. Back in 1986 Doug MacCurdy wanted me to conduct several coaches' courses in South America on behalf of the ITF and in 1997 Dave Miley asked me to work full time for the ITF as Development Research Officer in charge of coaches' education… until now.

2 How did you develop in sports yourself?
I started playing when I was a kid. My parents introduced all the family into the game, we enjoyed playing together first during the weekends, then two or three times a week and gradually we started playing everyday. Then the pastime became a profession and I played juniors and pro tennis while I went to Secondary school and to University. However, I have to say that apart from tennis I am a football fan, and that Valencia is my team.

3 Were you always interested in the psychology of coaching?
It is well known than the mental side of tennis is very important at all levels and I have always felt, even as a player, how important it is to know about the psychology of the game at all levels. When I decided to start my PhD, my director was Dr. Isabel Balaguer, a recognised expert in sport psychology and tennis psychology. We both agreed to study the leadership implications of tennis coaches and the psychology of coaching is an area that I am still very interested in.

4 You are the driving force behind the ITF Worldwide Coaches Workshops. What is the main goal of these workshops?
The main goal of the ITF WWCW is to serve as a forum to disseminate information on coaching and sports science to coaches wherever they are. I believe that gathering coaches from more than 100 countries and asking the assistance of some of the best coaches and sport science experts in tennis can be a perfect combination to help increase the quality of tennis coaches wherever they may be working, to produce more and better players and to spread the love of the game to all possible tennis fans and players.

5 At the last few workshops, you have invited medicine and science experts as well. What was the reason and how has it worked out?
We feel it is important to have quality coaching coaches need to be exposed to the best medicine and sport science experts possible. Sport science drives the coaching methods and ensures that our coaching practice is done with purpose. However, we need to ensure that these concepts and theories are relevant to coaches and presented in a user friendly way.
We are very fortunate because during the last years the ITF has been able to create a network of experts in the different fields of medicine and sport science that have both a broad scientific knowledge of specific areas and a great ability to express this knowledge in practical terms that can be easily understood and applied by tennis coaches of all levels. We got very positive feedback after the free communications sessions on sport science and medicine that we held at the ITF Worldwide Coaches Workshop last year in Antalya (Turkey), in which both members of the ITF Sports Medical Commission and STMS participated, and we would like to continue with this initiative in future workshops.

6 You are a member of the IOC Working group on children and exercise. What is the goal of that working group?
The IOC decided to create this working group to investigate the situation and the challenges facing the training of children. The most important consequence of this group has been the publication of an “IOC Consensus Statement on Training the Elite Child Athlete”. Protecting the health of the athlete is the primary goal of the International Olympic Committee’s Medical Commission and one of its main objectives is the promotion of safe practices in the training of the elite child athlete, who is one who has superior athletic talent, undergoes specialised training, receives expert coaching and is exposed to early competition.
In this document, the scientific basis of training the elite child athlete are explained and special issues and recommendations for training are made. These recommendations stress the need for more scientific research on the area, the importance of developing illness and injury surveillance programmes, monitoring the volume and intensity of training and competition regimens, ensuring the quality of coaching, following the World Anti-Doping Code, and stressing the need for adults to develop a strong support system to ensure a balanced lifestyle. The main goal is to ensure that the entire sports process for the elite child athlete should be pleasurable and fulfilling.

7 What are the major challenges facing tennis coaches at the moment?
I think that there are several areas in which tennis coaches should focus in order to provide a quality coaching experience no matter what level of players they are coaching. Those areas are, in my opinion, the following: Making tennis easier to play, introducing healthy competition from the start, following sport science sound principles in practice at all levels, periodisation and planning, incorporating the rating of players into coaching programmes, applying evaluation and control systems to the training process, applying the concept of integrated training (considering all sport sciences that are related to the training process), and developing clear criteria for talent identification, among others.

8 You are a member of the ITF Sports Science and Medicine Commission and representative of the ITF on the board of STMS. How do you see the relationship of this Society with the ITF?
I think most, if not all, of the members of the ITF Sports Science and Medicine Commission are members of the STMS. In my opinion, STMS is doing a great job in being the primary tennis medicine and
I have special appreciation for different aspects of all of them because each one has a special characteristic that made it unique. However, I am especially proud of the books we have edited with the contribution of other authors because of the challenge, the hard work and the satisfaction that goes with a joint effort. I am also thrilled with our next book on tennis psychology that we are editing together with Macher Reid and Ann Quinn and that will be available in the second half of 2006.

Rehabilitation of the shoulder completes the process of restoration of shoulder function that begins with accurate diagnosis of the injury and includes appropriate non surgical treatment as well as surgical repair. Surgery is best viewed as creating conditions that will allow optimum rehabilitation. This DVD demonstrates principles that can guide the progressive phases of rehabilitation from early post-operative return to play, and also shows the specific exercises. A key to this approach to rehabilitation is the emphasis on closed chain exercises and the involvement of the entire kinetic chain in the exercise protocols. This approach has been shown to result in superior outcomes with early functional return. I am glad to see that Dr. Giovanni di Giacomo and colleagues have produced this DVD, and I am sure that this will be of benefit to doctors and physiotherapists in their efforts to allow patients maximum return to their chosen activity.

W. Ben Kibler, MD
Lexington Clinic Sports Medicine Center

The DVD is intended to be a supplement to our book “Shoulder Arthroscopy” and is the result of four years of painstaking research. In our book we propose a post-operative rehabilitation programme, and expand and elaborate theories and techniques used by the most advanced international centres in this field. The rationale for the programme is to provide both the theoretical and practical basis of our work, ‘timings’ of the recovery phases, and basic knowledge and advice that can be adopted by all therapists, regardless of whether or not they have access to cutting-edge technology. We firmly believe that good teamwork between surgeons and rehabilitation specialists provides the key to a modern approach to shoulder surgery, and hope that this supplementary DVD will help further in the understanding and treatment of this particular condition.

Giovanni di Giacomo, MD
Concordia Hospital for Special Surgery

11 Are there any ambitions you would like to see fulfilled and what would they be?
I do not have any particular ambition. I really do feel that another coaching philosophy is possible worldwide. A better coaching based on quality principles that will enable tennis players to play their best tennis, enjoying our excellent game for life, while being injury free. If this can be achieved with the work of the ITF as catalyst of different coaching, medicine and sport science experts and initiatives, all my ambitions will have been fulfilled.

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Leather Box version 100 Euro +20 % VAT

The DVD was presented at the 2006 AAOS Annual Meeting – (Chicago, Illinois- USA). It was run from the 22nd till the 26th of March in the Multimedia Educational Center.
Specificity of Running Speed and Agility in Competitive Junior Tennis Players

MARIO LEONE, ALAIN S. COMTOIS, FRANÇOIS TREMBLAY AND LUC LÉGER

Abstract
The purpose of this research was to highlight the importance of the specificity of speed and agility on the performance of competitive junior tennis players. The participants (n=38) were assessed in two separate sessions using five different running speed and agility tests. The players (males, n=24; females, n=14) were evaluated for short sprints over four metres (two tests), 20 metres dash sprint (one test) and for sprints with changes of direction at various angles over 20 metres with and without hitting tennis balls (two tests). Test-retest correlations indicated that the five tests showed moderate to good reliability with values ranging from 0.704 to 0.830. Correlation coefficients among the five speed and agility tests showed low relationships (r=0.032 to 0.642). The results of this study suggest that speed and agility are very specific and must be assessed and developed in different tennis-related conditions. It has been shown that traditional linear sprint tests (20-40 metres) are not a good indicator of the player's running speed in real game situations. Indeed, assessment and training must be sport-specific for maximal efficiency.

Key words: speed, agility, specificity, tennis, assessment

Introduction
As with many other intermittent sports, tennis is characterised by repeated high-intensity short bursts of running and multiple explosive change of directions. Based on the USTA fitness testing procedure,1 speed and agility are assessed by tests which include the hexagon, the spider test and the 20 yard dash run. However, assessment of tennis performance using physical fitness tests is still controversial.2-5 In general, fitness factors seem to have a poor predictive value in estimating on-court performance. The principle of specificity is often cited in order to explain the lack of correlation among the different speed and agility parameters as reported for other sports.2,5,6 However, little information, if any, is available regarding sport-specific running modalities for tennis players. Thus, the purpose of the current study was to provide new insight into the relationship between different tennis-specific running and agility parameters. It was hypothesised that assessment of running speed and agility must be tennis-specific to produce valuable information about the player’s potential for speed.6,7 Our results show that they could be helpful to develop new training strategies to maximise tennis-specific running in game situations.

Materials and methods
Subjects
A total of 38 junior tennis players from two different tennis clubs participated in this study, but only 22 were available for some tests. The participants, 24 males (mean ± SD, 12.0 ± 2.5 years) and 14 females (13.1 ± 2.5 years) old, participated in a special sport program dedicated to elite tennis players. All players were engaged in tennis for at least two years for 10-15 hours per week on an average of ten months per year. To be selected for the study, the players had to compete at the provincial level (Quebec, Canada) in their respective age-group (indeed, six of the players competed at the national and/or international level). The project was approved by the institutional ethical committee (Université de Montréal). Informed consent for each participant was obtained prior to the beginning of the study because physical fitness testing was part of the tennis program policy.

Procedures
All players were assessed indoors on the same tennis court surface (hard court). Two testing sessions were scheduled, one in each tennis court. In order to assess the running speed and agility of the players, five tests were performed:
1. Short sprint to the right (SSR). In order to test their speed on a short distance, players were asked to start from a tennis-ready position (knees slightly bent) at the baseline and facing the net. Players stood at the left of the central mark with their right foot on the mark. When ready, the players ran to their right until they reached the singles sideline (approximately four metres), as indicated in Figure 1.
2. Short sprint to the left (SSL). The same procedure as presented above was applied to the left side (Figure 1).
3. Twenty metres dash sprint (20MDS). This test assessed the player’s maximal speed. The players had to run 20 metres in a straight line alongside the tennis court as fast as possible (Figure 1). The feet were placed side-to-side in the tennis-ready position behind the starting line.
4. Tennis drill test (TDT). This measured the player’s capacity to run as fast as possible while making multiple changes of direction. The players had to run as fast as possible from the starting point, from a tennis-ready position and facing the net, to their right (90° turn) for right handed subjects or to their left for left handed subjects, reach the singles sideline, make a 180° turn, run to the other singles sideline and then move up (approximately 45° turn) to the service line (T) (Figure 2). Thus, the players had to make three changes of direction during this pattern.
5. Tennis drill test while hitting balls (TDTB). Finally, the participants had to repeat the TDT while hitting tennis balls (TDTB) at each singles sideline. The players had to run to the first singles sideline and hit the ball forehand cross-court (suspended above the intersections of the baseline and the singles sideline), run to

Table 1 Descriptive statistics and test-retest reliability for the five running speed and agility tests

<table>
<thead>
<tr>
<th>Variables</th>
<th>n</th>
<th>Time (s)</th>
<th>Correlation (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSR(Test)</td>
<td>38</td>
<td>1.36±0.09</td>
<td>0.791</td>
</tr>
<tr>
<td>SSR(Re-Test)</td>
<td></td>
<td>1.38±0.11</td>
<td></td>
</tr>
<tr>
<td>SSL(Test)</td>
<td>22</td>
<td>1.35±0.06</td>
<td>0.704</td>
</tr>
<tr>
<td>SSL(Re-Test)</td>
<td></td>
<td>1.36±0.08</td>
<td></td>
</tr>
<tr>
<td>TDT(Test)</td>
<td>38</td>
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<td>0.830</td>
</tr>
<tr>
<td>TDT(Re-Test)</td>
<td></td>
<td>5.52±0.31</td>
<td></td>
</tr>
<tr>
<td>TDTB(Test)</td>
<td>22</td>
<td>6.10±0.40</td>
<td>0.754</td>
</tr>
<tr>
<td>TDTB(Re-Test)</td>
<td></td>
<td>6.02±0.28</td>
<td></td>
</tr>
<tr>
<td>20MDS(Test)</td>
<td>22</td>
<td>3.78±0.26</td>
<td>0.704</td>
</tr>
<tr>
<td>20MDS(Re-Test)</td>
<td></td>
<td>3.84±0.28</td>
<td></td>
</tr>
</tbody>
</table>

Values are means ± SD
the second ball backhand down-the-line and then move up to reach the service line at the T (Figure 2). The players were instructed to hit the ball similarly as during a match and to place the tennis ball at the baseline court by their opponents’ court.

In order to standardise the procedure, the two tennis balls were attached to a string with a small piece of “Velcro”. The height of tennis balls were adjusted as preferred by each player. Thus, fixing the tennis balls to a static position insures that each individual player would hit the ball under the same conditions. Moreover, because the drill pattern was simple and already pre-determined, the players could concentrate on their speed (which is the purpose of this research) instead of the technical or the tactical aspects of the drill.

Except for the TDTB, all the other tests were executed without the tennis racquet.

### Data collection

Prior to the beginning of the testing period, each player was allowed to hit five forehand and five backhand shots in order to choose their preferred ball height and to experiment the feeling of hitting a suspended ball. After this period of familiarisation, the participants had to perform each test twice. For each trial, the players were captured on film with a numeric video camera. The time for both trials was calculated by viewing individually and frame-by-frame, each player for all five tests.

This procedure presents several advantages:

1. It is easy to determine the exact moment of the beginning and/or the ending of each test. In this study, the tests started when either of the two feet leaves the ground and ends when one of the foot reaches the finish line.
2. It eliminates a part of the variability produced by the tester’s or the player’s reaction time, which reduces the internal and the external error of measurement;
3. The level of precision is good (0.017 second), which is important, especially when assessing time on short distances; and
4. Reassessment of each test can be done at any time and as many times as wanted.

### Statistics

Statistical analyses were performed using SPSS software. Descriptive statistics (mean ± SD) were conducted for the five running velocity tests. Comparison of the means was calculated using paired-sample (t-test) for the five tests, males and females were integrated into the same group. As shown in Table 1, comparison of the means indicated no significant differences between each trial (test-retest) for all of the five tests, suggesting a high intra player’s consistency. The latter is supported by the good correlations between each trial, which were 0.791, 0.704, 0.830, 0.754 and 0.704 for the SSR, SSL, TDT, TDTB and 20MDS, respectively. Pearson product moment correlations between the different tests indicated that a low relationship existed among the various types of running speed and agility tests used in this study (Table 2). No correlation was significant except between the 20MDS and TDT (p<0.001). When transformed in coefficients of determination (r2), all the results but one, showed values lower than 20%, which confirmed the lack of relationship among the different type of running velocity tests.

### Discussion

In real game situations, tennis players rarely run long distances in a straight line. Most of the running occasions, the participants are required to hit the ball under the same conditions. In this study, the shortest distance ran by the players was approximately four metres, which was running laterally in straight line from the central mark at the baseline to the singles sideline. Comparison of the times recorded for both sides (SSR-SSL) showed a low relationship (r = 0.331) between these two tests, while test-retest correlations were quite good for each one of these tests (SSR: 0.79 and SSL: 0.70). In other words, players could be quick to move to their forehand, and rather slow to their backhand side, vice-versa. Thus, to improve their overall speed, players must spend similar time to train their explosive starts either to their forehand and their backhand. As indicated in Table 2, most of the running procedures showed low correlations among them. The traditional 20m dash sprint (20MDS) shares only 12.7% of common variance with SSR (r=0.356), which indicated that 20MDS is not a good indicator of the player’s speed. This result is however, not very surprising since 20MDS is more related to maximum running velocity rather than acceleration. However, 20MDS showed a better but modest relationship with TDT which is also a 20m run test, which included three changes of direction (r=0.612). This result is in accordance with other studies that noted low to moderate relationship between sprinting in straight line and with changes of direction.6,7 The TDT and TDTB tests were designed in order to replicate, as close as possible, a simple but realistic tennis game situation (Figure 2). The fact that the two tennis balls were suspended at two pre-determined fixed heights allowed to reduce the inter-player variability by standardising parameters, such as the tennis ball bounce’s height, direction and depth. The slight difference (0.5 second) between these two patterns (without and with hitting balls) indicates that this goal was reached. However, even under imposed conditions, as indicated above, the correlation coefficient between these two procedures was only 0.109. This result indicates that some players can be very fast while running a particular pattern and be very slow in doing the same drill while hitting balls, even when the players had chance to practice both tests. Based on these results, it does seem that the best way to improve tennis-specific mobility is to train as close as possible to the real game situation.

Caution, however, should be taken since the results were obtained on individuals in early adolescence. Perhaps the results could be different with older or more skilled tennis players. In terms of training tennis players, it is perhaps more advantageous to make the players hit balls every time they reach a particular position on the court (as is the case during a match) instead of instructing players to run for the sake of running. For example, it may even be profitable to randomly assign the side of the run upon a signal from the coach when the player regains central position on the court. Not only will the players improve their speed and agility, but the coaches would be able to work simultaneously on technical or tactical aspects.

### Conclusion

Based on the results of the current study, we conclude that both running speed and agility are specific qualities, most of the time unrelated, and have limited transfer to one another. The findings suggest that tennis-specific testing and training procedures are needed to insure a full development of running velocity potential for players. Furthermore, the novel approach in using a commercially available numeric video camera offers better precision than a stopwatch. These cameras are today a common tool, easily available and reasonably priced. Finally, further research is necessary to include a broader population of tennis players.

### References


### Table 2 Pearson product moment correlations (r) and coefficients of determination (r² x 100) between the five running velocity tests

<table>
<thead>
<tr>
<th>Variables</th>
<th>Correlation coefficient of determination (r²)</th>
<th>Coefficient of determination (r² x 100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSR - SSL</td>
<td>0.331</td>
<td>11.0%</td>
</tr>
<tr>
<td>SSR - 20MDS</td>
<td>0.356</td>
<td>12.7%</td>
</tr>
<tr>
<td>SSR - TDT</td>
<td>0.392</td>
<td>15.4%</td>
</tr>
<tr>
<td>SSR - TDTB</td>
<td>0.178</td>
<td>3.2%</td>
</tr>
<tr>
<td>SSL - TDT</td>
<td>0.032</td>
<td>0.1%</td>
</tr>
<tr>
<td>SSL - TDTB</td>
<td>0.437</td>
<td>19.1%</td>
</tr>
<tr>
<td>TDT - TDTB</td>
<td>0.198</td>
<td>3.9%</td>
</tr>
<tr>
<td>TDT - 20MDS</td>
<td>0.642*</td>
<td>41.2%</td>
</tr>
</tbody>
</table>

* significantly different ps0.001
Efficacy of an Imagery Intervention to Increase Flow and Performance in Tennis Competition

Stefan Koehn, Tony Morris and Anthony P. Watt

Abstract

Imagery is one of the most powerful tools for sport psychological interventions to change cognitions and to increase performance.1 Flow is an optimal psychological state that facilitates superior performances.2 The purpose of this study was to investigate the efficacy of an imagery intervention to enhance flow and performance. In this single-case study, we followed an advanced junior tennis player over the course of eleven tennis competition matches. After having assessed a stable baseline trend, we introduced the intervention in the form of a tennis-specific imagery script. Results revealed that flow and performance increased from baseline to post-intervention phase, and that performance was more stable throughout the post-intervention phase.

Key Words: imagery, flow, performance, tennis, competition

Introduction

Imagery is a tremendously powerful tool, which has been frequently used in sport psychological interventions, including the change of psychological variables, such as increasing confidence and self-efficacy, or the enhancement of performance.1 The analytic framework of imagery distinguishes between cognitive and motivational modalities of imagery use, which are efficacious on a specific and on a general level.2 The cognitive specific function involves the rehearsal of specific sport skills, such as imaging the sequence of an ideal serve or groundstroke shot, whereas the cognitive general function refers to the imagery of game plans, strategies, or routines to be implemented in a performance situation. The motivational specific function includes goal setting and imaging actions that are most appropriate to achieve those goals. Developing the Sports Imagery Questionnaire (SIQ), Hall et al.3 found that the motivational general function split up into two constituents, which were termed as motivational general–arousal and motivational general–mastery. The motivational general–arousal component is related to physiological arousal and affect, which takes into account the regulation of arousal, such as increasing or decreasing arousal levels to an optimal individual level. The motivational general–mastery function incorporates images of mental toughness, confidence, and being successful and in control.

Flow is an optimal psychological state, which enables athletes to get the most out of their potential and to perform at their personal best.4 Jackson and Csikszentmihalyi5 designated nine antecedents of flow, which are termed challenge-skills balance, action-awareness merging, clear goals, unambiguous feedback, concentration on the task at hand, sense of control, loss of self-consciousness, time transformation, and autotelic experience. Research on flow in sport disclosed correlational evidence that flow state underlies performance.5,6 In addition, Young7 found that professional female tennis players experienced flow flow frequently during tennis competitions. Several researchers have suggested links between imagery use and the antecedents of flow. For instance, Munroe et al.8 proposed imagery to be facilitative in maintaining concentration on the task at hand, and Jackson and Csikszentmihalyi5 stated that imagery would help athletes to maintain clear goals. Furthermore, Morris et al.9 advocated that “imagery, which is specifically directed at the antecedents in a particular sport context, should enhance the experience of flow” (p. 327).

The purpose of this study was to investigate the effect of an imagery program that targeted key antecedents of flow to increase flow state and performance in tennis competition.

Methods

Participant

One male advanced junior tennis player participated in this study. When we commenced the study, the participant was 15 years of age and had seven years of tennis experience and four years of competition experience. He trained nine hours per week. The participant entered six to ten tournaments per year and was number 214 in the Australian Junior Ranking List, including all ranking list players under 18 years, at the time we started the study.

Measures

Flow State Scale – 2 (FSS–2). The FSS–2 assesses the intensity of flow state on one occasion. The 36-item scale consists of nine subscales, which represent the nine antecedents of flow. Each subscale comprises four items, which are anchored by 1 (strongly disagree) and 5 (strongly agree). The internal consistency alpha coefficients for the nine subscales were between .81 and .90.2 The FSS–2 has been used frequently in sport psychological studies to assess flow in recreational, training, and competition settings.10,11

Performance. Performance was assessed by focusing on the number of first and second service winners, and on forehand and backhand groundstroke winners played in each competition match. Winners are considered direct winners, as well as shots that the opponent could hardly reach and hit uncontrollably and inaccurately, for instance with the frame.

Social Validation. To further explore the player’s experience of flow, performance, the intervention, and the study as a whole, we interviewed him about these issues at the end of the study. Such social validation interviewing is a common procedure in single-case studies.12

Intervention

The imagery script encompassed three parts, namely a) relaxation, b) imagery of service performance, and c) imagery of groundstroke performance. The script also incorporated two imagery perspectives. Using internal imagery, the participant experiences situations as if he was performing. Using external imagery, the participant experiences situations as if he was outside his body. During the imagery session, we instructed the participant to imagine vividly, as if he was in the actual competition situation, and to use all his senses, such as visual, auditory, gustatory, olfactory, and kinaesthetic senses. The participant was instructed to imagine clearly and in detail.
what the performance situation is like, and to control the images, e.g., seeing himself being successful. We developed the imagery script based on findings of a previous study with 179 junior tennis players from 11 to 18 years of age, who completed the Sport Imagery Questionnaire (SIQ) and the Dispositional Flow Scale–2 (DFS–2) with reference to tennis competitions. The DFS–2 consists of the same items as the FSS–2, but the DFS–2 assesses the frequency of flow, that is how often athletes get into flow. We then translated the strongest correlation coefficients between the SIQ, such as cognitive specific, cognitive general, and motivational general-mastery, and antecedents of the DFS–2, such as challenge-skills balance, clear goals, and concentration on the task at hand, into the tennis service and groundstroke imagery script. For instance, a strong correlation between the cognitive specific function and the antecedent of challenge-skills balance led to the statement in the script which read, “You know you have the skills to hit the ball into the anticipated target area”. Additionally, the imagery script included marked areas of the tennis court for service and groundstroke performance, which, in agreement with the participant, we considered as valuable target areas, facilitating winning shots.

Procedures
We requested access and consent from tournament directors, referees, players, and parents. Within the baseline phase, we measured flow and performance over the course of five competition matches. At the point when flow and performance disclosed a stable or negative trend, respectively, we introduced the intervention. We instructed the participant to work with the imagery script three times per week for four consecutive weeks, with each imagery session taking between ten and 15 minutes. In the post-intervention phase, we assessed flow and performance again in competition matches. Finally, we conducted the social validation interview, we debriefed the player, giving him information about his flow and performance, and we thanked him for participating.

Results
The results of the intervention on flow state are shown in Figure 1, which illustrates the player’s flow experience over the course of the eleven competition matches. On the abscissa, numbers one to five mark the competition matches of the baseline phase and numbers six to eleven encompass the matches of the post-intervention phase. The ordinate displays flow state scores, with a maximum score of 180 points and a minimum of 100 points. We used the split-middle technique to determine the trend of the celeration line in baseline and post-intervention phases. The dotted line extending from the celeration line signifies the ongoing trend. The level of flow state increased from the last match of the baseline phase to the first match of the post-intervention phase from an FSS-2 score of 112.5 to 155. This was an increase of 42.5 FSS-2 scale points. The mean flow score increased from baseline (M = 138.43) to post-intervention phase (M = 161.83). Moreover, the negative trend of the baseline, which equals a slope of -5.83, changed to a positive trend in the post-intervention phase, which displays a slope of 1.33. The maximum flow score was reached in match nine with an FSS-2 scale score of 169.5. The scores during the post-intervention period were not only higher, they were also very stable across the six competitions. Figure 2 illustrates performance trends during baseline and post-intervention phase. The graphs indicate the combined serve and groundstroke performance in percent. The percentage score was calculated as follows: for serves, we added up the number of service winners divided by the number of service points played overall times hundred. We calculated the percentage score for groundstroke performance by summing up the number of groundstroke winner divided by the number of baseline rallies played overall times hundred. The accumulated service and groundstroke percentage score is represented on the ordinate in the graphs.

The trend within the baseline phase demonstrated a strong decrease of performance over time. The slope reveals a strong negative trend of -6.97. The lowest performance scores were found in matches four (10.17%) and five (8.51%). After the intervention, the performance increased by 22.36% to 30.87% in match six. The mean performance percentage score increased from baseline (M = 20.75) to post-intervention phase (M = 29.31). Even though, the slope in the post-intervention phase disclosed a slightly negative trend of -0.51, performance remained on a relatively high and much more stable level, with the highest performance score in match nine (34.49%).

Discussion
As the main aim of the study, we examined the efficacy of an imagery intervention for enhancement of some of the antecedents of flow to increase flow state and performance in tennis competition. The results revealed that a strong increase in flow and performance took place from the end of the baseline phase to the beginning of the post-intervention phase, which was opposite to the overall baseline trends. The level of flow state and performance were sustained across the post-intervention phase. The experience of flow over time reversed from a negative to a positive trend in the post-intervention phase, which partly exceeded the flow scores of the baseline phase.

The study encompassed eleven matches, in which only one match was lost (match five). Therefore, the performance results could have been influenced by the opponents’ skill level and ranking. For instance, match four and five were played against opponents, who had a higher ranking list position than the participant, which would partly account for the smaller percentage score of winners. The performance outcomes, in turn, could have had a negative influence on the experience of flow state. Interestingly within the post-intervention phase, the participant also played higher ranked competitors (match seven, eight, ten), which resulted in winners percentage scores that were twice to three times as high as in the baseline phase.

The social validation interview revealed that the participant strongly adhered to the instructions of the imagery script during the off-court sessions. With regard to flow.

Figure 1: Trends within Baseline and Post-Intervention Phase for Flow State in Tennis Competitions

Figure 2: Trends within Baseline and Post-Intervention Phase for Serve and Groundstroke Performance in Tennis Competitions

To be continued on next page
experience and match outcome, the particip-
tant perceived that meeting personal stan-
dards, such as performance-related goals, was more crucial for the intensity of flow than overall winning or losing. Imagery use also had a positive influence on competition performance in regard to playing winners. Beyond this, the participant’s national junior ranking improved from 214 up to 69 as the study concluded. The participant also reported a strong increase of confidence throughout the post-intervention phase. Based on previous research findings, the imagery script particularly emphasized images of successful performance and being confident in control.13,14 Confidence appears to be one of the main variables underlying flow and performance in competition.13,16

The results of the intervention study were especially valuable, because of the administration of a targeted intervention, which was based on our previous findings with junior tennis players in tennis competition. The efficacy of the imagery program supported the value of including flow in the development of the imagery intervention. Future studies would benefit from examining and pinpointing key flow antecedents in the particular sport before commencing an intervention to increase flow.

This study aimed to examine the efficacy of an imagery intervention to increase both flow and performance. It is possible that changes in flow and performance were connected. With reference to the interrelatedness between flow and performance, future research needs to elucidate four possible aspects of the flow-performance relationship, a) whether flow is a concomitant or by-product of performance, b) whether flow and performance are connected by a reciprocal relationship, c) if flow and performance are connected by a causal relationship, or d) if flow is a mediator between mental variables, such as imagery use, and performance. In addition, further studies need to take into account personal preconditions, such as imagery use, imagery ability, age, skill level, and environmental factors, to successfully employ imagery interventions. Especially young athletes with low imagery use and ability should be assisted in reinforcing their mental skills of imagery use before commencing an imagery intervention.

Conclusion
The results of this study provide evidence that the imagery intervention enhanced flow and performance within junior tennis competitions. The conclusion can be drawn that imagery use had a positive effect on flow state and performance over time. As a by-product of this intervention, the athlete experienced a higher level of confidence throughout the post-intervention phase. We need more sport psychological interventions that positively influence mental processes and antecedents of flow to enhance flow and performance in training and competition.

References

Tennis is played throughout the world, often in hot conditions, by players with wide ranging physical characteristics. There is widespread community concern in Australia about the risk of heat stress in sport.

Anecdotal evidence suggests that dizziness, nausea, vomiting and exhaustion occur during tennis play in hot, humid weather; however the actual incidence and the environmental conditions that cause these symptoms of heat stress are unknown. In the future, heat stress is likely to be an increasing problem for sport due to climate change and global warming. Therefore it is important to establish objective, evidence-based guidelines which determine conditions that are unsuitable for play. Currently, no objective information about players’ physiological responses exists on which to formulate guidelines. Therefore the aim of this study is to develop evidence-based recommendations for tennis participation to minimize the potential for heat illness and the impact on performance. In the field, over the course of twelve months (four seasons), the thermal environment, players’ physiological and subjective responses, and activity level and performance will be measured during singles tennis match play. The results will be used to develop equations for the rational analysis of heat stress and strain in competition tennis for a wide range of environmental conditions.

The data will be used to develop models that will predict environmental conditions that are potentially hazardous to player health and safety or impact on performance. In addition, evidence-based advice will be developed for women regarding tennis play in early pregnancy when the foetus is most vulnerable to high body temperature.

Thermal Stress and Strain in Elite and Community Level Tennis Players

SARAH M. MORANTE, JOHN R. BROTHERHOOD AND JACQUI RAYMOND

ABOUT THE AUTHOR
Sarah Morante completed a Bachelor of Applied Science (Exercise and Sport Science) at the University of Sydney in 2002. Currently, she is completing a Doctor of Philosophy at the University of Sydney. The title of the research is “Thermal stress and strain in elite and community level tennis players”, and is supported by an ITF Sport Science Research Grant, the New South Wales Institute of Sport and Tennis NSW.

Median & Science in Tennis

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Playing and training for tennis exposes the dominant arm to repeated high mechanical strains. The ability of the body to adapt to these loads is evident by the clear differences in size of the playing and the non-playing arm. However, the ability of the skeleton to adapt optimally to these loads may be dependent on the timing of exposure to the load; this question is explored in the following review. The following four articles put forward the case that training during growth may be an essential component required for maximising bone strength in the playing arm of adult tennis players. These articles explore how the age of starting may affect the osteogenic response; not only in bone mass but also in bone geometry and strength, and how skeletal benefits may be maintained when training is reduced or ceased.

**KANNUS P, HAAPASALO H, SANKELO M, SIEVÄNEN H, PASANEN M, HEINONEN A, OIA P, VUORI I**

**Effect of starting age of physical activity on bone mass in the dominant arm of tennis and squash players**


The aim of this retrospective study was to investigate how maturation influenced the osteogenic response to tennis training. Bone mass in the dominant and non-dominant arms were compared in 105 tennis and squash national-level players. The side-to-side difference in bone mass was two to four times greater in the players who had started their playing careers before or at menarche (10 to 24%) than in those who started more than 15 years after menarche (2 to 10%).

**Comments:**

This study clearly demonstrates that training before menarche resulted in a two to four times greater benefit in bone mass. This study delivers a “take-at-home message” concerning the benefit of tennis playing before or during puberty.

**HAAPASALO H, SIEVÄNEN H, KANNUS P, HEINONEN A, OIA P, VUORI I**

**Dimensions and estimated mechanical characteristics of the humerus after long-term tennis loading**

*J Bone Miner Res. 1996; 11(6):864-72*

Bone mass is often used as a surrogate measure for bone strength; however there are other factors such as bone geometry that can influence bone strength with or without a corresponding increase in bone mass. In this retrospective study, bone mass, cortical thickness and bone strength (approximated from DXA data) was assessed in the dominant and non-dominant arms of 67 healthy, competitive tennis players (17 young men, 30 young women and 20 older women). The young male and female players had started their playing careers in childhood, while the older female players started the training in adulthood.

Similar to the results of Kanness et al 1995 the osteogenic response (i.e. side-to-side differences) was on average 12% greater in the younger vs. the older starters (20% vs. 8% respectively). The important findings of this work however was that in the old starters despite the bone mass and the cortical thickness of the dominant arm being ~7-8% greater than the non-dominant arm this did not translate to an increase in bone strength (cross sectional moment of inertia and strength modulus).

**Comments:**

This study showed that the 7-8% increase in bone mass and cortical thickness in the old starters was approximately 10% less than the young starters; importantly this translated to an increase in bone strength in the young but not the old starters.

**BASS SL, SAXON L, DALY RM, TURNER CH, ROBLING AG, SEEMAN E AND STUCKEY S**

**The effect of mechanical loading on the size and shape of bone in pre-, peri-, and postpuberal girls: a study in tennis players**

*J Bone Miner Res. 2002;17(12):2274-80*

In this cross-sectional and prospective study Bass et al aimed to investigate the maturity dependent changes in bone parameters in 47 pre-, peri and post pubertal competitive female tennis players aged 8-17 years, training for six to ten hours a week. Bone mineral content, as measured by DXA, was 11-14% greater on the dominant side. Magnetic resonance imaging (MRI) revealed that the "extra" bone mineral mass on the dominant humerus was predominantly the result of an increase in bone size (periosteal expansion), thereby improving bone strength (resistance to torsion). The enlargement of the dominant humerus occurred during the prepubertal years. There was evidence of endocortical contraction in the post pubertal players but this did not translate to a significant increase in bone strength.

**Comments:**

The major interest of this study lies in the 3D investigation of bone tissue by MRI technology. The paper highlights that the majority of the benefit obtained early (pre-pubertal years) that translated to an increase in bone strength (due to a larger bone size) and after puberty the response was smaller and mostly limited to endocortical contraction which has minimal affect on bone strength. The findings showed different patterns of bone response to loading depending on the age of the players, the greatest effects for bone strength being observed during pre-puberty.

**SHONA BASS AND GAELE DUCHER**

**CURRENT REVIEW OF THE LITERATURE**

*The Importance of Training during Growth to Prepare the Adult Skeleton for Intensive Tennis*

**SHONA BASS AND GAELE DUCHER**


**Good maintenance of exercise-induced bone gain with decreased training of female tennis and squash players**

*J Bone Miner Res. 2001;16(2):195-201*

This 5-year longitudinal study aimed at determining whether the training-induced bone mass gains on the dominant arm would be preserved after detraining. Among the 64 female tennis and squash players who were recruited, the authors distinguished the young starters (mean starting age of playing: 10.5 years) and the old starters (mean starting age of playing: 26.4 years). At baseline, bone mass asymmetry in the upper limbs reached 15-21% in the young starters versus 9-11% in the old starters. During the follow-up, all the players markedly reduced their training time, but they were still training 1.5-2.0 hours per week. The results showed that the exercise-induced bone gain was maintained with reduced training in both the early and late starters.

**Comments:**

This study demonstrated that the benefits of repetitive impact-loading on bone tissue could be preserved despite a reduction of training. The starting age of playing did not seem to affect the maintenance of bone mass gain. It is not known if similar residual benefits can be maintained when there is a cessation of exercise.

**Discussion:**

The development of muscle and bone during growth is influenced by forces associated with gravity and physical activity. Mechanical strain imparted by muscle action is responsible for the development of the external size and shape of the bone and subsequently the strength of the bone. That is; the adult skeleton is the end product of the expression of the individuals genotype and the exposure to environmental factors such as exercise and nutrition. Exercise during growth is important for the optimal sculpturing and molding the skeletons unique and site specific shape for its function during adult years. Once growth has ceased the skeleton has limited capacity to change bone shape and bone strength. Strokes associated with playing tennis places the dominant arm under high mechanical strains, combining repetitive impacts and intense muscular contractions. Indeed, each stroke induces torsion and bending forces on forearm bones. In addition, the impact of the ball on the racket causes vibrations that can be transferred to the upper limb. Such a mechanical environment is known to be very osteogenic. The results of the studies reviewed here support the notion that the template for skeletal size and shape is laid during the adult years of playing tennis.
Junior Coaches’ Perceptions of Core Tennis Parenting Principles

LARRY LAUER, DANIEL GOULD, CRISTINA ROLO, CAROLINE JANNE AND NORI PENNISI

Abstract

This study’s aim was to better understand the role of parents upon junior tennis player development and ways in which coaches work effectively with them. Specifically, core principles of tennis parenting were identified across six focus group interviews conducted with 24 experienced American junior coaches. Transcriptions of the interviews were content analysed and are presented in three general categories of core principles, parents and their involvement in tennis, factors influencing parent affect and, and parent-coach-player interactions. Coaches indicated that parents are important to junior tennis and provided principles for optimal tennis parenting. They also discussed how the coach influences and can improve relations with parents.

Key words: tennis, parents, psychology, youth sports, coaching

Introduction

Parents are one of the most debated topics in junior tennis today. The debate is not of the importance of parents; talent development research has revealed that parents play an influential role.1,2 The parent’s role has been discussed as one of supporting and facilitating the child’s progress through the obstacles and barriers of development. Moreover, parents play an essential role in the psychological development of young athletes.3,4 For instance, parental actions have been shown to positively or negatively influence enjoyment in sport, motivation, perceived competence, and levels of stress.5,6 At coaching education programs many coaches voice their concerns with junior tennis parents’ attitudes and behaviours and how they are negatively influencing their child, as well as the coaches’ ability to develop the child’s talent.1,7 Specific to tennis, DeFrancesco and Johnson8 surveyed 101 junior players (mean age =12.4 years), and 45 of their parents, and learned that winning was very important to 33 percent of these parents. Moreover, 29 percent of the players reported that parents caused them embarrassment whereas 20 percent of the parents reported that they had displayed inappropriate behaviours while attending matches. As a part of the current study, coaches discussed the negative behaviours and attitudes parents exhibit, indicating that parents sometimes have an outcome orientation, place pressure on the child to perform and/or win, are overbearing, over-involved, and controlling. Finally, parents can make tennis too serious and be overly critical of their child.1,9 Yet, these coaches realised that parents can also play a positive role, and can have a special relationship with their child in tennis. Coaches remarked that parents often keep tennis in perspective, focus on the development of the child (not just the athlete), provide many forms of support including unconditional love and caring, and make the opportunity available. In fact, they felt that the majority of parents were a positive source of support. Nonetheless, they were concerned by the negative influences of problem tennis parents.

Due to the heightened concerns over parent involvement in junior tennis, USTA Sport Science funded a three-phase study to examine the role of parents in junior tennis success and failure. In Phase 1, coaches participated in focus group interviews to inform the role of parents. Phase 2 involved a survey of 152 experienced junior coaches while in Phase 3 nine elite tennis players, one of their parents, and one of their coaches were interviewed. The current article details core principles that help us understand and explain parental behaviour that were gleaned from focus groups with coaches in Phase 1 of this project.

Methods

USA Tennis Player Development invited the investigators to conduct focus group interview sessions (90 minutes each) at a high performance coaching program. Six focus groups were held over three evening sessions each day consisting of two simultaneous focus groups including four coaches. The facilitators were experienced in focus group and qualitative research. Coaches were randomly assigned to the focus groups except for one case where placing three African-American coaches in the same focus group would provide social support and increase group homogeneity. Informed consent was obtained from all participants prior to the focus group.

A prepared introduction was first read to participants providing the study purposes, sample characteristics, and ground rules. A semi-structured interview guide was created based on the parenting literature and the authors’ experiences in youth sport. Two general questions directed the focus group:

(1) What positive things do tennis parents do to help players develop?
(2) What negative things do tennis parents do to hurt players’ development?

The facilitator probed for further clarification and to follow an interesting line of conversation while also making sure that discussions were saturated on the main questions. At the end of the focus group notes were reviewed with participants, who affirmed these summary notes thus enhancing credibility of the data.10

Data Analysis and Interpretation

Constant comparative analysis was used to code the data11 and consensus was used to interpret the focus group data; the first author reviewed the tapes and created raw data themes (i.e., direct or paraphrased quotes recorded while observing the tapes). Then, two separate authors studied the transcripts, viewed the video tapes, and reviewed the first author’s themes to finalise raw data themes. The researchers then jointly met to verify all the identified raw data themes and content analyse them into more general categories of similar themes (e.g., positive parent behaviours, negative parent behaviours). This peer debriefing process enhanced the trustworthiness of interpretations12 and reduced researcher bias.

Participants

Twenty-four high performance junior tennis coaches (22 male and 2 female) with an average age of 37 participated in the six focus groups. Twenty coaches were Caucasian, three African-American, and one person listed themselves as ‘other.’ Similar to the American population of junior tennis coaches which is primarily white male, this sample was not diverse in gender or race. Coaches also had 14.94 years of coaching experience (range from 4.5 to 32 years). Additionally, coaches had worked with 4.3 nationally ranked and 7.4 sectionally ranked junior players. Finally, the majority of coaches (21 coaches, 91.3%) coached boys and girls.

Results

Tennis Parenting Core Principles

One general category that emerged from the analysis was what the investigators labelled core principles involved in the tennis parenting process. Core principles went beyond the identification of positive or negative parent behaviours and, instead, explained the tennis parenting context and how and why tennis parents behave the way they do and ways coaches interact with parents. Three general core parenting categories emerged:

(1) parents and their involvement in tennis;
(2) factors influencing parent involvement; and
(3) parent-coach-player interaction.

Themes contained within each of these subcategories are discussed below.

Parents and their Involvement in Tennis

Three focus groups felt that parents must be involved in their child’s tennis as parental involvement is needed and important. However, they noted that each parent is different and must be approached differently, thus reminding us that a coach must individualise their interactions with parents. For instance, coaches talked about how the parent’s goals and beliefs tie to their background, and that each parent has their own

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Larry Lauver, Christine Rolo

Larry Lauver, PhD

Larry Laurer, Dan Gould, Cristina Rolo, Caroline Janes and Nori Pennisi
idea of how to use tennis to teach life lessons. Finally, a coach discussed the idea that because of these individual differences, parents treat tennis differently, and one should not assume that they are necessarily out of line (e.g., in some cultures it is normal to be boisterous and highly involved) if unconventional behaviors are exhibited. The most frequently cited themes in this category focused on principles of optimal parenting. Respondents indicated that parents, whose children most effectively develop in tennis:

- understand their role and by doing so allow their child to be more successful;
- are not totally focused on going professional in tennis;
- are open to evaluation of their behaviours;
- support, are dedicated to and have confidence in their parenting role;
- provide unconditional love which makes their children process-oriented and, in turn, love competition;
- are “coachable” and ask the coach for advice, and;
- focus on long term development over short term success.

One coach discussed the characteristics of an under-involved parent.

It’s a fine line between under-involved and letting the kid do his or her thing. I think the under-involved person would show no support, be very almost detrimental to that person.

Another coach was insightful when he talked about how more self-confident parents have good communication abilities, and better relations with their child.

...the comfort level the parents have with themselves, their communication abilities, and if that is at a high level, that then dictates a very healthy relationship with their son or daughter. And the moment you see question marks about that parent’s self esteem or self confidence, that’s when you start to see the (parent’s involvement) going over the line.

Another theme that emerged from several focus groups was that good parents often go unnoticed and that the negative behaviours of parents often overshadow the positive. Moreover, groups from parents have good intentions but negative behaviours creep into their parenting practices. Respondents felt these negative behaviours often involved parents overemphasizing winning which in turn hurt the player’s self confidence.

Finally, themes within this general category also focused on the notion that some parents do not understand that the child must have the intrinsic drive to develop and that the most successful parents focus on total child development and life skills versus solely focusing outcome and rankings. It was also noted that while it has been successfully done, it is very difficult to coach one’s own child.

Factors Influencing Parent Involvement

The second subcategory of themes focused on factors influencing parent involvement in their child’s tennis. The coaches believed that the tennis system emphasizes competition and rankings that can lead to the parent losing a child development perspective. The result: players “burnout” and coaches lose their ranking. A second theme that emerged in the focus groups was that a parent’s financial status influences their child’s tennis involvement. Specifically, one focus group discussed how less financially secure parents are less likely to change coaches, and consequently are more supportive of the coach. And finally, an interesting topic was that of high achieving, wealthy parents best reflected in the comments of the following coach.

...the parents for the most part are successful, they’re high up in their particular fields, and they are very success oriented. I would say that about 80% of the kids coming into our program (were) just there for an activity, not to get better at tennis, but they were often discouraged from continuing because they didn’t succeed at a higher level quickly. If they were 12 years old and they weren’t in the highest group, the parent says ‘what are you doing this for?’ If they weren’t in tournaments, if they weren’t ranked highly, they were often discouraged, and it took a really motivated kid in that situation to continue playing...

Coaches also asserted that parents often do not realise how difficult it is to play tennis, thus making it harder for some critical of their child. Lastly, several groups noted that the higher the level of the player one coaches, the more demanding are the parents.

Parent-Coach-Player Interactions

A third core principle category addressed how parents, players and coaches interact. First, coaches felt that parents must place trust in their child’s coach and not be constantly second guessing him or her. Additionally, three focus groups reported that the parent needs to trust the coach to be a role model. If they do so, the child may feed off of that trust. For instance, the coach must work hard to empathise and understand parents and their needs. Knowing this, coaches should try to view parental issues from different perspectives. One coach stated, “You know your child is the most important child you have.”

Because of this, a coach has to give special attention and understand it is important. Good parent-coach partnerships also involve regular communication and understanding. Coaches emphasised that it must be a supportive relationship and that coaches rely on parents, and vice versa. Interestingly, coaches asserted that parent education is an ongoing process that makes the coach improve and also helps lead off coach-parent-player problems. Therefore, these coaches felt parent education not only helps the parent but also the coach as well.

An especially interesting theme focused on the belief that the coach-parent relationship depends on the coach’s age, experience and maturity. Specifically, as coaches’ less experienced coaches often do not feel as comfortable interacting with a parent or setting boundaries in the relationship.

Discussion

Focus group methodology was used in this investigation because it is useful for discovering new insights, gaining an in-depth view into the context and principles of a phenomenon,13 and used asking participants to verify statements made during data collection.14 This research is limited in that only coaches participated. While highly experienced, the coaches do not reflect the parent-child relationship at home or in off-court situations. Moreover, these high performance coaches may have inherent biases and may not be representative of other less experienced coaches throughout the country. These high performance coaches provided a number of core principles offering explanations of the tennis parenting context and best parenting practices. Three general categories of principles were parents and their involvement in tennis, factors that influence parent problems, and parent-coach-player interactions. These findings corroborate other studies showing that parents often overemphasise winning or rankings.12 More importantly, however, coaches reaffirmed the parent’s importance in talent development as well as in the enjoyment of the sport.14 Moreover, it revealed ways in which parents can facilitate a positive tennis experience for their child. These tennis parenting core principles set strong guidelines for directing parenting practices. In addition, these coaches information which they should integrate into their relationships with tennis parents.

Acknowledgments

The study was funded by a United States Tennis Association Sport Science and Technology Grant. The authors thank the USA Tennis Player Development Department and, in specific, Dr. Paul Lubbers for their assistance.

References

A Field Study to Evaluate Side-To-Side Differences in the Upper Limbs of Young Tennis Players

Olivier Brosseau, Christophe Hautier and Isabelle Rogowski

Abstract

This study aims to investigate the side-to-side differences in upper limb volumes in young national tennis players using a field method. Fifty-nine tennis players (7–17 years) were described by 24 anthropometric measurements in order to calculate each dominant and non-dominant upper limb volumes, using the truncated cone method. The total volume of the dominant upper limb was 7.8% larger than that of the non-dominant one. Moreover each respective cone of the playing upper limb was greater than that of the non-playing one. The easiness and reliability of the truncated cone method should lead to coaches being able to follow the anthropometric development, and especially the incidence of segmentary volume asymmetry, of their players.

Key words: truncated cone method, segmentary volume, prevention, longitudinal follow-up

Introduction

It is recognised that repetitive stress placed on the dominant arm of adult players creates anatomical differences and asymmetries when compared to the non-dominant one. However, this asymmetry should be related to laterality,1 and associated with high-impact activity.2 Few data of these differences are currently available in national young tennis players.3 Several measurement techniques have been used to measure side-to-side differences in the upper limbs of tennis players. The internal techniques have included computed tomography, dual-energy x-ray absorptiometry and magnetic resonance imaging.3,4,5 These laboratory instruments have enabled researchers to study the morphological differences: for example, the forearm bone area in adult players,4 the bone mineral content of the humerus in prepubescent girls5 and the muscle area of the arm in prepubescent players.6 Using these methods, it is possible to quantify the differences between the dominant and non-dominant upper limb, but they are expensive, inappropriate for field study and unusable for coaches.

The external techniques used to measure side-to-side differences in the upper limbs of players have involved limb volume measurement using water displacement volumetry.3,7,8 The water submersion method has made it possible to quantify the side-to-side differences in the hand, forearm and upper arm of the high performance tennis player.9 But even if the water displacement volumetry is currently the gold standard for limb volume determination,7 this method is time consuming, unportable and can be unhygienic. For these reasons many researchers choose not to use this measurement technique. Another external technique has involved measuring the length and the circumference of the different segments in order to calculate the segmentary volume using the truncated cone method. Developed by Jones and Pearson9 and used by Martin et al.10 on the lower limbs in adolescents, this method was recently adapted to evaluate upper limb volumes and presents high reliability and validity compared to the water displacement volumetry technique.4 The truncated cone method, based on anthropometric measurements, appears to be portable, non-invasive and inexpensive.

The aim of this study, therefore, is to compare the side-to-side differences in the upper limb volumes, using the truncated cone method; the hypothesis being that the magnitude of the differences between the dominant and the non-dominant upper limbs in national young tennis players should be similar to that which is reported in the literature for young and adult tennis players.

Materials and methods

Fifty-nine young national tennis players (40 boys and 19 girls) volunteered to participate in the study. All participants used a double handed backhand. To verify their standard as young national players, they all successfully passed the “Ligue du Lyonnais de Tennis” players detection programme. At the time of testing, the players were training at least five times a week. The subjects’ physical characteristics are depicted in Table 1. Informed consent was obtained from each of the players and their parents. Each player was characterised by anthropometric measurements that were made by the same investigator trained in physical assessment.

The anthropometric measurements were assessed using conventional criteria and measuring procedures.11 For both upper limbs, the circumferences of the wrist, forearm, elbow, arm, distal and proximal insertions of the deltoid were marked (Figure 1) and measured to the nearest 0.1 cm with a non-elastic tape. Then each length between two lines of the circumference for both upper limbs (Figure 1) was measured with an anthropometer (GPM Siberhegner). All these measurements were made with the upper limb hanging relaxed at the subject’s side. Upper limb volumes (UL) were calculated with the truncated cone method7 for dominant and non-dominant sides. Five truncated cones, noted UL1, UL2, UL3, UL4, and UL5, were determined in each upper limb (Figure 1). Each cone volume was calculated as follows:

\[
UL = \frac{h}{3} (R^3 + Rr + r^3)
\]

with \(h\) being the considered cone height, \(R\) the radius of the large surface and \(r\) the radius of the small surface. Both radii were based on the circumference (C) with

\[
R = \frac{C}{2\pi}
\]

The total upper limb volume, noted ULT, was determined by the sum of the five respective cones.

All data are reported as mean ± standard error (SE). The difference in a considered volume between the dominant (ULTD) and non-dominant (ULTN) side was calculated as:

\[
\text{Delta volume} = \frac{\text{ULTD} - \text{ULTN}}{\text{ULTD}} \times 100\%
\]

Table 1 Subject characteristics

<table>
<thead>
<tr>
<th>Subject characteristics</th>
<th>Tennis players (n=59, mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>11.5 ± 1.7</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>148.4 ± 10.4</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>39.7 ± 8.6</td>
</tr>
<tr>
<td>Sum of 4 skinfolds (mm)</td>
<td>26.5 ± 5.7</td>
</tr>
<tr>
<td>Current training quantity (h/week)</td>
<td>6.23 ± 1.5</td>
</tr>
<tr>
<td>Tennis practice (years)</td>
<td>8.4 ± 2.0</td>
</tr>
</tbody>
</table>
the non-dominant (UL\textsubscript{ND}) sides was expressed as a percentage of the non-dominant value, calculated as:
\[
\frac{(UL\textsubscript{D} - UL\textsubscript{ND})}{UL\textsubscript{ND}} \times 100
\]

Paired t-tests were used to assess side-to-side differences between the dominant and non-dominant upper limbs (SPSS 11.0; SPSS software, Chicago, IL). The level of significance used was p<0.05.

Results
Figure 2 displays the total upper limb volume UL\textsubscript{1} for the non-dominant and the dominant sides. The dominant upper limb volume was significantly 7.8% greater than that of the non-dominant one (p<0.001). Figure 3 presents the volumes of the five cones defined for each upper limb. UL\textsubscript{1}, UL\textsubscript{2}, UL\textsubscript{3}, UL\textsubscript{4} and UL\textsubscript{5} were significantly 7.8%, 8.8%, 7.2%, 6.7% and 8.6% greater in the dominant side than in the non-dominant one (p<0.001).

Discussion
The main result of this study was that the truncated cone method was well adapted to evaluate side-to-side differences between upper limb volumes. Regarding the total segmentary volume, the dominant upper limb was 7.8% larger than the non-dominant one. Similar results were obtained in adult tennis players using the water displacement volumetry method. Concerning the arm segment, the comparison of the side-to-side differences revealed that the muscle area was 6-8% greater in the playing compared to non playing arm\textsuperscript{3} and that humeral bone traits were 6-13% greater in the dominant compared to the non-dominant arm in competitive female players aged 8-17 years\textsuperscript{4} using magnetic resonance imaging.

The differences obtained in the present study were in accordance with previous results because the mean difference was 7% larger for the dominant arm volume than the non-dominant one. Focusing on the forearm segment, the high performance tennis player aged 23.6 ± 7.6 years possesses significantly 12.6% greater mass in the dominant limb than in the non-dominant one, using the water submersion method.\textsuperscript{3} These findings are superior to the differences observed in the population of the present study, but the fact that the players tested in the former study were older and therefore had longer careers could account for the greater hypertrophy of the dominant forearm.

To our knowledge, no published data is available on the side-to-side differences in bone and muscle areas or volumes of the forearm segment in young tennis players, using internal techniques. The truncated cone technique cannot evaluate the relative contribution of bone and muscle hypertrophy to upper limb segmentary volume differences. Nevertheless, the evaluation of the global volume is sufficient because an increment in muscle size is correlated to an increase in bone mass and size during growth and/or exercise.\textsuperscript{5}

The follow-up of side-to-side differences between the non-dominant and dominant upper limb volumes especially in young tennis players appears to be important in order to prevent the unexpected onset of injuries. Indeed, the imbalance in the limb volumes can be a risk factor of injury\textsuperscript{11} because the anatomical alignment of the joints and skeletal system can be modified by an unilateral musculature hypertrophy.\textsuperscript{13} As well as being able to obtain similar results with other internal and external methods, the truncated cone technique is only based on anthropometric measurements and can therefore be used easily by coaches in the field.

Conclusion
The truncated cone method for calculating segmentary volume is a reliable field test that evaluates volume differences between dominant and non-dominant upper limbs in young national tennis players. This study highlights the practical benefits of using the truncated cone method in order to monitor the anthropometric development of tennis players. Adopting this field technique as general practice would help to detect the incidence of asymmetry and, with correct follow-up treatment, could therefore reduce the occurrence of musculoskeletal injuries.

Acknowledgments
The authors thank the Ligue du Lyonnais de Tennis, and particularly the coaches, the young tennis players and their parents.

References
Protecting the health of the athlete is the primary goal of the International Olympic Committee’s Medical Commission (IOC MC). While athletes should be encouraged to strive for excellence, there is an obligation on the part of coaches, team physicians, other health care providers, International Federations, and sport governing bodies to recognise pressures, actions, and situations that may be detrimental to the athlete’s health. One area of concern for many female athletes is the pressure to meet unrealistic weight or body fat levels. Some may respond to this pressure with excessive dieting and slippage into disordered eating, which in turn can lead to a serious eating disorder such as anorexia nervosa or bulimia nervosa. Disordered eating can lead to low energy availability (an energy intake inadequate to meet energy expenditure), which can disrupt the reproductive cycle and result in amenorrhea. The combination of disordered eating and irregular menstrual cycles eventually lead to a decrease in endogenous oestrogen and other hormones, resulting in low bone mineral density hence the term “Female Athlete Triad”.

Effect of the Female Athlete Triad on the health and performance of the athlete

Child and Adolescent Athletes

Pubertal growth is a critical component of the growth process; the increase in oestrogen is related to clinically important increases in bone length and bone mineral content, and fusion of the epiphysis. Participation in regular exercise is important to optimise physical and psychological development. However inadequate nutrition (particularly low energy intake) creates a scenario where athletes may be at increased risk of reduced growth, delayed maturation and primary amenorrhea, as well as impaired performance. This may expose these athletes to increased risk of future short stature, low bone mineral density and secondary amenorrhea. Catch-up growth of bone length and mass, and pubertal progression have been reported with dietary intervention and/or reduced training schedules, and may reduce deficits in skeletal growth; however, final stature may be compromised when maturation is severely delayed or when the epiphysis is nearing fusion.

It is recommended that the nutrition and growth and development of all young athletes are monitored, particularly in sports where body image or leanness is a performance advantage.

Adult Athletes

Low energy availability and pathogenic weight control behaviours predispose the female athlete to menstrual dysfunction, subsequent decreased bone mineral density, increased risk of stress fractures, and a potential increase in the risk of premature osteoporosis and cardiovascular disease. Disordered eating is often accompanied by psychological problems, including decreased self-esteem, anxiety, and depression. These problems affect performance significantly. When the three disorders of the Female Athlete Triad occur together, the potential health consequences become more serious, and often life-threatening.

Identifying the Female Athlete Triad

Early identification of athletes at risk of developing the Female Athlete Triad is important for preventing its progression and improving prognosis. Therefore, athletes who display symptoms of disordered eating and/or menstrual irregularity should be referred for further evaluation by a health care provider. Disordered eating may include behaviours such as using extreme weight control methods and restricted and/or binge eating. The Female Athlete Triad does not necessarily manifest itself in athletes who are thin; the Female Athlete Triad can occur in athletes of any size. Physicians, health care providers and coaches should be aware of risk factors such as cultures that equate thinness with popularity and success, previous history of disordered eating and sports in which leanness or specific weight is important. The coach can also play an important role in identifying “at risk” or symptomatic athletes.

Treating the Female Athlete Triad

Effective treatment of the Female Athlete Triad involves a multidisciplinary team including a nutritionist, psychologist, and/or psychiatrist, headed by a physician experienced in sports medicine. The goal of treatment is to restore energy balance, healthy eating habits, mental health and normal menstrual cycles, and to improve bone health. Nutritional counselling is an essential component of the treatment plan. If the athlete is unable to respond to the recommendations of the physician and nutritionist, then a referral to a psychologist or psychiatrist specialised in eating disorders is necessary. Increased nutritional intake with a subsequent weight gain will result in the resumption of menses and an increase in bone mineral density.

A decrease in training may be necessary. Hormone therapy is often prescribed for amenorrheic athletes, however scientific evidence supporting its use is inconclusive. Education of the athlete, coach and the athlete’s entourage is an important component of the treatment plan. Athletes with anorexia nervosa or bulimia nervosa should be excluded from competition. It is important that coaches emphasise that good health rather than weight ensures optimal performance. The coach’s support of treatment will encourage an athlete’s compliance with the treatment plan.

Preventing the Female Athlete Triad

Preventing disordered eating is the key to Female Athlete Triad prevention. It is essential for coaches to increase awareness of the Female Athlete Triad and increase understanding of nutritional principles and how they impact health and performance. Athletes, health care professionals and their entourage should have the opportunity to undertake educational programmes to support the female athlete. Annual pre-participation screening should include questionnaires and physical examinations to identify early signs of the Female Athlete Triad.

Other medical encounters can also be used for this purpose. International and National Federations and National Olympic Committees are encouraged to develop coaches and team physician Female Athlete Triad education programmes, and where possible modify rules to reduce the incidence of the drive for thinness and subsequent unhealthy eating behaviours.
Imaging of Articular Cartilage

David Connell

Imaging of hyaline articular cartilage is assuming more importance as new surgical and pharmacological treatments become available for cartilage injury. Standard techniques for assessing morphological changes include fast spin echo (with or without fat suppression) and spoiled gradient echo imaging. The advantages of fast spin echo imaging include fast imaging times, good differential contrast with native intraarticular joint fluid, reduction in instrumentation artefact and also concomitant evaluation of the menisci, ligaments and bone. A TE of 34 will optimise magnetisation transfer effect inherent in hyaline articular cartilage. Spoiled gradient echo imaging suffers from long imaging times, susceptibility artefact and poor contrast resolution, but has the advantage of achieving extremely high resolution and is the technique of choice when assessing the small joints of the hand and foot. It is also a useful technique for volume assessment and quantitative analysis.

New methods of morphological imaging include steady-state free precession imaging. The speed of these techniques allows for assessment in the routine clinical setting. MRI can also be applied to provide information about the microscopic structure and physiology of cartilage. These techniques include T2 mapping, sodium MR imaging and diffusion-weighted imaging. Imaging of all joints should be performed using a validated cartilage sequence. There are many types of validation including referring to the literature, performing one’s own research/audit and liaising closely with referring orthopaedic surgeons. It is useful to report in such a way as to make it meaningful for the referring doctor. Hence, we attempt to use descriptive parameters that mirror the arthroscopic changes described by Outerbridge. This will ensure that scan results are optimised for the patient’s benefit.

When to image
MRI, CT and ultrasound can provide exquisite anatomical detail of the exoskeleton. Muscle injury and bone fatigue are a common occurrence in athletes pushing themselves to and beyond their physiological limits. The fundamental structure to consider is the muscle-tendon-bone unit and breakdown may occur anywhere within this unit. Common muscle injuries include hamstring, calf, rectus abdominis and internal oblique sprains. The role of MRI and ultrasound is to confirm and localise the muscle injury, assess the extent of muscle damage and attempt to provide some prognostic information, particularly in the elite athlete. MRI can also be used to monitor healing and augment a confident return to the sporting field.

Bone fatigue manifests itself as a stress response leading to cortical breaches and stress fractures. A recently reported injury in tennis players is a stress response to the humerus. MRI will identify abnormal signal to the intramedullary bone reflecting stress to the trabecular matrix. Scintigraphy demonstrates increased bone turnover reflecting osteoblastic and osteoclastic activity as these cells are stimulated during bone injury. CT scanning is the most sensitive technique for detecting early changes to the cortical bone. MRI can be used to monitor healing and augment a confident return to the sporting field.

Recovery Strategies in Tennis

Angela Calder

Recovery is one of the basic principles central to the methodology of current training practices. Recovery in this context addresses issues related to training and competition fatigue in order to promote adaptation to training stress. This means that players can train hard and improve their performances, with the added benefit of a reduced risk of training illnesses and injuries from heavy workloads.

Unfortunately with the emphasis on preparation and competition, recovery strategies are often ignored or forgotten by coaches and players. Recovery has two main aims. The first is to monitor a player’s adaptive responses to training and stress. The second is to manage and encourage adaptation by selecting and applying specific recovery techniques and strategies to offset training and competition fatigue.

Monitoring Adaptation
There are three levels of observation that are used by Olympic and professional sports to monitor a player’s adaptation to stress. The player, the coach, and the sport scientist/medical staff all contribute to this process through their observations and recording of select variables and markers.

Management
The techniques and strategies that are integrated into training programs come from all the sport science disciplines and coaching. The balancing of work/rest ratios; nutrition, a wide range of physical therapies, and psychological skills provide a holistic approach to managing fatigue and stress for the individual player. This presentation will focus on some of the most commonly used recovery strategies that are used.

Conclusion
Every training session is important as it is an opportunity for the player to improve. Players should aim to start each training session or match in as fresh a state as possible so that they can maximise the training benefits and experiences of the session or event. Recovery strategies assist players to do this by focusing on reducing residual training fatigue and stress.
Functional Assessment & Therapeutic Exercises for Stability of the Hip & Pelvis

ALISON GRIMALDI

Instability Concepts

Passive stability mechanisms including relative congruence of the femoral head and acetabulum, the labrum, capsular and ligamentous structures, and negative intra-capsular pressure make the hip joint one of the most stable joints in the body. A tennis player with bony abnormalities such as acetabular dysplasia, labral insufficiency, or ligamentous laxity will have relatively less inherent stability. Research studies have reported however that instability of the hip may also be demonstrated in the absence of structural abnormality or trauma. Excessive translation, even of small magnitude will, with repetition, lead to cartilage damage. Well before any radiographic evidence of such cartilage damage, a young athlete with inadequate stability mechanisms may be plagued by low grade aching, snapping/popping, signs of impingement and labral injury. Hip arthroscopy may reveal the presence of chondromalacia, a result of excessive shear forces. The muscular system may have a very important role in control of these translatory forces. Adequate activity and balance in the deep hip rotators may provide a rotator cuff effect and assist in prevention of excessive translation of the femoral head in the acetabulum. This deep stability also provides a key component to pelvic stability. Co-ordination and balance in the more superficial muscles provides stabilisation of the pelvis on the femur. In the absence of adequate deep stability, compensatory overactivity in the more superficial active stabilising systems may accentuate destructive forces within the hip, and give rise to abnormal mechanics that have a negative impact throughout the lower kinetic chain. Specificity in assessment and rehabilitation of muscle function around the hip will optimise joint protection mechanisms and minimise musculoskeletal injury.

Footwear for Tennis

JASON AGOSTA

The kinematics and load of the lower limb during sideways movements in tennis are highly influenced by the type of shoe worn. This paper focuses on a review of the role of the tennis shoe in providing stability during lateral movements.

Several authors have focused on the stability of tennis shoes and the incidence of injuries in tennis players. Simpson et al (1992) reported that players with poor lateral stability of a shoe had greater incidence of pain. Soft flexible shoes lead to greater inversion angles of the calcaneus during lateral movements. The wearing of firm midsoled shoes during lateral movements has been shown to control rearfoot motion and therefore less calcaneal inversion. Although greater control of the rearfoot is achieved with firm hard shoes, joint forces are greater when inversion is small. Harder stiffer shoes limit the movement of joints though compressive forces in the joints are correspondingly greater. A player may misjudge the material properties of a surface due to adaptation to other surfaces and footwear. The depth of the upper of a shoe during lateral movements has been shown to influence the motion of the rearfoot. Medium to high cut shoes provide greater lateral stability than low cut shoes by reducing rearfoot inversion during sideways movements. Shoes that have firm midsoles and are stiff provide greater stability of the rearfoot. The depth of the upper of a shoe has been shown to influence and reduce the rearfoot motion during lateral movements. Borders surrounding the midsole do not provide greater stability. Players adapt to a surface and change their kinematics accordingly to cope with low or high friction during rapid movements.

ABOUT THE AUTHOR

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Jason Agosta trained in podiatry at La Trobe University, graduated in 1988, and was awarded the Harley Award for excellence in diagnosis and orthoses manufacture. His Masters degree in Biomechanics was on the “Effect of running spikes on Achilles tendon load in distance runners”. Jason has a private practice and is the podiatrist for Essendon Football Club, Melbourne Storm Rugby League Club and many national track athletes.

ABOUT THE AUTHOR
Tennis demands lateral agility and quick foot speed. It also requires three-dimensional upper and lower core stability to provide a stable power platform for the extremities to work off of during the multi planar joint and muscle activities that involve acceleration and deceleration forces.

This practical session will take participants through an activity specific dynamic warm-up suitable for off and on court activities. We will explore a variety of circuit type functional three-dimensional upper and lower core exercises that augment the bodies myofascial slings in closed, open and partially closed kinetic chains. The session will focus on movement and make use of common, easily transportable equipment such as steps, balls, bands and balance equipment.

We will also explore the ABC’s of Smart Training and how they apply to the Off & On Court Core Clinic. Ideas surrounding alignment and athletic stance as well as agility, balance, coordination, deceleration control and dynamic hip extension will be demonstrated with practical applications that can be implemented immediately.

Performance and Loading in the Tennis Serve

Bruce Elliott and Craig Morris

The great majority of injuries in tennis have a mechanical cause. Therefore good service mechanics must be appropriate if performance is to be optimised and the potential for injury controlled. Number of repetitions is also a factor that must be controlled if injury is to be kept to an acceptable level. In this presentation we will discuss the mechanics of the serve from a mechanical perspective.

THE SERVE

1. The link of the lower limb and lower trunk (hips)
   - Foot position
   - Trunk rotations
   - Ground Reaction Force
   - Lateral and rotation of knee

2. Positions at maximal external rotation
   - Shoulder position (eccentric loading)
   - Trunk position

3. Drive to the ball
   - Shoulder rotation (shoulder over shoulder; twist; forward)
   - Internal rotation
   - Kinetic Chain

4. Impact positions
   - Shoulder abduction angle
   - Body alignment

5. Follow through
   - Shoulder internal rotation; forearm pronation
   - Eccentric loading of shoulder external rotators

ABOUT THE AUTHORS

Professor Bruce C. Elliott, PhD, FACHPER, FASMF, FISBS, FAAKPE, is the senior biomechanist in the School of Human Movement and Exercise Science at the University of Western Australia. He has a keen interest in performance optimisation and injury reduction in sport having published over 160 refereed articles, 50 refereed conference proceedings, along with 40 books or book chapters in this general area. Craig Morris is currently the manager of Coach Education for Tennis Australia. In his role he directs the national operations of all coach education policies and programs. He holds a Tennis Australia Elite coaching qualification and is an accredited coach on the WTA tour. Morris has completed his Masters of Sport Management, holds a Graduate Diploma in Sports Management and Recreation, and a Bachelor of Education.
The interaction between court surfaces and shoes is crucial to successful tennis performance at all levels of play. The forces generated while the player is in contact with the ground can be divided into two components: those in the vertical direction – known as the ‘normal’ force – that determine the loads imposed on the musculo-skeletal system; and those in the horizontal direction – friction – that provide the player with the means to move around the court quickly and safely. Although vertical and horizontal forces have different functions, they both influence injury propensity. The link between surface compliance (or hardness) and injury is well accepted, and runners are advised to use soft paths rather than hard roads. There is a school of thought, however, that other factors influence injury susceptibility. For one thing, all tennis players wear shoes, and there are products designed for specific surfaces. Shoes act as a medium between the surface and the player, and are known to significantly modify the ground reaction forces. Secondly, players are known to modify their responses to different footwear/surface combinations.

Anecdotal reports from elite players suggest that changing from one ball to another can have significant influences on upper limb soreness. The recent biomechanical theory of muscle tuning may provide an insight into the mechanisms by which such maladaptations occur.

The large ranges and velocities of movement in upper body joints during normal play result in both biopositive and bionegative adaptations, including changes in flexibility, bone and physiological capacity. In general terms, utilising biomechanical principles of co-ordinated movement, such as the stretch-shorten cycle and unweighing, can confer benefits to the player, both in terms of improving performance and reducing injury risk. Choosing racquets with appropriate mass, performance and reducing injury risk.

Just as the movement around the court creates a multiple loading situation on players’ lower limbs, racket/ball impacts also have a cumulative loading function. About 300 shots are taken by each player during a two-set match, and 750 during a five-set match. Given the vigorous nature of tennis, and that players may play several matches per week, and most weeks of the year, it is not surprising that many players report upper limb injuries.

The impact between a ball and racket is of short duration, during which large forces are generated. These forces are transmitted to the arm in the form of shock (sudden acceleration), vibration and twist of the racket handle in the hand. These movements are believed to cause biomechanical adaptations of the musculo-skeletal system. Despite considerable research, however, no single commonly-accepted cause of some common tennis-related problems, such as tennis elbow, has been identified.

Frictional forces are required for effective movement around the court, and are dependent on the magnitude of the normal forces between the shoe and surface, the friction coefficient of the shoe and surface material combinations, and their roughness. Friction helps players accelerate, decelerate and turn, and this is achieved in different ways on different surfaces, hence why shoes are designed with different materials and tread patterns. Such is the importance of shoes that they can fully offset the differences in impact-absorbing properties between surface types. Furthermore, it is known that humans are capable of modifying their movement patterns to accommodate potentially detrimental changes in externally imposed forces. Thus, researchers must consider the shoe, surface and athlete interaction to fully understand how each influences performance and injury.

Racquet and Ball Issues

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The STMS is a group of Sports Scientists and Sport Medicine professionals who all share a love of tennis and an interest in research and sharing of sports science and medical aspects related to tennis.

Our mission is to serve as an international forum for the dissemination of knowledge about tennis medicine and science.

Our primary objectives are:
• To facilitate the collection, dissemination and review of scientific and medical research and publications relevant to tennis and other racquets sports.
• To promote networking with other professionals who have special interest in, and knowledge about, tennis specific medical injuries.

• To promote networking with the leading organisations in the tennis world.
• To encourage members to undertake continuous learning activities and be as current as possible on the latest developments in tennis sports science and medicine.
• To provide knowledge and understanding about the scientific basis of injuries and treatment of injuries in tennis and to correlate it to other sports and physiotherapists.

Our long-term objectives are:
1 To ensure STMS strives for effective management to provide a sustainable organisation.
2 To ensure that STMS gains and retains members by offering quality services that do not duplicate those of other organisations.
3 To enhance the reputation of the journal and expand its circulation.
4 To host a prestigious annual international conference.
5 To disseminate up-to-date information about tennis sports medicine and science education and research.

Membership is open to all people and includes subscription to Medicine and Science in Tennis (peer reviewed journal, three issues per year), discounts to STMS conferences (we hold a World Congress every year) and access to our membership section of the web (www.stms.nl) where you can network with other members with similar clinical or research interests as well as find other STMS members in your area.

Winning at Tennis

Tennis is a mental game. Players and coaches alike agree that it is one’s ability to remain mentally composed and strong that not only sets the elite apart, but also provides for peak performances in our sport, irrespective of playing standard or age.

The merits of psychological on and off court training for competitive and high-level players have been heavily promoted in recent times, however, the practical and systematic application of such training continues to represent a major challenge for many tennis coaches.

Antoni Girod’s book, “Winning at TENNIS,” deals with the most important concepts in tennis psychology today and shows coaches how to use these effectively. It starts with the basics: the identity, the values, the beliefs and the mental mechanisms of a player, before moving on to cover the specific mental strategies that can be used before, during and after match-play.

Girod’s approach is very practical and easy to understand. He manages to examine the psychological factors needed for optimal tennis performance in a user-friendly manner. Throughout the book Girod provides psychological tips and examples that can be used in daily coaching practices.

It is vital for coaches to develop the psychological and behavioural skills that contribute to peak on court performance and this needs to be catered for. “Winning at TENNIS” will undoubtedly help coaches to nurture and improve the techniques that will enable players of all levels to give their very best on court.
Abstract
The article reports results from two studies that are presented elsewhere.2 Importantly, parental positive and negative behaviors and the relationship in tennis can be special if done well. The authors felt that two-thirds of parents are negative. They also made a number of recommendations to coaches and administrators including that coaches proactively educate parents, and that coaches be trained to do such education.

Key words: tennis, parents, psychology, youth sports, coaching

Introduction
In the previous article,1 results from a USTA sponsored study described how parents play an influential, positive role and concurrently create problems for coaches. In particular, that article reported results from the first phase (coach focus groups) of a three-phase project developed to understand the role of parents in junior tennis success. In Phase 1 focus group interviews with 24 high performance American junior coaches, it was found that on average, almost 13 years of experience. A total of 132 of 250 coaches completed the survey (return rate = 52.8%). One hundred twenty-five were male (94.7%) and seven were female (5.3%). The male coach’s average age was 40.5 years while female coaches averaged 39 years of age. The sample was not diverse as 108 (84.4%) participants were Caucasian, nine (7.0%) African-American, four (3.1%) Asian and four more coaches were Hispanic. Finally, three coaches listed ‘other’ and four coaches did not complete the item. Coaches had an average of 17.3 years of coaching experience.

Usefulness of Strategies in Working with Parents
In the Phase 2 survey the coaches were asked to rate the “usefulness” of 19 strategies for working with junior tennis parents (on a Likert-type scale from 1 = not at all useful to 5 = extremely useful). Overall, little variability in the mean usefulness ratings were found, ranging from a mean of 4.76 to 4.44 (Table 1). Hence, these strategies were considered “useful” to “somewhat useful” by coaches. Several coaching strategies rated as extremely useful were being honest and open (M = 4.76), building trust (M = 4.68), and listening to the parent (M = 4.59). Moreover, defining the parent’s roles and responsibilities (M = 4.40), educating the parent on positive parental behaviors (M = 4.38), and educating parents on negative parental behaviors and the consequences (M = 4.28) were considered useful strategies. Meanwhile, coaches did not feel being a mediator between child and parent (M = 3.44) was as useful.

Recommendations Regarding the Role of Parents
During focus group coaches were asked what recommendations they would make to other tennis coaches working with parents, and to administrators. Specifically, all focus groups offered recommendations to coaches for working with junior tennis parents. Most frequently discussed was the need to foster coach, parent, and partner relationships which involved proactively developing open, effective, and honest communication with parents, and involving them in the many steps of the tennis process. Involving parents meant getting them to volunteer, inviting them to practice, and informing them of what you are teaching so they can support it, thus developing a team approach. In addition, coaches felt they should buffer the parent-child relationship thus taking the pressure off the child (possibly by deflecting criticism). Finally, coaches must understand that parents play a “big role,” so they should provide support to the parent and child.

An important recommendation mentioned by all coaches was the need for coaches to catalyze parent education. According to respondents tennis education for parents should include information about:
- rules;
- tournaments, and how to conduct one’s self at them;
- alternative approaches to teaching tennis to young kids (e.g., Frisbee, medicine ball, etc.);
- their role and the coach’s role;
- an appropriate view of sacrifice for their child’s tennis (i.e., not an investment for which they need a return);
- the idea that tennis is a long process and there will be many matches with emotional highs and lows;
- how to deal with wins and losses, and;
- how to ask questions of the coach (i.e., not through the child).

Coaches also recommended setting the rules from the start of the relationship, especially relative to the parent’s role during practice. As one coach indicated:
I think that a lot of pros probably don’t educate the parents to start off and that is where you can get yourself in trouble because if you don’t let them know some of the ground rules or if you don’t let them know that, ‘listen, I am glad that Bill wants to take lessons and these are some of the ground rules I have set.

Coaches also asserted that education meetings with parents are necessary. How coaches would do this varied. Coaches suggested...
meeting one-on-one with parents and in groups. Another coach felt that daily informal meetings were needed to educate the parent. One dissenting opinion was that few meetings are needed unless there are problems. Finally, coaches felt other means could be used to educate parents such as providing a parent role model or having positive parents educate new tennis parents.

Each focus group recommended identifying roles and responsibilities and then conveying clear role expectations and goals with parents and players. This process often involved compromising on the coach’s personal opinions with parent expectations. One coach has parents and players sign a contract that covers responsibilities of each party, and asks them to post it. Another letter suggests that when a player first enters a USTA tournament, there should be a “welcome” meeting by the governing body. They hoped that tennis coaches around the world would be a part of this education. Effective relations were thought to be developed by being honest and open, building trust, and listening to the parent. These behaviors are considered hallmarks of effective coaching and are frequently discussed in coaching education programs. In addition, defining the parent’s roles and responsibilities was perceived as a key strategy to working with parents which supports previous research with award-winning American high school football coaches.

This finding is not surprising because coaches often view the player, parent, and coach as a developmental team. For a team to function cohesively, roles and responsibilities should be clarified and accepted. Additionally, coaches felt that teaching parents to manage emotional reactions to wins and losses was essential. In fact, parents’ emotional reactions were often a concern to elite junior tennis players, and in several cases players confronted their parents and asked them not to look nervous during matches. Coaches felt that parents, in general, should be educated on positive and negative parental behaviors and the consequences of these actions. It was recommended that coaches take a proactive approach to educating parents. This finding supports the findings of focus group interviews conducted in Phase 1: there is a need to educate parents on their role in junior tennis. Moreover, it was clear that coaches wanted assistance from administrators in educating parents by training the coaches and educating the parents at competitions.

Conclusion
The purpose of this article was to present what was learned from experienced junior tennis coaches relative to working effectively with parents. Strategies such as effectively communicating and educating parents were seen as highly useful. In addition, coaches made a number of insightful and sometimes new (i.e., developing an assessment of parents) recommendations to coaches and administrators. It is hoped that tennis coaches around the world can integrate many of these strategies into their relationships with parents to develop healthy, working relationships.

Acknowledgements
The study was funded by a United States Tennis Association Sport Science and Technology Grant. The authors thank the USA Tennis Player Development Department and, in specific, Dr. Paul Lubbers for their assistance.

References

### Table 1

<table>
<thead>
<tr>
<th>Usefulness of Strategies in Working with Junior Tennis Parents</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Being honest and open</td>
<td>4.76</td>
<td>.45</td>
</tr>
<tr>
<td>Building trust</td>
<td>4.68</td>
<td>.53</td>
</tr>
<tr>
<td>Listening</td>
<td>4.58</td>
<td>.58</td>
</tr>
<tr>
<td>Defining the parent’s roles and responsibilities</td>
<td>4.40</td>
<td>.67</td>
</tr>
<tr>
<td>Educating on positive parental behaviors</td>
<td>4.38</td>
<td>.60</td>
</tr>
<tr>
<td>Educating on negative parental behaviors and the consequences</td>
<td>4.28</td>
<td>.69</td>
</tr>
<tr>
<td>Communicating your expectations/ program costs</td>
<td>4.22</td>
<td>.74</td>
</tr>
<tr>
<td>Holding one-on-one meetings</td>
<td>4.17</td>
<td>.87</td>
</tr>
<tr>
<td>Educating on how to act after losses and wins</td>
<td>4.09</td>
<td>.71</td>
</tr>
<tr>
<td>Trying to get parents to make child take more responsibility</td>
<td>4.08</td>
<td>.77</td>
</tr>
<tr>
<td>Mentoring/educating of less experienced coaches</td>
<td>4.03</td>
<td>.85</td>
</tr>
<tr>
<td>Using experienced parents as models</td>
<td>3.98</td>
<td>.86</td>
</tr>
<tr>
<td>Developing about the game of tennis</td>
<td>3.96</td>
<td>.91</td>
</tr>
<tr>
<td>Developing tools that parents can use to assess tennis parenting</td>
<td>3.95</td>
<td>.76</td>
</tr>
<tr>
<td>Anticipating parents need and addressing them before they bring it up</td>
<td>3.91</td>
<td>.87</td>
</tr>
<tr>
<td>Holding group parent meetings</td>
<td>3.81</td>
<td>.90</td>
</tr>
<tr>
<td>Requiring specific training for parents of higher level players</td>
<td>3.78</td>
<td>.96</td>
</tr>
<tr>
<td>Displaying/providing education via books/email</td>
<td>3.69</td>
<td>.85</td>
</tr>
<tr>
<td>Being a mediator between child and parent</td>
<td>3.44</td>
<td>.98</td>
</tr>
</tbody>
</table>

**Note:** A usefulness rating of 1 = not at all, 2 = slightly, 3 = somewhat, 4 = useful, and 5 = extremely.
On Wednesday February 1, 2006, the Society of Tennis Medicine and Science in collaboration with the American College of Sports Medicine presented a conference entitled “Tennis Medicine and Science: Optimising Performance while Reducing the Risk of Injury (and treating the injuries if they do occur)” preceding the American College of Sports Medicine’s annual Team Physician Conference. The half day Tennis Medicine and Science meeting was highlighted by a presentation by professional tennis legend Stan Smith, winner of 39 singles and 61 doubles titles, and the number one ranked player in the world in 1972, International Tennis Hall of Fame enshrine in 1987 and coach of the 2006 U.S. men’s Olympic tennis team. The meeting included presentations by several STMS members and USTA Sports Science committee members. This conference, which was attended by 50 physicians and health professionals, was an outstanding compilation of lectures and interactive discussion involving knowledge and cutting edge research in the many areas of tennis medicine and science. The format of the meeting included 10 full minutes for discussion after each 20 minute presentation which led to some lively discussion.

The meeting began with an excellent presentation by W. Benjamin Kibler, one of the founders of the STMS, from the Lexington Clinic on the Biomechanical Basis of Tennis – Function and Dysfunction / Technique and How It Relates to Injury. This informative lecture discussed tennis biomechanics of strokes, especially the serve, and correlated the mechanics and altered mechanics with adaptations to meet the demands of today’s game. Specifically, he reviewed the concepts behind strength and conditioning, strength and flexibility and the importance of how to build strength functionally.

Marc Safran, vice-president of the STMS and Chief of the Sports Medicine Division of the Department of Orthopaedic Surgery at the University of California, San Francisco, provided an overview of injuries sustained in tennis, their evaluation, treatment and prevention.

Next, William Micheo, Professor and Chairman of the Department of Physical Medicine and Rehabilitation and Sports Medicine at the University of Puerto Rico School of Medicine, reviewed the rehabilitation of the injured tennis player. Dr. Micheo covered many topics, including treatment strategies and phase of rehabilitation of many injuries seen in the tennis player, as well as the importance of pre-habilitation.

Scott Riewald, the administrator of Sports Sciences for the United States Tennis Association presented his thoughts and research about Strength and Conditioning for Tennis. This outstanding presentation by Dr. Riewald stressed the importance of strength and conditioning in today’s tennis game to prevent injury, optimise performance and condition the body’s energy systems to meet the demands of today’s game. Specifically, he reviewed the concepts behind strength and conditioning, strength and flexibility and the importance of how to build strength functionally.

Dan Gould, a psychologist who is a member of the USTA Sports Science Committee and Head of the Institute for Study of Youth Sports at Michigan State University deftly tackled the large and complex topic of the Psychology of Tennis – Parents, Kids, Stress of Play and Injury. He specifically focused several topics: the influence of tennis parents, children’s motivation for involvement, the stress of play and burnout, and psychological factors involved in injury.

Heat, fluid and electrolytes expert, Michael Bergeron, STMS member and Assistant Professor at the Medical College of Georgia, reviewed his outstanding work and the work of others with regard to Tennis in the Heat: Fluid, Electrolyte and Thermal Strain Challenges. He stressed the extent and effects of sweat fluid and electrolyte losses and deficits during tennis, as well as rehydration strategies and the effect of hydration on thermal strain during competition and practice.

Page Love, Sports Nutritionist from Nutrifit and Nutrisport Consulting in Atlanta, Georgia gave an important presentation on the importance of appropriate nutrition to optimise tennis play, especially with regard to diet, pre-match meals and snacks, and dispelled myths about things like eating bananas during the match. Ms Love stressed the importance of high energy foods and adequate hydration, timed appropriately before and after competitions.

Next, Kathleen Stroia, the Vice President Sport Sciences & Medicine and Professional Development for the Sony Ericsson WTA Tour, reviewed the history of the Age Eligibility Rule and the results of the review 10 years after its implementation, most importantly, the positive effects it has had on the longevity of careers of the players. Before Stan Smith concluded the meeting giving a humorous and informative presentation about his career and the affect tennis medicine and science have had in his on court and off court activities, there was a panel discussion and presentation of cases regarding tennis injury, prevention and treatment.

The meeting was well received, based on the attendance and the fact nearly all the attendees stayed through the very end of the entire meeting as well as the many e-mails received since the meeting by health professionals seeking even more information about tennis medicine and science. All who attended gained valuable information and insight into the breadth of information and research being performed to help advance the professional and recreational tennis player alike. All the participants expect such lively discussion to continue at the Greenbrier Resort in West Virginia in August.