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 first issue of 2005. Already the STMS has had a productive year with our World Congress being held in Palm Springs.

I would like to congratulate Dr Marc Safran and Mr Bill Durney on staging a most successful conference, and the speakers, whose standard of presentations were first class. It was great to see many familiar faces and also to meet new people who attended their first STMS conference.

During the conference the STMS also conducted its Annual General Meeting. As part of the AGM, elections of officers took place with four nominations being received for three positions. I would like to congratulate incumbent nominees Dr W Ben Kibler (USA) and Dr Peter Jokl (USA) on retaining their positions and to extend a warm welcome to Dr Bernard Montalvan (France) on his election.

Prof. Savio Woo (USA) leaves the Board of STMS after 14 years of service and in appreciation of his invaluable work for the STMS, he has been awarded Honorary Life Membership. Details on Prof. Woo receiving this award and the work he has done for the STMS can be found on Page 24.

In this issue we have several full-text articles. I would like to draw your attention to the following two original articles: ‘Skill-Level Related Injuries in Recreational Competition ‘Tennis Players’ from Neeru Jayanthi and his colleagues from the USA, and ‘Exercise Intensity in Tennis: Simulated Match Play Versus Training Drills’, from Jaime Fernández Fernández and his colleagues from Spain. Also included in this issue are ‘Dietary Supplements for Health and Performance; the Good, the Bad and the Ugly: Socratic Debate’, a thought-provoking article on dietary supplements, written by last year’s key note speaker, Timothy Noakes and ‘Validation of Questionnaire for the Epidemiology of Sports Injuries in Wheelchair Athletes’ by Marc Safran, Jani Macari Pallis and Kimberly Workman. In ‘Meet the Expert’, you will find an interview with our re-elected board member Peter Jokl. There is also information on the new ITF Sports Science and Medicine Commission, and in our new section ‘Coaches Corner’, Carl Petersen presents practical information on recovery.

Dr Babette Pluim, MD, PhD
President STMS
CONFERENCE REPORT

7th STMS International Conference and ATP and WTA Tour Tournament Physicians’ Meeting

Beautiful Miramonte Resort in southern California was an ideal setting for the 7th Society for Tennis Medicine and Science (STMS) meeting held during the final weekend of the Pacific Life Open, March 18-20, 2005. Attended by approximately 85 people from around the globe the meeting covered a wide range of topics relevant to tournament physicians and medical staff. The University of California, San Francisco co-hosted the meeting with the STMS. Hosts Marc Safran and Bill Durney from UCSF deserve much credit for the meeting’s superb logistics and organisation. Many, many thanks to educational grants from Aircast, Arthrex, ATP, DJ Ortho, Genzyme, Histogenics, Pacific Life Open, and Smith & Nephew. The exhibit area was educational and the representatives from sponsoring companies were very informative.

The meeting agenda was balanced in terms of medical and surgical issues and between injury treatment and rehabilitation and injury prevention. The speakers represented many countries and medical specialties. The Sony Ericsson WTA Tour played a bigger role than in past in line with the “One Game” program, created by the Sony Ericsson WTA Tour and the ATP to explore and develop synergies between the two global organisations. There was healthy dialogue between ATP and the Sony Ericsson WTA Tour during the meeting, which made it clear that the organisations have much to gain from the interactions.

Friday morning was a combined session of Sony Ericsson WTA Tour and ATP physicians and paramedical staff. The agenda addressed common problems encountered by tournament physicians, e.g., use of non-steroidal anti-inflammatory drugs (NSAIDs) and intravenous hydration. Drs. Babette Plum and Brian Hainline presented the issues and gave helpful recommendations that, if followed, will prevent inconsistencies in medical management from one tournament to the next. Acetaminophen or paracetamol should be the first line analgesic, followed by a nonselective NSAID. NSAIDs do not speed recovery, but may be used in the first few days after injury to reduce pain. Aspirin and selective Cox-2 inhibitors are not recommended for tennis players.

Tournament physicians should have a high threshold for intravenous fluid replacement. If oral hydration is possible, intravenous fluid replacement is not indicated. The World Anti-Doping Agency (WADA) code states, “Except as a legitimate acute medical treatment, intravenous infusions are prohibited.” In spite of this tournament physicians are often pressured to provide intravenous hydration by coaches and players convinced that it will speed recovery. This pressure should be resisted and players should instead be educated about how to best recover from one match and prepare for the next.

“One Game Initiatives” were discussed including an injury documentation system, anti-doping and annual player physicals. WADA’s position on the use of nutritional supplements was reviewed. It is WADA’s position that taking a poorly labelled nutritional supplement should not be regarded as an adequate defence in a doping hearing.

A session on ATP medical services completed the morning session and described a medicine dispensing policy, a new collaboration with GlaxoSmithKline and injury prevention and treatment protocols.

Friday afternoon’s session included talks on core stability, serve mechanics, age eligibility, scapular stabilisation, and tennis epidemiology. The Sony Ericsson WTA Tour’s revised age eligibility rules were described which limit and gradually increase the number of tournaments in which young players can compete. The age eligibility rule is designed to promote longevity and fulfilment and to decrease burnout.

Dennis Van Der Meer teamed with Dr. Ben Kibler for the talk on serve mechanics with Dennis providing humorous, practical insight to Ben’s biomechanical analyses. Ben also described the role of scapular stabilisation in tennis followed by Robert Donatelli describing scapular dysfunction in athletes.

Saturday’s agenda focused on rotator cuff and wrist injuries and knee and foot injuries and their rehabilitation. Sunday’s agenda focused on thermoregulation and hip stabilisation and injuries and included a talk on hip arthroscopy by Dr. Tom Byrd and a talk by Prof. Savio Woo on functional tissue engineering for ligament healing. A lively discussion occurred on whether or not cramps are heat-related. Comments ranged from “I have never seen cramps in ice hockey players” to “I have seen cramps in athletes when the temperature and humidity were not very high.”

Five abstracts were also presented and discussed during Sunday’s session.

Overall the meeting was loaded with practical information for physicians, trainers and therapists treating athletes generally and tennis players specifically. The faculty had gender and geographic diversity and was a good blend of well-known names and seasoned investigators along side young investigators just launching their careers.

Amy S. Chappell, M.D.

Teamwork among members of the ATP, WTA and STMS!

Bill Durney, UCSF Sports Medicine, Clinical Research Co-ordinator and Leslie Aguayo, Director, UCSF Office of Continuing Education

Amy Chappell

Gary Windler (ATP) and conference organiser Marc Safran

Hard at work during the SWOT-analysis: Javier Maquirriain, Kathy Martin, Ben Kibler and Alan Pearce
MEET THE EXPERT:

Dr. Peter Jokl

I am an orthopaedic surgeon specialising in sports medicine. My expertise is based at the Department of Orthopaedics and Rehabilitation at Yale University. I have a busy clinical practice, and spend a significant amount of my time doing academic research and teaching.

1 What is your specialty and your daily work?

I am an orthopaedic surgeon specialising in sports medicine. My day-to-day work involves treating and evaluating how muscle recovers from injury and surgery. The treatment of muscle injuries, especially contusion injuries, is often based on non-scientific information. Some treatment protocols used are even detrimental to recovery. I am interested in evaluating how muscle recovers from injury and what methods enhance its repair. I have done research on NSAIDs and muscle injury. It would be difficult to summarise all of this research in one or two sentences but I can outline some of my findings:

- Muscle atrophy following injury can be prevented by avoiding immobilizing the muscle in a shortened position.
- Prolonged use of NSAIDs does appear to have a negative long-term effect on muscle healing. My use of NSAIDs is limited to short-term use to decrease painfull inflammation. If there is pain but no significant inflammation, anti-inflammatory medications such as TYLENOL or PARACETAMOL are effective.

2 When did you first get involved in tennis and ‘tennis medicine’?

I have enjoyed playing tennis at a recreational level since childhood. My good friends Per Renstrom and Ben Kibler were instrumental in getting me involved in STMS. We had the first meeting of STMS in 1991 at Yale University.

3 In 1958, you were co-author of an article with your father, which was published in the American Journal of Cardiology. It was entitled Ballistocardiographic studies on Olympic athletes. What was that about article and what did it mean to you? What influence did your father have on your (sports-)medical career?

My father was one of the founders of sports medicine in his native Germany, then in South Africa and in the USA. He was eager for me to go into sport sciences and realised that my talents were not in that area of study and I decided to go into medicine. Of course my attraction to medicine, and then specifically sports medicine, was influenced by my father’s interest and my participation in some of his research projects. I should mention that my mother was a German Olympic, participating as a gymnast in the 1928 Olympic Games. She was a sports teacher at a school in Durban where I was educated. My early sports experience had a big influence on the kind of careers I ended up choosing. My early experiences involved being part of an elite team, where training sessions were gruelling and the pressure to perform was intense. These experiences taught me the importance of discipline, determination, and the need for continuous improvement.

4 One of your areas of expertise is basic research on muscle injury, its prevention, etiology, and rehabilitation. Why did you choose this research topic and what are your main findings?

The treatment of muscle injuries, especially contusion injuries, is often based on non-scientific information. Some treatment protocols used are even detrimental to recovery. I am interested in evaluating how muscle recovers from injury and what methods enhance its repair. I have done research on NSAIDs and muscle injury. It would be difficult to summarise all of this research in one or two sentences but I can outline some of my findings:

- The use of corticosteroids in muscle injury is deleterious to the muscle injury repair process. Although controversial, in animal studies, anabolic steroids appear to improve recovery in injured muscles.

5 You have done a lot of research on NSAIDs and muscle injury. What would you recommend to a tennis player with a grade 1 muscle strain and a player with tendinosis?

We need to remember that the inflammatory process is a normal healing process. If we stop inflammation completely, as one can do with corticosteroids, healing will not occur. Judicious use of NSAIDs to reduce, but not eliminate inflammation, appears to have no detrimental effect.

6 Presently you are a co-investigator in a National Institute of Health (NIH) funded study assessing the effect of psychosocial factors on recovery from elective surgical procedures. The aim of this study is to identify important non-surgical factors influencing recovery in individuals undergoing elective surgical procedures, and be able to intervene to enhance recovery. What are your main findings so far?

As many of us are well aware the patient’s attitude and emotional status appears to affect recovery from injury and surgery. The prospective NIH study we are completing measures various psychosocial parameters and their correlation to recovery from knee surgery. So far some early results indicate that the patient’s attitude to recovery is a much better predictor of surgical outcomes than the surgeon’s preoperative estimates.

7 You have been medical director of the Volvo/ Pilot Penn Tennis Tournaments since 1990. What is your most remarkable experience as tournament doctor?

I am always impressed by how focused and intelligent the professional players are concerning their training, injury diagnosis and treatment. I have found the trainers both from the ATP and WTA to be highly professional and dedicated. I have learned a lot from them in the management and treatment of professional tennis players.

8 It seems there are more injuries among the top female players than there used to be. Do you agree with this observation and what do you think is the main cause? Do you have any suggestions on how to reduce the number of injuries?

My experience is that during tournament play, the women have a much lower incidence of play-related injuries than the men. Assessing injury rates among players is very difficult as many factors are involved. The Pilot Penn tournament occurs just before the US Open. Some of the injuries that cause withdrawal from play in New Haven would not happen in the Grand Slam play. In order to obtain accurate data on injury cause and incidence, we need to have a clear definition of what constitutes an injury, how its severity can be graded and its cause. Only then can we address questions such as you raise.

9 You have been a member of the STMS since the very beginning in 1991. What do you see as the main tasks of the Society?

Our roots were in bringing together health professionals who are interested in tennis and its particular medical concerns. STMS should be the international resource to discuss and share information about tennis-related medical issues. In the future we should be a resource for data (i.e. gathered epidemiological raw data) about tennis health issues so that prevention, treatment and rehabilitation recommendations can be based on substantiated information.

10 You recently published a very interesting article on marathon running, entitled ‘Master’s performance in the New York City Marathon 1983-1999’. What are the main findings of this study? Have you ever run a marathon yourself or do you plan to?

The marathon study you are alluding to is a revival of early studies we did on the prediction of world record performances in elite athletes. I saw an opportunity to use the vast data available from the NY marathon participants to evaluate whether masters [50 years and older] athletes are improving their performance levels at a rate equal to or at a faster rate than the younger runners (Jokl P, Sethi PM and Cooper A. Ageing Successfully: Performance results of the New York City Marathon 1983-1999. Medicine & Science in Sports & Exercise 2004). The major findings are that masters athletes are improving their performance times at a much faster level than their younger counterparts and that master women athletes are improving at the fastest rate. Although I was a short distance runner in college, I have run several marathons just to see if I could complete them. I was probably more genetically equipped with fast twitch muscle, making short distances my forte. A marathon takes too long for me, I have too much time to think about the race. In sprinting the gun goes off, you run as quickly as you can and its over. That is what fast- switch is all about!!

As a sports physician I think it is important that we encourage all of our patients to stay physically active. The benefits of remaining active throughout life are well documented. In most western countries now, inactivity and obesity are one of the leading causes of chronic illness and death. I encourage my patients to participate in a sport they enjoy — that way there is a good chance they will continue to stay active.

I do not advocate one sporting activity over another. To complete my answer, for training for any sport, one needs a balance of strength and endurance activities. Much of this can be sport-specific.

11 What research do you feel is most needed right now in the area of tennis medicine?

As a scientific society we need to disseminate evidence-based scientifically validated information as it relates to tennis medicine.

12 What are your plans for the future?

I intend to continue my academic activities at Yale. I plan to modify our Orthopaedic curricu- lum in the near future years, and continue to support our medical students and young doctors in their training to become our future leaders in medicine.
Degree in Tennis Offered at Victoria University Melbourne, Australia

DR ALAN J PEARCE1,2, PROF. JOHN CARLSON2, AND MS JANE MCLENNAN3
1School of Human Movement, Recreation and Performance, 2Centre for Aging, Recreation and Exercise Science, Victoria University, 3Department of Sport, Recreation and Performance

**Rationale**

Australia is recognised as a major nation in the sport of tennis, having produced many great players. Now Victoria University has continued the tradition of leadership in tennis with the introduction of a Degree in Sport Science focusing on tennis. With the increased professionalism and technology advancements in tennis, the knowledge and scientific background needed to achieve excellence in tennis performance and coaching is becoming paramount. Victoria University has recognised the need for specialised and advanced education and training which specifically meets the industry driven demands for expertise and training for the tennis industry.

Prior to the development of the Victoria University Degree, Bachelor of Applied Science in Sport Science [Tennis], there did not exist a tertiary level of study which focuses on the scientific foundations underpinning and practical skills in learning and performance of the sport of tennis.

**Why the Degree in Tennis Science?**

The introduction of this course follows a critical appraisal of professional preparation of tennis players from around the world. To date, no opportunities exist for education and preparation of elite tennis players, teachers/coaches, and sports scientists with a focus on the sciences in tennis. Currently, there are limited tertiary studies in tennis at Universities across the world. Further, these programs focus primarily in the areas of Management and Administration with little, if any, attention placed on the scientific aspects of the performance of the game itself. Educational content traditionally has thus focused on giving students with an interest in tennis, the business qualifications to work in an administrative position. These qualifications provide students with competencies such as management for clubs, recreational resorts and other tennis-related businesses, but the scientific preparation of the tennis athlete and the coach is generally ignored or only covered superficially.

Many promising tennis players aspire to play on the professional tour, but the competition is extremely tough, creating limited opportunities. Many of these players who do not remain on the tour will turn to coaching or teaching tennis. Under the current conditions in which these elite tennis players are trained and prepared, very few would be qualified to coach as they have not been trained or educated to be coaches in the specific field of tennis.

The Victoria University degree is aimed specifically at this void in the preparation of players and coaches. It will assist the players to aspire to achieve his/her maximum playing ability armed with the scientific knowledge and skills to understand the many aspects of tennis which need be optimised to achieve their personal best. For the development of the coach this will be the first tertiary degree program which aims to produce coaches who have solid tertiary backgrounds in the sciences for tennis.

**Where is the Degree offered?**

Victoria University is located in Melbourne, Australia. Melbourne is the home of the Australian Open, one of the four Grand Slam events.

Victoria University is also in a unique position to offer this course as it has both access to specialised staff knowledge and strong industry partnerships with high calibre and quality tennis facilities and expertise around Melbourne.

**Structure of the Tennis Degree**

The Bachelor of Applied Science in Sport Science [Tennis] is a 3-year (7 Semester) full time (or part-time equivalent) course of study.

<table>
<thead>
<tr>
<th>Diploma of Sport Coaching [Tennis]</th>
<th>B.App.Sci. in Sport Science [Tennis]</th>
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<tbody>
<tr>
<td>2 years full time (4 semesters)</td>
<td>3rd year full time (3 semesters)</td>
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</table>

Academic classes will typically be taken in the morning with the afternoons dedicated to practice, coaching and competitive play. Coursework in the Degree includes subjects such as: Physiological Bases of Tennis Performance, Applied Psychology of Tennis, Tennis Biomechanics, Technology and Tennis, Teaching and Coaching techniques, Exercise Prescription and Training for Tennis & Motor Learning and Skill Development. Full subject details are available upon request.

**Who are the potential students?**

The Bachelor of Applied Science in Sport Science [Tennis] course is designed for students who aspire to study and develop both a skills and a strong scientific knowledge base for tennis performance, sports science and coaching expertise. The course will appeal to elite developing tennis players but also those who aspire to enter the tennis industry in other roles.

**What is required to enter the Course**

Successful completion of final year of study at High School and successful English language requirement of IELTS 5.5. There is no playing competition standard required at this time, but some experience at playing tennis would be considered as mandatory.

Advanced standing from other overseas study will be considered, such as two-year sport or human movement programs at Junior or Community Colleges.

**Outcomes from the Degree**

The Bachelor of Applied Science in Sport Science [Tennis] will allow graduates to extend scientifically strategic competencies and build upon existing skill levels. Demands for a higher level of knowledge increasingly reflect growth in opportunities of recreation-
al, semi professional and professional players and greater demands for qualified coaches both nationally and internationally.

The new course will provide specialist education and practical skills in the area of Tennis Education and Professional Preparation. In addition to expanding the specialist knowledge base of Tennis performers and coaches, the course will promote awareness of the broader issues that surround tennis performance and professional career development in a sporting climate in which the demands placed on participants, and the gains or costs of participation, can be exceedingly high. The current proposal will focus on the attainment of professional skills and knowledge related to performance in the profession of tennis both from a playing and teaching perspective. Graduates will be able to pursue positions in the tennis industry in the knowledge that they possess the latest scientific developments and expertise.

**Cost of the Course**

The cost of the course for non-Australian students is $10,000 each per semester. This fees covers:

- Academic tuition and materials;
- Tennis coaching of three days at three hours per day with fully qualified coaches to student ratio of 1:4 and one day in which coach supervises students with practice match-play. These are conducted at Kooyong International Tennis Stadium;
- Competition each week in a registered Tennis Victoria pennant competition;
- Access to use of practice facilities at Kooyong Tennis Clubs;
- Membership at Tennis Victoria registered tennis clubs around Melbourne (subject to confirmation with clubs);
- Access to University facilities such as weight training, gyms and swimming pool.

For further details regarding this unique course of study visit the website www.vutennis.com or alternatively, contact:

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john.carlson@vu.edu.au

**Dr Alan Pearce**

alan.pearce@vu.edu.au

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1 Subject to change at anytime without notification.

Course costs differ between Australian and International Students. For the latest information please visit our website www.vutennis.com
Exercise Intensity in Tennis: Simulated Match Play versus Training Drills

JAIME FERNANDEZ FERNANDEZ, BENJAMIN FERNANDEZ-GARCIA, ALBERTO MENDEZ-VILLANUEVA, NICOLAS TERRADOS.

Abstract
The purpose of this study was to compare selected physiological responses during simulated singles match play with typical training drills used by male players during on-court practice sessions. There were two parts to the study, with one week separating each part. In Part One, six internationally (ATP) and nationally ranked players completed an incremental treadmill test to exhaustion, which measured maximum oxygen uptake (\( \text{VO}_2\text{max} \)) (58.2 ± 2.2 ml kg\(^{-1}\) min\(^{-1}\)), maximum heart rate (HR\(_{\text{max}}\)) (191 ± 4 beats min\(^{-1}\)), and lactate concentrations (LA) (6.6 ± 0.7 mmol L\(^{-1}\)). In Part Two, players were asked to complete two tasks on outdoor clay courts. Task One consisted of two different technical (‘control’) drills and the second task was a competitive set. Subjects were equipped with a portable metabolic system, which measured oxygen consumption (\( \text{VO}_2 \)) and heart rate (HR). During the training drills, oxygen consumption (i.e. \( \text{VO}_2 \)) and average heart rates (i.e. HR\(_{\text{ave}}\) and \( 5\times \text{HR}_\text{ave} \)) were significantly higher (\( P < 0.01 \)) than during a simulated competitive set. Results from this study suggest that monitoring the physiological workload associated with on-court training drills would assist in optimising training efficiency (i.e. the combined improvement of conditional and technical abilities) in competitive tennis players.

Key words: competitive tennis, physiological workload, maximum oxygen uptake (\( \text{VO}_2\text{max} \)), heart rate (HR), blood lactate (LA), technical drills.

Introduction
Recent efforts in exercise science have generated enthusiasm to promote scientific-based training programs. Several investigations have examined the physiological demands of singles match play in tennis, based on oxygen consumption, heart rate and blood lactate concentration measures.\(^5\),\(^6\),\(^7\) Data from these studies has allowed the design of scientifically-based training protocols adapted to sport-specific demands. However, in tennis, the sport-specific technical skills are predominant factors.\(^8\) Therefore, tennis players devote a great amount of time to improve their tennis skills through technical training. For example, for high-performance players, the ITF recommends between fifteen to twenty hours of technical training per week.\(^9\) The problem we found is that the specific technical and tactical training in tennis is not really associated with an estimated physiological load.\(^1\) Presently, the specific nature of the physiological load associated to technical-tactical training is unknown. Ignoring this information may lead us to duplicating specific aspects of physical work, already taken care of in the technical-tactical session, during the physical part of the training program. For instance, intermittent exercises, simulating competitive situations, are essential and very often used during both kinds of training (technical-tactical and physical). The purpose of this study was to compare selected physiological responses during simulated singles match play and typical training drills used by tennis players during on-court practice sessions.

Materials and methods
Subjects
Six trained and healthy players (four ATP and two nationally ranked) voluntarily participated in this study. The subjects characteristics of age, height and weight were 23.9 ± 2.5 years, 183.7 ± 1.2 cm and 83 ± 3 kg, respectively for the ATP ranked players and 15.3 ± 0.4 years, 158.9 ± 0.3 cm and 61 ± 8 kg, respectively for the nationally ranked players. The experimental design was divided into two parts: a maximal treadmill test and a field test. All players were subjected to a maximal treadmill test to gain information on their individual aerobic capacity (\( \text{VO}_2\text{max} \)). This laboratory data was used as reference values for the comparison between the individual aerobic capacities of players and the physiological demands of the field test. Before providing informed consent, the exercise protocol and all possible risks and benefits associated with participation in the study, were explained to each subject.

Laboratory test
The exercise was performed on a motorised treadmill (Technogym ‘Runrace’, Italy). The treadmill test consisted of an initial workload of 7 km per hour with an increase of 2 km per hour every three minutes, at a constant grade of 3%. During this test, blood samples were taken during each stage after completion of each stage. The purpose of each test was for analysis of blood lactate concentration. A rating of perceived exertion (RPE) scale was used between each stage to estimate how hard the subjects themselves thought they were working. Respiratory gas exchange was measured using a portable telemetry system (Vmax29, Sensormedics, USA) and recorded at 10 second intervals. Heart rate was determined by means of a chest-belt telemetry monitor (Polar S610, Kempele, Finland), which was transmitted to the portable system. The volume calibration of the system for gas analysis was conducted before each test day and the gas calibration was performed before each test.

Field testing
One week after the treadmill testing, the players performed the field test. The exercises and competition set were conducted on an outdoor clay court. A set of four new balls were used for each test. Before each exercise, players performed an standardised warm-up for five minutes. Players were asked to hit groundstrokes to each other up and down the centre of the court, each player to take some volleys and overheads from the net position while the other fed from the baseline, and then both players to hit some serves. The field test was divided into two tasks. The first task consisted of two different technical (‘control’) drills. The first exercise involved players hitting crosscourt forehands against each other from the baseline. The second exercise was for players to hit two crosscourt forehands and two down the line backhands from the baseline. The duration of each exercise was five minutes. During these exercises players were exposed to a similar metabolic system, which measured oxygen consumption (\( \text{VO}_2 \), K4BL2, Cosmed, Italia) and heart rate (Polar S610, Kempele, Finland). Blood samples from hyperemised earlobes were taken every five minutes and immediately at the end of each exercise to analyse lactate. A RPE scale was used at the end of each exercise to estimate individual perceived exertion.

The second task of the field test was to play a competitive set. Both players were equipped with the same portable metabolic system as in the ‘drill test’. Blood samples from hyperemised earlobes were taken to analyse lactate and a RPE scale was used at the end of each exercise to estimate individual perceived exertion. Players were encouraged to play at their best level as in an official tournament.
in our study was 60% of VO₂max measured on HRavg and %HRmax) were significantly higher and %VO₂max) and average heart rates (i.e. HRavg), maximum lactate concentration (LAmax) and rate of perceived exertion (RPE) during the field test.

Table 2 Maximum oxygen uptake (VO₂max), heart rate (HR), maximum heart rate (HRmax) and average heart rate (HRavg), maximum lactate concentration (LAmax) and rate of perceived exertion (RPE) during the field test.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Exercise 1</th>
<th>Exercise 2</th>
<th>SET</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO₂ (mL·kg⁻¹·min⁻¹)</td>
<td>34,8 ± 2,2</td>
<td>35,5 ± 1,4</td>
<td>36,0 ± 3,3*</td>
</tr>
<tr>
<td>%VO₂max</td>
<td>59,9 ± 5,3</td>
<td>60,9 ± 4,7</td>
<td>64,6 ± 7,2*</td>
</tr>
<tr>
<td>HRmax (beats·min⁻¹)</td>
<td>181 ± 13</td>
<td>179 ± 9</td>
<td>181 ± 14</td>
</tr>
<tr>
<td>HRavg (beats·min⁻¹)</td>
<td>169 ± 12</td>
<td>169 ± 11</td>
<td>147 ± 15*</td>
</tr>
<tr>
<td>%HRmax²</td>
<td>80,4 ± 8,1</td>
<td>80,0 ± 7,5</td>
<td>65,9 ± 10,2*</td>
</tr>
<tr>
<td>LAmax (mmol·L⁻¹)</td>
<td>2,9 ± 1,8</td>
<td>3,5 ± 0,7</td>
<td>4,0 ± 1,1</td>
</tr>
<tr>
<td>RPE</td>
<td>12,2 ± 1,7</td>
<td>13,8 ± 1,7</td>
<td>12,5 ± 2,1</td>
</tr>
</tbody>
</table>

* Significantly smaller than in exercise 1 and 2 (P < 0.01)

** Discussion **
Our results showed that the physiological workload of two regular technical drills was higher than the registered workload in a simulated competition set. Apart from the technical aim (hitting and ball control), the higher physiological load associated with the technical work, compared to the load registered during the set, would suggest that technical drills might be also used to train the hitting and ball control skills in specific situations, under conditions of physiological overload.

To our knowledge, there is no published data about the physiological demands of different kinds of on-court training (technical-tactical). Only a few studies described the influence of training stimuli (intensity, duration and density) on the stroke efficacy (precision and velocity) and running speed of ‘typical’ exercises. For example, Weber et al. revealed that the intensity, density and duration of the training stimuli often exceeds the physiological demands of match play. Therefore, it would seem important to quantify the workload that the tennis player has to withstand during the accomplishment of technical exercises, in order to be able to train the quality by simultaneously developing conditional and technical aspects (integrated training).

Our results are in agreement with those presented in other studies and thus support the proposal that a technical training session might demand a VO₂ level high enough to produce adjustments in the aerobic system, particularly in individuals with a low level of physical aerobic condition. Besides, as the duration of the exercises performed in the present study was of only five minutes, it is reasonable to suggest that a longer duration of certain technical training sessions might assure a sufficiently intense training stimulus at an aerobic system level and, most importantly, its training effect would be specific. This could lead to the reduction, or even suppression, of additional aerobic training that could have been planned by the trainer.

The results presented here show that very little is known about the physiological responses during training drills used in tennis, and suggest, therefore, that it is important for new research to be undertaken in this area of tennis performance.

Statistics
The results are expressed as mean values ± SD. The Kolmogorov-Smirnov test was used to verify that all parameters presented a normal distribution. A Student t-test was used to verify that all parameters presented a normal distribution. The results are expressed as mean values ± SD. The Kolmogorov-Smirnov test was used to verify that all parameters presented a normal distribution. A Student t-test was used to verify that all parameters presented a normal distribution. The results presented here show that very little is known about the physiological responses during training drills used in tennis, and suggest, therefore, that it is important for new research to be undertaken in this area of tennis performance.

Address for correspondence: J. Fernández Fernández, Functional Biology Department, University of Oviedo, Spain.
Dietary Supplements for Health and Performance; the Good, the Bad and the Ugly: Socratic Debate

Timothy Noakes

The passage of the Dietary Supplement Health and Education Act (DSHEA) by the Congress of the United States of America in 1994 fundamentally changed the nature of the nutritional supplement industry worldwide. For it essentially opened the international market to the unregulated dispersion of poorly evaluated products of uncertain composition, heavily marketed and targeted at a vulnerable audience of aspiring athletes and uncertain adolescents who have been led to believe that there is a single nutritional "magic bullet" that will finally produce all the desirable bodily changes and enhanced athletic performance that they covet.

Fully to understand the fundamental nature of the changes produced by DHSEA 1994, it is appropriate to compare the controls that apply to the production of therapeutic pharmaceutical agents (prescription drugs) and of dietary supplements, especially the ergogenic aids. First, prescription drugs must undergo decades of development and evaluation to insure that they are safe and effectively achieve the outcomes they claim.

Then their production and distribution is rigorously controlled to insure that they contain only those ingredients that are listed on the package insert. Next they can be marketed only for the specific medical conditions for which their beneficial effects are proven and then usually only on prescription.

Finally, post-marketing surveillance evaluates the lifelong safety and efficacy of these products (Figure 1).

In contrast, nutritional supplements can be marketed without most of these controls. Provided they make no medical claims, nutritional supplements can be sold on the basis of claims that may never have been evaluated, much less proven. Nor do these products need to prove their safety since it is usually presumed that nutritional supplements must be safe, regardless of dose. Nor is there control of the exact composition of these products. Nor are there stringent labelling requirements so that covert or accidental contamination of products cannot be detected. Nor is there a system of post-marketing surveillance to insure that the products are as safe and effective as is presumed and that unexpected drug/supplement interactions do not occur. As a result the modus operandi for this industry is that shown in Figure 2.

In brief, the idea for a new dietary supplement is entertained, the product is sourced – since being a nutritional product it does not usually require to be developed de novo – then it is appropriately packaged and forcefully marketed. Thereafter, it is usual that the product is "researched" usually with funds provided from the profits of the sale of the previously untested supplement.

But unlike the situation in the pharmaceutical industry, the goal of such research is not principally to determine the safety or even the efficacy of the product since these are assumed, but is usually undertaken in the hope that an ergogenic effect might be uncovered by an influential scientist whose academic "endorsement" of the product may further enhance the commercial value of the product.

However the commercial success of these products is clearly not dependant on their proving an ergogenic effect since there is relatively little evidence that most such products do indeed enhance athletic performance. Rather the commercial return on the product is probably dependant on the extent of the advertising campaign that supports the product and the hype that such a campaign can generate.

Currently the key issues that need to be addressed in this debate are the following:

Are all nutritional supplements safe? Are there any nutritional supplements that are either effective or even necessary? If so, how cost-effective are those specific supplements? Are some supplements effective only because they also contain banned substances such as anabolic steroids? And can such substances lead unwittingly to chemically-positive doping offences in international sport?
Elsewhere I have reviewed the evidence supplements? if so, how cost-effective are those specific allowed. the United States would have been ephedra alkaloids would have escaped unlikely that the adverse consequences of for the passage of DSHEA 1994, it seems adverse events have been identified. But there is the problem of what different athletes would interpret as a sizable improvement in athletic performance. For example, the world record holder in the 100m foot race wishes only to improve his or her time by a maximum of 0.01 of a second or less than 0.1% to advance the record. Current scientific methods are unable to disprove that any of the ergogenic agent depicted in Figures 3 and 4 does not provide this minute effect. Thus the better the athlete and the closer he or she is to the world record, the less able are scientist to advice them on whether or not a specific supplement or intervention will produce an ergogenic effect that would fulfil their specific needs. In contrast a 4hour 42km marathon runner is unlikely to be interested in an ergogenic aid that will improve his or her performance by only 0.1% or about 15 seconds. Thus the athlete is likely to be interested only in those products that will lower her time by between 30 and 60 minutes, that is, by between 12.5 and 25.0%. Thus in the case of ergogenic aids, if the scientists determine a significant effect, then athletes and the lay public assume that this means that this product will produce a sizable and desirable improvement in their athletic performance. But, second, there is the problem of what different athletes would interpret as a sizable improvement in athletic performance. For example, the world record holder in the 100m foot race wishes only to improve his or her time by a maximum of 0.01 of a second or less than 0.1% to advance the record. Current scientific methods are unable to disprove that any of the ergogenic agent depicted in Figures 3 and 4 does not provide this minute effect. Thus the better the athlete and the closer he or she is to the world record, the less able are scientist to advice them on whether or not a specific supplement or intervention will produce an ergogenic effect that would fulfil their specific needs.

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Figures 3 and 4 provide a comparative scale of the magnitude of benefit that an athlete might expect from the use of different ergogenic aids or training or other interventions. The analyses are somewhat subjective in that the actual percentage improvements are a “best guess” based on a review of the currently published evidence. Two points are immediately clear. First, that the use of banned substances including the anabolic steroids and erythropoietin provide far greater benefit that does even the most effective ergogenic supplement. Second, that the vast majority of so-called ergogenic agents likely have little or no substantive performance-enhancing effect that would be of any assistance to the aspirations of the average athlete to whom their sale is targeted. Whether or not any or all of these agents would add the 0.1% improvement required by the world’s best cannot be answered by current scientific methods. But the circumstantial evidence that the world’s best stick with the proven and large effects of the banned anabolic steroids and erythropoietin suggests that any small effect of these ergogenic agents is not of particular interest even to the elite athletes.

Are some supplements effective only because they also contain banned substances such as anabolic steroids, and can such substances lead unwittingly to positive doping offences in international sport? Because of the ‘liberal’ labelling requirements for nutritional supplements, there is a real possibility that the less scrupulous would wish to include those drugs that are known to be really effective, especially anabolic steroids or their metabolic precursors in their “nutritional supplements”.

Professor Christiane Ayotte, head of the International Olympic Committee’s (IOC) accredited Doping Control Laboratory in Montreal has reported that an IOC-initiated study found that of 634 supplements from 15 different countries, 94 contained steroid prohormones including 64 testosterone precursors, 23 nortestosterone precursors and the remaining seven included multiple anabolic steroid precursors. It is possible that athletes ingesting those supplements might test positive if submitted to appropriate doping control procedures. An interesting such example has been provided by the study Catlin et al. who provided subjects with two doses (100 and 200mg) of the testosterone precursor, androstenedione, and showed that urinary concentrations of the nandrolone metabolite, 19-norandrostenedione, increased above the IOC designated legal limit of 2, reaching urinary concentrations of 3.8 and 10.2ng.ml⁻¹ with the respective doses. Nandrolone is one of the original anabolic steroids used by athletes since the 1950’s. Since there is not known biochemical pathway by which androstenedione can
appear in the urine as 19-norandrosterone, they postulated that the androstenedione product that they tested may have been contaminated with either norandrosterone or nandrolone.

To test this possibility, they next had subjects ingest a trace amount (10 micrograms) of norandrosterone and measured the urinary concentrations of that metabolite for the first eight hours after ingestion. Figure 5 shows that urinary 19-norandrosterone concentrations remained above the IOC cut-off values for nearly six hours. This study clearly shows that trace contamination of supplements could produce positive doping tests and might explain the large number of positive nandrolone doping tests in the past five or so years.

Another study showed that even if the active ingredient is listed on the label, the dose may not be accurate (Figure 6). Thus Figure 6 shows that of 16 products claiming to contain certain amounts of dihydroepiandrosterone, three contained no such substance, four contained less than 80% of the amount listed on the label, eight contained approximately the correct amount and one contained in excess of 150% of the listed amount.

**Summary and Conclusions:** In summary, the widespread public ignorance of the consequences of the passage of DSHEA 1994 allows the producers and marketers of the so-called ergogenic supplements actively to target impressionable athletes and uncertain adolescents without the controls that constrain the manufacturers and distributors of pharmaceutical agents. In particular there is no requirement scientifically to prove any claimed performance-enhancing benefits. Since a majority of these products probably do not improve performance substantially, there may be cheaper and more effective ways for achieving greater performance enhancements, for example proper physical training and greater attention to psychological preparation. In addition, the long-term safety of all ergogenic aids is not known nor has it been necessary for potential drug-supplement interactions to be excluded. Indeed the current position is that the FDA must first prove that supplements are unsafe before their sale is discontinued. This contrasts absolutely with the controls that regulate the pharmaceutical industry. There is also a lack of quality assurance and lax labelling requirements which do not exclude the possibility of active contamination of these supplements with banned substances, in particular anabolic steroids or their precursors. Although most so-called ergogenic substances are probably both ineffective and harmless, some health risks have been documented. Thus the use of ephedra alkaloids has been associated with an increased incidence of cardiovascular and cerebrovascular complications.

The conclusion must be that the absence of reasonable and appropriate controls, as are present in the regulation of the pharmaceutical industry, creates the potential for malpractice in the supplement industry.

**References**

The Symposium for Tennis and Ski Medicine took place in St. Anton am Arlberg from December 8 to 11 2004. Standards and news in the treatment of sports injuries were discussed, as were certain aspects of the minimally invasive knee prosthesis. The congress was organised for the third time by Prof. Dr. Rudolf Schabus, with support from Univ. Doz. Dr. Thomas Müllner, PhD.

A total of 25 speakers, each with their own topics of interest, were ‘recruited’ for the congress. The speakers shared their experiences with the audience using professional, well-researched presentations and questions and answer sessions.

Prof. Dr. David Backstein from Mount Sinai Hospital in Toronto gave his guest lecture on December 9th. The title was ‘News and Updates on the Hemi-Arthroplasty of the Knee Joint’. Initial studies on the implantation of the knee hemi-arthroplasty were first published in the fifties by McKeever and McIntosh, with follow-up studies in the seventies by Marmor and Insall. Bad experiences after surgery in the 1970s led to a decline in the frequency of implantation in the 1980s. The advantages of this type of prosthesis are the minimal invasiveness, the preservation of almost normal knee kinematics, the preservation of the anterior or cruciate ligaments, the preservation of bone tissue, a quicker rehabilitation time, and if necessary an easy revision into a total knee arthroplasty.

The primary indication of this type of surgery are deep medial cartilage defects, without large bony erosions (anteromedial arthritis, according to Goodfellow), when the cause is not inflammatory or metabolic, in patients under 50 years of age who do not put a lot of pressure on their knee. Both cruciate ligaments should be intact, there should be no medio-lateral subluxation, and essentially no limitation in the range of motion (S >0-5-90) or malalignment (axis deviation (mechanical axis 170°<x<185°). While the early reports indicated that the findings for the lateral replacement were better than for the medial replacement, more recent studies are in favour of the latter. The leg axis should not be over-corrected (2-3 degrees varus would be ideal) to protect the contralateral compartment from overuse. Use of the minimally invasive technique has contributed to functionally better results in recent years, but one should be warned not to become overzealous in proposing patients for this operation. The operation technique is critical.

On 10 December the state of the art cartilage surgery was presented and discussed.

When using imaging techniques, one faces the problem that cartilage is small and thin, but geometrically 3D very complex, and investigated by using 2D technique. Therefore, the images are sometimes difficult to interpret, and with small joints, one has to pay special attention to indirect signs such as subchondral oedema, sclerosis, and cysts. A cartilage defect identified with MRI is most often underestimated, and never overestimated.

The cartilage lesions can be divided into four degrees of severity:
1. Alteration of the cartilage signal;
2. Fibrillation, superficial fissures;
3. Deep fissures, defect >50;
4. Bare bone.

The development of hyaline cartilage can be explained with the theory of causal histogenesis by Pauwels (modified after Kummer). This theory proposes that cells exposed to stress produce an extracellular matrix that withstand the acting forces (deformation or compression). This way hydrostatic pressure may lead to the development of cartilage, whereas pulling forces enable the development into tendon. In cartilage there are no fibres but fibrils. These fibrils consist of collagen II + XI + IX. In between there are proteoglycans which bind fluid. For the management of cartilage lesions there are essentially two types of treatment. Firstly, an operation that stimulates the intrinsic regeneration: abrasion arthroplasty, Pridie drilling, and the Steadman’s microfracture technique. Secondly, as extrinsic regeneration the autologous chondrocyte transplantation is available.

In the past defects were covered with peristeme and injected with a chondrocyte suspension. Nowadays matrix associated techniques are more likely to be used. The matrix-associated techniques have the advantage of cell differentiation, a defined cell number, an easier operation technique (also possible arthroscopically) and up to a certain degree the defect can be filled up. If the osteochondral defect is deeper than 5 mm, such a defect needs to be filled up with a spongioplasty, e.g. a cylinder taken from the iliac crest. Only a narrow indication for operation guarantees satisfied patients. Complex cases and arthrosis are no indication for operation, and should first be analysed in controlled studies.

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From left to right: Rudi Schabus, Mrs. Trnka, Thomas Müllner, Mr Labs, Babette Pluim, Mr Sieckmann, Mrs. Millenkovics, Lisi Bosina, Harald Millenkovics, Hanns Flenk, Doa Trnka
Skill-Level Related Injuries in Recreational Competition Tennis Players

Neeru Jayanthi, Peter I. Sallay, Patti Hunker and Mike Przybylski

This study was a retrospective review of prospectively collected data. Injury incidence and prevalence were calculated for 528 recreational league tennis players of varying age, gender, and skill level who responded to an injury survey. The questionnaire included an injury history and specific tennis-related questions. The study showed that skill level had a significant relationship with injury cause, injury location, IME and gender. When skill level alone was compared to overall injury rates, age and time played, there were no relationships. It was concluded that despite trends, skill level had no effect on overall injury rates in recreational league tennis players. Injury rates appear to be independent of time played, age, and gender in these recreational league tennis players.

Key words: tennis, tennis injuries, skill level, recreational athlete, injury rates

Abstract

Studies identifying injury rates in recreational league tennis players do not clearly define injury and fail to compare skill levels among players. It was hypothesized that when skill level is considered, there are significant differences in injury incidence and prevalence among recreational league tennis players with regard to age, injury location, injury cause, injury modifying equipment, skill level, gender, and hours played.

Table 1 NTRP (ITN) Ratings*

<table>
<thead>
<tr>
<th>NTRP</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 (10.1-10.3)</td>
<td>This player is just starting to play tennis</td>
</tr>
<tr>
<td>1.5 (10)</td>
<td>This player has limited experience and is still working primarily on getting the ball into play</td>
</tr>
<tr>
<td>2.0 (9)</td>
<td>This player needs on-court experience. This player has obvious stroke weaknesses but is familiar with basic positions for singles and doubles play</td>
</tr>
<tr>
<td>2.5 (8)</td>
<td>This player is learning to judge where the ball is going although court coverage is weak. This player can sustain a short rally of slow pace with other players of the same ability</td>
</tr>
<tr>
<td>3.0 (7)</td>
<td>This player is fairly consistent when hitting medium paced shots, but is not comfortable with all strokes and lacks execution when trying for direction, control, depth, or power</td>
</tr>
<tr>
<td>3.5 (6)</td>
<td>This player has achieved improved stroke dependability with directional control on moderate shots, but still lacks depth and variety</td>
</tr>
<tr>
<td>4.0 (5)</td>
<td>This player has dependable strokes, including directional control and depth on both forehand and backhand shots, plus the ability to use lobs, overheads, approach shots and volleys with some success</td>
</tr>
<tr>
<td>4.5 (4)</td>
<td>This player has begun to master the use of power and spins and is beginning to handle pace, has sound footwork, can control depth of shots, and is beginning to vary game plan according to opponents</td>
</tr>
<tr>
<td>5.0 (3)</td>
<td>This player has good shot anticipation and frequently has outstanding shot or attribute around which a game may be structured</td>
</tr>
<tr>
<td>5.5 (2)</td>
<td>This player has developed power and consistency as a major weapon, and can vary strategies and styles of play in a competitive situation</td>
</tr>
<tr>
<td>6.0/7.0 (2,1)</td>
<td>National and World Class players</td>
</tr>
</tbody>
</table>

* These ratings were adopted from USTA (United States Tennis Association) description of NTRP ratings. The ITN number is indicated in brackets.
prevalence in recreational league tennis players as they relate to skill level.

The USTA hosts nationwide USA leagues for any amateur player 19 years of age or older. A National Tennis Rating Program (NTRP) rating is given either by a United States Professional Tennis Association (USPTA) teaching professional or a computer rating system that is based on previous performance. An NTRP rating can be converted into an International Tennis Number (ITN). Leagues include players with NTRP ratings of 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, (ITN 8, 7, 6, 5, 4, 3) and open divisions (>5.0) (ITN 2 and 1) (Table 1).

Players may play on multiple teams, singles and/or doubles, and in different divisions that are equal to or higher than their assigned rating. The 2002 Central Indiana Tennis Association (CITA) had 3808 registered players on 324 teams. Our goal was to administer a survey of injury histories, and capture a representative population from this sample. We compiled injury distributions as they pertained to skill level, age, gender, time played, injury type, injury locale, and injury-modifying equipment. We performed a rigorous statistical analysis to determine potential important relationships. Our intent was to identify injury distributions and trends in order to help incorporate more preventative measures for players, as well as to provide useful information for teaching professionals and sports medicine providers. This data could serve as a baseline for larger prospective studies in other settings and may be applicable to recreational players of most ages and skill levels.

Materials and Methods

We defined injury as 'any injury or pain the player had experienced in the past 12 months that had prevented them from playing for seven days or more’. Injury incidence was defined as 'the number of injuries per 1000 hours (athletic exposures)', while injury prevalence was defined as 'the number of injuries per 100 athletes'. The CITA hosted two mandatory captains meetings for all the registered teams before the beginning of the summer leagues. After obtaining approval for the study from the Methodist Hospital Institutional Review Board, a packet containing anonymous injury history surveys with instructions were given to 308 of 324 captains who were present at the pre-season meetings. To maintain anonymity, the captains were given the responsibility of distributing the surveys to team members at a practice or a team meeting. The completed surveys were collected over a 12-week period at the beginning of the season and mailed back in a postage-paid envelope, addressed to the principal investigator.

The survey included questions with regard to player demographics, tennis and injury histories. The anatomic locations of the injuries as well as injury type (overuse or traumatic) were also recorded. Lastly, in order to gain a better understanding about injury-modifying equipment, we obtained specific information about the use of vibration dampeners, tennis elbow straps, knee sleeves/braces, and wrist splints.

The age distributions were divided into cohorts by 10-year increments that were most consistent with the USTA age divisions. Gender and the number of players at each NTRP rating were recorded. The 4.5 and 5.0 NTRP ratings (ITN 4 and 3) were collapsed into one category because the groups were too small for statistical comparison. The average number of hours per week playing tennis was extrapolated to one year (52 weeks) so that incidence could be calculated for each NTRP level.

Statistical Analysis

Differences in incidence and prevalence of injury were evaluated using an independent sample t-test for two-group comparisons and a one-way ANOVA for multiple group comparisons. For example, the observed significance level reported for the incidence of injury by NTRP rating (five levels) was based on an ANOVA to determine if a relationship existed between incidence of injury and NTRP rating (skill level). Subsequent paired comparisons could then be made between two classes with potential significant differences. For example, the p-value for incidence of injury by gender was based on an independent sample t-test to determine if one group had higher incidence than by chance alone.

When analysing incidence (the number of injuries per 1000 hours played), the unit of analysis is important. Incidence calculated once for a group of players (i.e. the total injuries in one NTRP rating class divided by the total hours played) can be quite different from the average incidence values calculated separately for the individuals in the group. This study focused on the latter, where the individual player is the unit of analysis. In order to perform statistical tests of the difference in incidence between two groups (i.e.: male vs. female), the independent sample t-test must be based on the difference between average incidence of all individuals in each group.

Results

A total of 528 surveys (388 female, 140 male) were completed sufficiently for statistical evaluation. The average age of the players was 46.9 years of age. These demographics were representative of the total players who participated in all leagues.

Table 2 details the injury distributions within the study population categorised by gender, NTRP rating, age, hours played, and number of pieces of injury-modifying equipment. There were a total of 299 injuries, with an incidence of 3.04 injuries/1000 hrs played, and a prevalence of 52.9 injuries/100 players. Nine respondents did not specify their injury type and were excluded from this particular portion of the statistical analysis. One hundred and ninety-eight (66%) respondents reported overuse injuries and 92 (31%) reported traumatic injuries (p<0.0001). Approximately 43% of the respondents had upper extremity injuries and 41% had lower extremity injuries. The most common injuries were to the elbow and shoulder.

Firstly, injury incidence and prevalence was compared with NTRP rating. Despite trends seen in Figure 1, no statistical relationship was seen between incidence and prevalence of injuries and skill level determined by NTRP ratings (Table 4). Injury incidence and prevalence were then compared by NTRP level and by specific group. Within the following groups we found the NTRP level to make a difference: injury cause, injury location, injury-modifying equipment, and gender. The NTRP level compared with age and hours played was not significant (Table 4).

NTRP and Gender

No statistically significant differences were found specifically when males and females were compared (Table 2). Injury incidence and prevalence by NTRP rating and by gender were significant only for females. Females at the 4.5/5.0 level reported more injuries per 100 players (158.3 injuries).

NTRP and Equipment Use

There were significantly higher incidence and prevalence of injuries when players used more pieces of injury-modifying equipment (Table 2). A relationship existed between injury prevalence, those players using one piece of injury-modifying equipment and NTRP level (Table 4). The number of pieces of injury-modifying equipment used were significant for all players (p=0.0127) and for females (p=0.0088).

NTRP and Cause

When traumatic and overuse injuries were compared to NTRP ratings, a significant relationship was seen only for traumatic injuries in both injury incidence (p=0.0008) and prevalence (p<0.0001) (Table 4). Traumatic injury incidence and prevalence were the highest within the 4.5/5.0 NTRP ratings category when compared to the lower NTRP ratings (Table 2).
**Table 2** Demographics and Injury Rates

<table>
<thead>
<tr>
<th>SEX (N=528)</th>
<th>Number</th>
<th>Incidence</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>140 (26.5%)</td>
<td>3.75</td>
<td>61.4</td>
</tr>
<tr>
<td>Female</td>
<td>388 (73.5%)</td>
<td>2.78</td>
<td>49.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NTRP (N=529)</th>
<th>Number</th>
<th>Incidence</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>64 (12.1%)</td>
<td>3.16</td>
<td>47.6</td>
</tr>
<tr>
<td>3.0</td>
<td>216 (40.8%)</td>
<td>2.72</td>
<td>45.4</td>
</tr>
<tr>
<td>3.5</td>
<td>132 (25.0%)</td>
<td>3.04</td>
<td>55.5</td>
</tr>
<tr>
<td>4.0</td>
<td>71 (13.4%)</td>
<td>2.77</td>
<td>69.4</td>
</tr>
<tr>
<td>4.5/5.0</td>
<td>46 (8.7%)</td>
<td>4.89</td>
<td>89.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AGE (N=529)</th>
<th>Number</th>
<th>Incidence</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;45</td>
<td>207 (39.1%)</td>
<td>2.38 *</td>
<td>38.2 *</td>
</tr>
<tr>
<td>45-55</td>
<td>195 (36.9%)</td>
<td>3.79 *</td>
<td>60.0 *</td>
</tr>
<tr>
<td>&gt;55</td>
<td>127 (24.0%)</td>
<td>3.01 *</td>
<td>66.1 *</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IME (N=530)</th>
<th>Number</th>
<th>Incidence</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 pieces</td>
<td>226 (42.6%)</td>
<td>1.63 *</td>
<td>23.5 *</td>
</tr>
<tr>
<td>1 piece</td>
<td>196 (37.0%)</td>
<td>3.09 *</td>
<td>57.1 *</td>
</tr>
<tr>
<td>2-3 pieces</td>
<td>108 (20.4%)</td>
<td>5.88 *</td>
<td>106.5 *</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HOURS PLAYED (N=510)</th>
<th>Number</th>
<th>Incidence</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;200/hr (&lt;4 hr/wk)</td>
<td>191 (37.5%)</td>
<td>4.90</td>
<td>48.69</td>
</tr>
<tr>
<td>200-300/hr (4-6 hr/wk)</td>
<td>154 (30.2%)</td>
<td>2.58</td>
<td>58.44</td>
</tr>
<tr>
<td>&gt;300/hr (&gt;6 hr/wk)</td>
<td>165 (32.3%)</td>
<td>1.66</td>
<td>58.79</td>
</tr>
</tbody>
</table>

1) Pairwise comparisons made between groups by independent Sample t test (p <0.05).

**NTRP and Location**

As shown in Table 4, a significant relationship was seen between injury incidence and prevalence of lower extremity injuries and NTRP rating. Lower extremity injury incidence (3.08 inj/1000 hrs) and prevalence (44.9 inj/100 players) were the highest within the 4.5/5.0 NTRP ratings category.

**Discussion**

Consistent with anecdotal experiences as well as with published studies on recreational players, the most common injuries in our study were to the elbow, followed by the shoulder, knee, and back.2,12(Table 3) The study demonstrated that 54% of upper extremity injuries (0.11 inj/100hrs Weijer,17 0.5-1.2 inj/1000 hrs Winge18) were to the elbow, followed by the shoulder and knee (which were the two most common sites of injury in our population). As expected, the majority (66%) of overuse injuries was due to overuse and 75% of them were to the upper extremity. However, there were more overuse injuries than traumatic injuries at every skill level (Figure 1).

Von Kramer et al.16 sent a questionnaire to 126 recreational tennis players with an average age of 43. Seventy-nine percent indicated a previous injury. Forty-seven and a half percent of the injuries involved the upper extremity. We also noted significantly more overuse injuries in this older, recreational population. As expected, the majority (66%) of overuse injuries was due to overuse and 75% of the injuries were to the upper extremity. In fact, there were more overuse injuries than traumatic injuries at every skill level (Figure 1).

Kibler2 also found that the majority of tennis injuries were due to overload, particularly in recreational players. In our study, beginner as well as advanced players had a significant number of overuse injuries. Presumably this occurred due to one of two mechanisms: 1) isolation of upper body segments by breaking the kinetic chain (particularly in less skilled players) or 2) excess force generation. In the elite player, Kibler2 demonstrated that 54% of force generation on a serve originates from the legs/trunk, while only 21% was elicited from the shoulder, and 15% from the elbow. These numbers seem to be reversed in some recreational players whereby force is primarily generated through the shoulder and elbow (which were the two most common sites of injury in our population). Advanced players generally have appropriate technique, but still generate similar

**Table 3** Injury locations

<table>
<thead>
<tr>
<th>Location</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elbow</td>
<td>59 (20%)</td>
</tr>
<tr>
<td>Shoulder</td>
<td>46 (15%)</td>
</tr>
<tr>
<td>Knee</td>
<td>36 (12%)</td>
</tr>
<tr>
<td>Back</td>
<td>31 (10%)</td>
</tr>
<tr>
<td>Ankle</td>
<td>24 (8%)</td>
</tr>
<tr>
<td>Foot</td>
<td>23 (8%)</td>
</tr>
<tr>
<td>Wrist</td>
<td>11 (4%)</td>
</tr>
<tr>
<td>Calf/Achilles</td>
<td>16 (5%)</td>
</tr>
<tr>
<td>Thigh/Groin</td>
<td>16 (5%)</td>
</tr>
<tr>
<td>Lower Leg</td>
<td>4 (1%)</td>
</tr>
<tr>
<td>Other</td>
<td>8 (3%)</td>
</tr>
</tbody>
</table>
rates of overload injuries. Therefore, despite improved mechanics, repetitive, excessive force may be more of a factor in producing injury in advanced players, especially over time as they age.

Finally, a large number of injury-modifying equipment were used by our players. These included vibration dampeners, tennis elbow straps, wrist splints, and knee sleeves or braces. There was a relationship between the number of pieces of equipment used and injury rates. Players who used more pieces of injury-modifying equipment had a higher incidence and prevalence of injuries (Table 2). It is uncertain whether this equipment was meant to be a response to the occurrence of an injury, or for injury prophylaxis. Further studies of individual equipment either in the prevention of new injury or recurrence of previous injury may help to clarify these findings.

There were several limitations to our study. Firstly, our study was retrospective, therefore recall bias may have artificially lowered the number of injuries reported. However, we felt that our injury rates were already quite high despite our recall bias being 12 months. This potential inflation of injury rates may be due to the fact that injured players may have been more likely to complete the survey than non-injured players. Secondly, our response rate was low due to insufficient distribution of the questionnaire by the team captains and the difficulty in quantifying the number of players participating in multiple leagues. Nevertheless, we felt that our study group was a reasonable sample of the total population. Thirdly, with an older population consisting largely of females, comparisons to other studies primarily involving males or younger, elite players was more difficult. The lack of advanced players also created the need to combine the 4.5 and 5.0 NTRP (ITN 4 and 3) groups into one category, which made it difficult to achieve statistical significance in some instances. Finally, definitions used to describe overuse, traumatic, and injury location may have varied in interpretation between individuals.

Additional factors not evaluated by our questionnaire may have influenced results such as court surface, injuries during doubles or singles, indoor vs. outdoor injuries, and length of time lost from injury.

### Conclusion

This study describes incidence and prevalence of injuries incurred in recreational competition players of different NTRP ratings (ITN numbers) as they relate to various intrinsic and extrinsic factors. Despite trends, there were no statistical differences in overall injury incidence and prevalence rates across all skill levels. Additionally, injury rates appear to be independent of time played, age, and gender in these recreational league tennis players.

Advanced players sustained more traumatic as well as a greater number of lower extremity injuries than beginners. Despite this finding, overuse injuries did predominate at all levels in our study with the majority of these involving the upper extremity. In general, it seems that excessive or improper force generation, particularly in the older tennis player may increase the risk of injury in all levels of recreational players. Further larger scale and prospective studies on league tennis players over an entire season may acquire more exact injury data. Sports medicine professionals, teaching professionals, and tennis players may utilise this information and contemplate a more cautious or alternative progression to hitting harder shots, particularly for older players.

### References


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### Table 4 NTRP Differences for Subgroups

<table>
<thead>
<tr>
<th>Groups</th>
<th>Comparing rate of:</th>
<th>Incidence</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>NTRP Alone</td>
<td>all injuries</td>
<td>p=0.3956</td>
<td>p=0.0612</td>
</tr>
<tr>
<td>NTRP by Age Groups</td>
<td>all injuries</td>
<td>p=0.0602</td>
<td>p=0.0509</td>
</tr>
<tr>
<td>&lt;45</td>
<td>all injuries</td>
<td>p=0.6150</td>
<td>p=0.7959</td>
</tr>
<tr>
<td>45-55</td>
<td>all injuries</td>
<td>p=0.2117</td>
<td>p=0.4711</td>
</tr>
<tr>
<td>55&gt;</td>
<td>all injuries</td>
<td>p=0.0970</td>
<td>p=0.8976</td>
</tr>
<tr>
<td>NTRP by Gender</td>
<td>all injuries</td>
<td>p&lt;0.0001</td>
<td>p=0.0003</td>
</tr>
<tr>
<td>Male</td>
<td>all injuries</td>
<td>p=0.9462</td>
<td>p=0.7054</td>
</tr>
<tr>
<td>Female</td>
<td>all injuries</td>
<td>p=0.1387</td>
<td>p=0.0296</td>
</tr>
<tr>
<td>NTRP by Equipment Use</td>
<td>all injuries</td>
<td>p=0.2134</td>
<td>p=0.4111</td>
</tr>
<tr>
<td>No Equipment</td>
<td>all injuries</td>
<td>p=0.3194</td>
<td>p=0.5201</td>
</tr>
<tr>
<td>1 Piece of Equipment</td>
<td>all injuries</td>
<td>p=0.1037</td>
<td>p=0.1332</td>
</tr>
<tr>
<td>2 or 3 Pieces of Equipment</td>
<td>all injuries</td>
<td>p=0.8796</td>
<td>p=0.9015</td>
</tr>
<tr>
<td>NTRP and Cause</td>
<td>all injuries</td>
<td>p=0.7263</td>
<td>p=0.0687</td>
</tr>
<tr>
<td>Overuse</td>
<td>trauma injuries</td>
<td>p=0.0008</td>
<td>p&lt;0.0001</td>
</tr>
<tr>
<td>Trauma</td>
<td>trauma injuries</td>
<td>p=0.0008</td>
<td>p&lt;0.0001</td>
</tr>
<tr>
<td>NTRP and Location</td>
<td>Upper Extremity injuries</td>
<td>p=0.6733</td>
<td>p=0.4830</td>
</tr>
<tr>
<td>Lower Extremity</td>
<td>Lower Extremity injuries</td>
<td>p=0.0051</td>
<td>p=0.0008</td>
</tr>
<tr>
<td>Back</td>
<td>Back injuries</td>
<td>p=0.1269</td>
<td>p=0.2022</td>
</tr>
<tr>
<td>Other</td>
<td>Other injuries</td>
<td>p=0.8004</td>
<td>p=0.5490</td>
</tr>
</tbody>
</table>

*Statistically significant at p <0.05
Competitive wheelchair tennis players were surveyed to validate an injury questionnaire. Twenty-five competitive wheelchair tennis players were surveyed twice to validate the questionnaire while 108 players with varying levels of physical disabilities completed the survey at least once. The validated questionnaire is now being used to determine the injury pattern, incidence and prevalence for all skill levels of wheelchair tennis players through a subsequent study. Results will direct injury prevention research for wheelchair tennis players.

The purpose of this overall study is to determine the injury pattern, incidence and prevalence in wheelchair tennis players that will direct injury prevention research. The questionnaire was developed to help identify injury patterns in wheelchair tennis athletes and their possible relation to various training, wheelchair use, and disability classification variables. Wheelchair tennis players may be more vulnerable to injuries which require them to take time off from training and/or competition than able-bodied tennis players. Further, the frustration of injury, particularly prolonged, chronic or recurrent injury may result in participants giving up the game.

To establish a database of this information, first a pre-participation questionnaire was validated. Once validated, the questionnaire will be used to establish a wheelchair tennis player database and a baseline for future studies of interventions to prevent injury. Thus, it may help keep competitive and recreational wheelchair tennis players participating regularly and for a long period of time.

This report summarizes the validation process and the questions validated.

PROJECT TEAM

A core team of researchers participated in the development and analysis of this injury questionnaire. The project team included: Marc Safran, MD, principal investigator, orthopaedic surgeon and co-director of Sports Medicine at the University of California, San Francisco (UCSF); Kim Workman, MD, a resident in orthopaedic surgery at UCSF; Jani Macari Pallis, Ph.D. project administration and analysis; Fred Dorey, Ph.D., biostatistician from UCLA; and two members of the USTA wheelchair tennis committee (through 2002) responsible for sport science, Dan James, US wheelchair tennis head coach, World Team Cup and Paralympic coach and Randy Snow, elite wheelchair tennis player and coach.

QUESTIONNAIRE DEVELOPMENT

A wheelchair tennis player injury questionnaire was created with input from the entire team. Although based on a previously validated questionnaire used for junior tennis players developed by Dr. Safran, the survey was heavily modified to address the unique equipment, conditioning and medical conditions common to wheelchair tennis players.

Initial Survey

This initial questionnaire was mailed by post, along with a cover letter stating the general purpose and assurance of confidentiality, to a select group of competitive wheelchair tennis players from the United States.

Players were asked to complete the survey and return it in a pre-paid postage envelope. Once the player had completed and returned the questionnaire, a new blank copy of the same questionnaire was sent to the player accompanied by a letter stating the need for the second mailing to assure questionnaire answers were reproducible and its purpose for validation. The purpose of this phase was to identify additional questions needed, questions which needed clarification or general problems in the page layout of the questionnaire. The questionnaire was revised based on this initial mail survey.

Statistical Analysis

A statistician specializing in bio-statistics performed all the necessary statistical analyses to validate the reliability and reproducibility of the questionnaire. Based on statistical analysis, some questions in the questionnaire may be revised. This will allow the questionnaire to be applied on a larger basis to identify the prevalence of injury, and later the incidence of injury.

RESULTS

The majority of questions provided reproducible results and are discussed here. Based on the validated questions, results...
were summarized for all 108 players who completed the survey. These results are divided into demographics, playing history, training history, equipment, preventive measures and injury history.

Demographics: Gender, age, physical disability, neurological level of disability and division were tabulated. Of the 108 players participating in the study 92 were men and 16 were women.

Physical Disability: Results were tabulated by medical condition and summarized in Table 1.

Table 1 Medical Condition By Gender

<table>
<thead>
<tr>
<th>Medical Condition</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spinal Cord Injury</td>
<td>62</td>
<td>13</td>
</tr>
<tr>
<td>Spina Bifida</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Post-Polio Paralysis</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Spinal Cord Tumor</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Amputation</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Arthrogryposis</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Muscular Dystrophy</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>92</td>
<td>16</td>
</tr>
</tbody>
</table>

Playing History:
Years Of Tennis: Players were asked about their playing record: how long they had played tennis, wheelchair tennis and competed in wheelchair tennis.

Frequency of Play: Questions were asked regarding the number of weeks study participants played singles and doubles tennis in a year including time off for injuries or rest and vacation. Although participants were asked to total the weeks in a year to 52, this did not occur in many cases making reproducibility difficult. As described in the “Conclusions” section this is an area where an interactive computer based form could automatically total the weeks in a year for the player and not accept the answer until 52 weeks are appropriately accounted.

Court Type: Players were asked about court surfaces. A majority of the study participants played on hardcourts almost exclusively. There was almost no play on grass courts.

Training History:
Players were asked a series of questions regarding their training practice habits and length of time players spent conditioning.

• Do you stretch before practice?
• Do you stretch after practice?
• Do you stretch before matches?
• Do you stretch after matches?
• Do you weight train?
• Type of lifting: Free weights? Machines?
• Do you use an upper extremity ergometer or cycle (UBE) as part of your training?
• Do you distance train in your chair as part of your training?

• Do you do any wheelchair training (other than distance training as above)?
• Do you participate in other sports?

Answers on length of time (stretching, training) and for a question on other sports played were not consistent. A closed form of the question with specific answers to choose from will be considered.

Equipment:
Tennis Wheelchair: Players were asked questions regarding their tennis wheelchair and characteristics of their wheels, tires, seat slope and availability of an anti-tip tube. Player’s wheelchairs included the full range of models from all the major manufacturers. Understanding wheelchair characteristics is important; wheel camber in particular may affect stroke performance.

Tennis Racquets: Players were asked questions regarding characteristics of their racquets including racquet length and racquet head size. As with their tennis wheelchairs, player’s racquets covered a wide range of popular styles.

Preventive Measures:
Players were asked the questions regarding protection from the sun:

• Do you wear a hat when you play: Always/Sometimes/Rarely/Never
• Do you wear sunscreen when you play: Always/Sometimes/Rarely/Never
• Do you wear sunglasses when you play: Always/Sometimes/Rarely/Never

Injury History:
Players were asked questions about injuries and other medical conditions. These included:

• Have you ever had pain in the following body areas during or after playing tennis (circle all that apply): front of your shoulder, back of your shoulder, elbow, dominant wrist (hand you use for your forearm), non-dominant wrist, dominant hand, non-dominant hand, non-dominant hand, lower back, mid-level back, carpal tunnel syndrome, other.
• Have you ever had heat stress (including heat illness and heat stroke)?
• Have you ever had to stop play due to dehydration?
• Have you ever had high blood pressure (hypertension) related to playing tennis?
• Have you had decubitus ulcers?

Injuries players reported which required missing at least seven days of playing, competing or practicing tennis:
Players were asked to record injuries which required missing at least seven days of play, practice or competition. Fifty players out of 108 (46%) reported one or more injuries within these parameters. These 50 players incurred 77 injuries requiring at least 7 days of missed time.

Conclusions
A great deal was learned by the project team during the process of conducting the injury survey. Based on the validation results, the research team is converting the validated questionnaire to a secured online form. This will provide several benefits:

• legibility of the answers;
• provide easy access to players, especially international players;
• provide flexibility to the players;
• provide automated checking and completion of answers;
• support confidentiality;
• reduce manual paperwork;
• automate data entry;
• automate a portion of the analysis.

Due to their medical conditions some players were unable to write or write legibly. Consequently, this made it impossible to record some hand-written questionnaire answers into the computer database. Providing an online form can support the automation of data entry and alleviate legibility problems.

Some of the players participating in the study do not reside in the United States and many travel a great deal during the year competing. Access to a secure online form will provide the players easy access and flexibility in participating in the study.

The automated form can provide self-checking. For example, specific questions ask players to record percentages or weeks of play. Percentages must total to 100% and weeks in a year to 52, however in many cases this did not occur. The online form would also automatically check that all information on the form had been completed/submitted by the player.

Additional minor revisions will be made to the form to provide more closed questions. For example, players were asked to record in which division they play. On the hand-written form players wrote in numerous terms and spelling variations for the same identical division. The statistics software package of course had to be told that all these terms were identical. However, if the names of the divisions are in an online pull-down menu this will alleviate those problems.

Providing numerous choices made the survey longer for players. Pull down menus on an online form would make the questionnaire look shorter/smaller/less cluttered than the hand-written form.

Results from this initial questionnaire do show a trend toward upper body injuries. However, the validated questionnaire now needs to be distributed in the next phase of this project to additional wheelchair tennis players.

Acknowledgements: The authors wish to thank the United States Tennis Association, which supported this project through a Sport Science grant.
The subjective benefits of utilising recovery techniques have been known by players and coaches for years. The scientific benefits of utilising these techniques, however, are now also rapidly becoming evident. Recovery is a generic term used specifically with reference to the restoration of physiological systems and regeneration of psychological parameters that have been altered during activity.

Developing an effective post training and competition routine is very important as it helps players recover physically and psychologically. Recovery sessions therefore should always be incorporated into sports specific training programs. This approach to recovery and regeneration enhances athletic development and contributes to optimal performance.

Today’s tennis players have to be in great shape and recover well to be competitive on a consistent basis. As with elite athletes in most sports, they are exposed to a very demanding training and competition schedule. Under these circumstances, it is possible for players to be pushed beyond physiological and psychological norms which may result in decreased function.

Training causes micro-trauma to the body’s tissues leading to super compensation. Being smart about training and recovery means recognising non-adaptive responses to training and picking up early warning signs of overtraining.

All players are subjected to various forms of stress. These can include training, practice, travel, lifestyle, environmental and health stressors. Each player has a different ability to cope with each stressor: one may cope with training stresses easily but nutritional stress poorly, another the opposite. Heavy training should not be undertaken until a player is fully recovered. Adequate time should be allowed for recovery, and training should be modified to optimise, taper and peak, if a player is preparing for an important tournament. Here are some practical tips to help players recover quickly and stay ‘Fit to Play’.

1 Re-Hydrate
Drink plenty of water or clear fluid. Try clear juice or sports drinks diluted with water, the minimum is ½ - 1 litre per hour during training. The goal is to have light coloured urine. The harder, higher and hotter conditions you train or play in, the more you need to drink. Pre-hydration and immediate re-hydration are key. Losing as little as 2% of body weight through sweat can impair your ability to perform due to low blood volume and less than optimal utilisation of nutrients and oxygen. Also, younger players may need to be more vigilant about hydration strategies as dehydration seems to be more detrimental to children than to adults.

2 Re-Fuel
Ensure that you consume appropriate nutrition (carbohydrate fuel) post-training. You need adequate supplies of glycogen in the muscles and the liver to support your energy requirements and promote recovery for the next training session. Dietary carbohydrate is the primary source for the body to manufacture glucose. Since glycogen stores take 24-48 hours to replenish, you must replace these stores daily.

3 Re-Align the Body
As part of your recovery training, make sure you do activities that exercise the body equally on both sides. Most training and sports like tennis are asymmetrical in nature and can torque your body’s muscle and fascial systems leading to an imbalance in the length and strength of muscles and tendons. The types of postures that result from competitive tennis (in particular flexion) further adds to this imbalance. While upper body development is asymmetrical in tennis, the development of strength and flexibility in the legs and lower torso is symmetrical. Therefore

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**ABOUT THE AUTHOR**

Carl Petersen, B.P.E., B.Sc. (PT), is a physical trainer and is a partner and Director of High Performance Training at City Sports & Physiotherapy Clinics. He and former WTA Pro, Nina Nittinger, have recently co-authored a new training book titled: ‘Fit to Play: Practical Tips to Optimise Training & Performance’. www.fittoplay.com

Eat as soon as you can after training or competition. There is a window of opportunity within the first 20 minutes after strenuous exercise, to replenish muscle fuel stores at a faster rate than if carbohydrate intake is delayed for longer. Small amounts of protein taken with carbohydrates before, during and after strenuous training, help minimise muscle protein breakdown as a result of heavy workloads. You should consume between 1.2 and 1.5 g/kg body weight of simple carbohydrates as soon as possible after exercise.

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**COACHES CORNER**

Fit to Play
Practical Tips for Faster Recovery

Carl Petersen
equal training to both sides of the body is necessary for optimum court mobility and to reduce injury risk.1,2

4 Recovery Workouts
Make sure recovery techniques become habitual and part of your daily routine.3 Studies suggest that light aerobic exercise following anaerobic training (e.g. sprint) might facilitate recovery of force or speed/power by increasing lactic acid removal, thus possibly helping restore normal calcium levels within muscle fibres.13

Try the following routine ‘spin only’ light resistance cycle at 85-90 RPM (revolutions per minute) and a heart rate of 100-115 beats per minute for 15-20 minutes. At higher pedalling rates there is a greater recruitment of slow-twitch fibres. Since slow-twitch fibres are more resistant to fatigue, a higher pedalling rate will prove advantageous and is less likely to cause premature fatigue.8 Try other types of activities such as pool running or walking in the absence of a bike.

5 Regain and Maintain Muscle Length
With the advice of a physical trainer or physiotherapist, try to establish a regular stretching routine to aid recovery and prevent injury.15 Performing static and facilitated stretches optimises muscle and tendon length prior to training. If possible, find a training partner to help you stretch. ‘Hold, relax’ and ‘contract, relax’ PNF (proprioceptive neuromuscular facilitation) techniques have been shown to be more effective than just static stretching.7,10 PNF techniques can also be an effective means of post exercise relaxation11 as you can lie down while being stretched passively.

Static stretching, however, as part of your recovery routine, can also help to prevent injury. Research suggests that static stretching prior to exercise does not prevent lower extremity overuse injuries, but additional static stretching after training and before bed can result in 50% fewer injuries occurring.3

Assess the state of tension in other muscle groups on a daily basis and if necessary add new stretches to your routine. This will ensure that a good length-tension balance is maintained in all muscle groups responsible for on-court performance.

Conclusion
Training and competition fatigue experienced by players is a necessary part of the adaptive training process. The challenge for most coaches and players is to identify which specific capacities are fatigued and then select appropriate recovery strategies to restore the player to a normal functioning state. Training for and playing tennis are both physically and mentally demanding, and recovery sessions must be incorporated into tennis-specific training programs. Coaches and players alike need to be more aware of the importance of restoration and regeneration following heavy workloads and how best to use the equipment, facilities and activities available to facilitate recovery.

References
The Sport Science and Medicine Commission (SSMC) is one of 17 International Tennis Federation (ITF) committees and commissions. Comprised of experts (which defines it as a ‘Commission’ rather than a ‘Committee’), the SSMC meets twice yearly to discuss issues relevant to its remit in the areas of sport science and medicine. The SSMC has recently become part of the ITF Development Department, under the Directorship of Dave Miley.

Membership
Dr. Stuart Miller, the ITF Technical Manager, oversees the membership, management and administration of the SSMC. Janet Page is administrator for the SSMC and the ITF Technical Department. Dr Brian Hainline, Chief Medical Officer of the US Open Tennis Championships, is the SSMC Chair. The Commission membership for 2004-5 is as follows:

Chair: Brian Hainline (USA)  
Member: Javier Maquirrain (Argentina)  
Member: Babette Pluim (Netherlands)  
Member: Karl Weber (Germany)  
Member: Tim Wood (Australia)  

ATP representative: Per Renström (Sweden)  
WTA representative: Kathleen Stroia (USA)  

A brief (recent) history of the (S)(S)MC
The SSMC has its (recent) origins in the ITF Medical Commission, the main remit of which was anti-doping. To recognise the increased time being consumed by anti-doping, an Anti-Doping Sub-Commission (Anti-Doping Working Group) was formed in 1995. Even so, much of the Medical Commission’s subsequent activities were still focused in this area. When WADA took over the administration of the Tennis Anti-Doping Program in 2000, the Medical Commission changed its name to the Sports Medical Commission, which recognised and formalised its new (broader) remit, which included sport science and sports medicine. In 2004, a name change to Sport Science and Medicine Commission was approved by the ITF Board of Directors, giving full recognition to the importance of the sport sciences. Some key activities and achievements are given below:

1987: Researched a list of prohibited drugs and the relationship between hormone imbalance and burnout.
1988: List of prohibited drugs produced and collated research on hormone imbalance.
1989: Staged a Drug and Health seminar.
1990: Conducted first drug testing at a Grand Slam event. Produced a booklet on play in extreme heat.
1991: Established database of players’ ages to help prevent burnout.
1992: 2 ITF Medical Commission members join ATP and WTA medical review panels.
1994: Consensus agreement for worldwide anti-doping programme for tennis. First drug testing at Davis Cup final.
1995: Considered cardiac arrest and standard of medical care at tournaments. Anti-Doping sub-commission formed.
1996: Studied use and effects of intramuscular injections, playing at altitude and heat exhaustion.
1997: Tracked player injuries.
1998: Contributed to World Conference on Doping in Sport (WCDS) debate on proposal of mandatory 2-year suspension for a Class I offence.
2001: Participated in Anti-Doping Education Project for junior players.
2002: Began the investigation of injury tracking software.

Remit
The remit of the SSMC includes biomechanics, physiology, psychology, nutrition, motor learning and sport medicine. The Commission intends to establish itself in these areas, which it will accomplish through a variety of means, including the effective dissemination of information (primarily through its web site), but also through other sources such as publications, presentations at conferences and original research.

Mission statement
To focus its activities and provide a sense of direction, the SSMC has adopted the following mission statement:

To analyse, develop and disseminate tennis information relevant to sport science and medicine worldwide in order to maximise healthy participation in tennis, to reduce injury risk and to facilitate optimal performance.

Projects
The SSMC’s key research project is the Injury Registration Project, the aim of which is to produce and/or identify a software package that will unify the recording, storage and analysis of health and injury information for tennis players. The SSMC has committed a substantial portion of its budget to the project, which has the support of ITF Juniors, ITF Circuits, the ATP and WTA. The SSMC is also supporting projects in heat stress, player perception of surface pace and upper limb loading during the serve.

In gathering such a distinguished and active group, the ITF is confident that the SSMC can make its mark on the world of tennis sport science and medicine. The SSMC is proud of its ongoing relationship of mutual support with the STMS, and hopes to strengthen the links between the two groups during 2005 and beyond.

Dr Stuart Miller
CURRENT REVIEW OF THE LITERATURE

Strengthening your Game

MACHAR REID AND MIGUEL CRESPO

Strength training for improved tennis performance is nothing new. Tales of players from the 60’s and 70’s swinging racquets without racquet covers on, or performing bodyweight exercises are entrenched in the game’s folklore. This is not to say however, that strength training has not evolved in the ensuing decades... it has! It has become more sophisticated, more player-centred and for the most part, better understood. The empirical work of physicians, trainers and coaches has largely contributed to this advance, while research has played a similarly central role.

A bit like forehand drop shots where some are better than others, certain studies also have more application to the game than others. By critically reviewing study protocol and findings, practitioners can keep abreast of recent training developments, and simultaneously assess whether or not the information may be of value to their work. In the commentary to follow, we will adopt this approach in reviewing two studies that have investigated the link between strength training and tennis performance.

TREIBER FA, LOTT J, DUNCAN J, SLAENES G, DAVIS H.

The prescription of theraband and lightweight dumbbell exercise is common to the strength training programs of many professional tennis players. Yet, the study of Treiber and co. ranks as a first effort to quantify the merits of recent training developments, and simultaneously review the information that may be of value to their work. In the commentary to follow, we will adopt this approach in reviewing two studies that have investigated the link between strength training and tennis performance.

KRAEMER WJ, RATAMESS N, FRY AC, TRIPIETT-MCIBRIDE T, KOZIRIS LP, BAUER JA, CIAMPI GO, THOMAS DB.

The value of periodizing training programs is anecdotally well accepted. Limited research exists however, to authenticate its perceived worth. Logistically difficult to administer and notorious for complications with study design and methodology, these investigative efforts are only now beginning to increase in number. Indeed, Kraemer and co.’s look at the effect of resistance training and volume on female tennis players is a significant and performance is among the first of its kind in tennis.

By randomly placing 24 collegiate female players into one of three training groups – no resistance (C), periodised multiple-set (MS) or single-set circuit (SS) – the researchers were able to compare the impact of the different exercise protocols on body composition and functional performance. Over the 9 month training period, the SS group performed 8-10 repetitions of all exercises, while the MS group rotated workouts comprising of 2-4 sets of 4-6 (heavy resistance), 8-10 (moderate resistance) and 12-15 (light resistance) repetitions per exercise. Sessions were completed around match schedules 2-3 times per week (100 workouts in total), and post-tests were undertaken after 4, 6, and 9 months. Analysis of the results almost emphatically endorses high-volume MS protocol for the development of a tennis player’s physical abilities. When compared to the players who completed the low-volume SS protocol, MS-trained players lost more body fat and produced superior increases in muscular strength and power, lean body mass, and serving velocity throughout the 9 month training block. Upon closer inspection however, it would be

remiss not to acknowledge the potential significance of the variation in exercise/movement speed between protocols. That is, with MS training performed at high-speed, and the SS protocol executed at slower, more controlled velocities, this likely accounted for much of the difference observed in the power performance measures. So too, does it bring into question subsequent suggestions that a threshold of volume is needed to elicit performance change. That no reference was made to the strength training history of the sample also confounds the interpretation of results to some extent. Nonetheless, other findings of interest from an exercise prescription perspective include:

• Both groups increased muscular strength during the first 4 months of training, but only MS-trained players improved significantly beyond that. This suggests that program differentiation may take longer than a few months in this population and/or rapid neuromuscular change may be expected in response to almost any overload.

• Fat-free mass increased significantly at 4, 6, and 9 months for MS-trained players, but no changes were observed for the SS group. The acute increase in growth hormone associated with high-volume resistance exercise was proposed as one possible explanation for this change to body composition.

Conclusion
Training for improved performance is common to most sports disciplines. In tennis, traditional on-court practices have been complemented by off-court conditioning techniques for many years. With the advent of enhanced equipment design, improved facility integration, and more expansive research, players are better positioned than ever to take advantage of this supplementary off-court work. To do so optimally however, exercise selection and the periodisation of the programs to which these exercises belong, are among the areas of research interest that demand regular and critical evaluation.

ABOUT THE AUTHORS
Machar Reid was the Assistant Research Officer for the International Tennis Federation from 2000-2004. During this time, he also filled the role of strength and conditioning coach of Greg Rusedski. In Australia, Machar completed under- and post-graduate studies in Human Movement, and worked for the AIS Tennis program. He is a regular presenter at workshops and is currently completing his Ph.D. in Biomechanics at the University of Western Australia.

Miguel Crespo is the Research Officer for the Tennis Development Department of the International Tennis Federation (ITF) and is responsible for the ITF Coaches Education Programme. Miguel holds a Ph.D. in Sports Psychology and a B.A. in Philology. He is former Director of the National Coaching School for the Royal Spanish Tennis Federation. Between 1984 and 1989 Miguel was travelling coach and captain of Spanish National Junior Teams. Miguel has taught coaches at all levels and has written articles and books for coaches, players and officials of the game.
From the Membership Office

I feel like it was only last week that I was writing this for the December issue and now here we are at April already. Where has the time gone? It was great to catch up with so many of you at the World Congress. It was a pity I didn’t get to spend more time meeting and speaking to everyone, but I’m sure there will be many more opportunities. I will keep this short as we have a number of news items and don’t forget, you can always send your contribution of news and/or information to the Membership Officer on membership@stms.nl. I always look forward to your contributions!

Alan Pearce PhD
Membership Officer

Welcome
New Members

Dr Kenneth Andersen
Dr Thierry Bonnabesse
Mr Glenn Busby
Dr James Bragman
Dr Rudolfo Cepero
Ms Elizabeth Chaffin
Dr George Charuk
Dr Robert Cowan
Dr David Doward
Mr Mark Edney
Dr John Gayner
Dr Asghar Husain
Dr Vance Johnson
Ms Daria Kopsic
Mr Mark Kovacs
Dr Steve Lim
Dr Lorenzo Masci
Dr John McShane
Dr Rhonda Meier
Dr Ulf Michaelis
Dr Ignacio Muñoz
Dr Tom R. Norris
Dr Keith Overland
Dr Jacques Parier
Dr Scott Riewald
Dr Steven Rokito
Mr Lindsay Trigar
Dr Albert Volk
Dr Peter Wind
Dr Jerett Zipin
Dr Wart van Zoest

STMS Review – Update

Julia Phillips M Spt Mgt

Phase one of the STMS review has been completed with questionnaires being completed and returned by members and stakeholders. I would like to thank those who took the time to fill out the questionnaires as the feedback has been very useful.

Phase two of the review is now underway with an in depth interview of selected individuals being completed at the recent World Congress in Palm Springs and also a SWOT (Strengths/Weaknesses/Opportunities/Threats) analysis workshop being completed during the STMS AGM meeting. I would like to thank Bill Durney for facilitating this workshop in my absence.

Further updates will be presented in upcoming Membership Pages issues with the final report to be published in Medicine and Science in Tennis.

Award presented to STMS member
Dr Javier Maquirriain

Congratulations to STMS member Dr Javier Maquirriain on winning the Annual Award of Surgery from the Buenos Aires College of Physicians. The jury consisted of members from the Buenos Aires University.

Along with the prestige of winning the prize, Javier was awarded a certificate and $1000. The award presentation was made on 21 December 2004.

Well done Javier!

Javier (centre) with Members of the Board (Dr. Carlos Quinn, left and Dr. Rubin Tucci, right)
1ST ANNOUNCEMENT
‘Closed Meeting’: The Shoulder
Rotator Cuff Lesions: Surgical and Rehabilitative Treatment

Moderators and Speakers
The Congress announces the presence of international and national speakers:
Wesley M. Nottage, M.D., University of California, Irvine (USA);
Todd S. Ellenbecker, Physiotherapy Associates, Scottsdale Sports Clinic, Scottsdale, AZ (USA);
Per Bastholt, Michal Novotny, ATP Trainers; Robin Cromwell, Timothy L. Uhl, Lexington Clinic Sports Medicine Center, Lexington, KY (USA).

Objectives
The course intends to offer participants a day of intensive theory and practice on the innovative techniques for the clinical analysis, diagnosis, and functional recovery of the shoulder joint following ‘arthroscopic rotator cuff repair’.

Targeted participants
This is a ‘dedicated specialist’ update, which takes place over one day. The morning session is basic-science oriented, and addresses all participants; the afternoon session is ‘dedicated’ and has a theory-practice set-up with real-life surgery and live rehabilitation examples. The meeting targets physicians and paramedics who are involved directly or indirectly in the diagnosis and treatment of one of the most frequent shoulder pathologies: the rotator cuff lesion. Our experience has led to an effort that attempts to co-ordinate and optimise the relationship between orthopaedic surgeons, physiatrists, sports physicians, general practitioners, anaesthesiologists, radiologists, rehabilitation specialists, professional nurses, osteopaths, and chiropractors.

Dates
The dates are: 21, 3, 16 and 17 April. The course will be repeated in September, October, and November, on dates yet to be decided.

Registration Fee
110 Euro + VAT

Scientific Secretariat
Chairman: Dr Giovanni Di Giacomo
Dr Alberto Constantini
Rehabilitation Therapist Piergiorgio Luciani

Organisational Secretariat
Dr Andrea de Vita
Rehabilitation Therapist Alessandro Danieli

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ANNOUNCEMENT


The I.C.O.R.E.T. is pleased to announce a special award for young researchers of orthopaedics, biomechanics/biology, operative techniques, and sports – the Y-ROBOTS Award. Manuscripts in the areas of orthopaedic biomechanics, orthopaedic biology, operative techniques in orthopaedics or sports medicine are being accepted for consideration of this outstanding research award.

The first author must be less than 40 years or within no more than 8 years after his/her last academic degree (Ph.D. or M.D.) at the time of submission.

All applications will be reviewed and up to 10 finalists will be selected and invited for presentation at the 9th International Conference on Orthopaedics, Biomechanics, Sports Rehabilitation in Assisi Perugia, Italy, between 11-13 November 2005.

The winner of the Y-ROBOTS Award will be selected following the presentations by the finalists.

The Members of the Award Committee are:

Chair: Savio L-Y. Woo, Ph.D.
Members: Giuliano Cerulli, M.D.,
         Mario LaMontagne, Ph.D.,
         Ejnar Eriksson, M.D., Ph.D.,
         Ronny Lorentzon, M.D.

The award consists of:
- 5,000,00 Euro
- Award Certificate
- Consideration for Publication in Knee Surgery, Sports Traumatology, Arthroscopy after the peer review process

The deadline for receipt of manuscripts will be October 1, 2005.

Six (6) copies of the completed application and manuscript should be submitted to:

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c/o Let People Move
Via G.G. Pontani, 9
06128 Perugia
Italy
Phone: +39-075-500-3956
Fax: +39-075-500-0921
Email: letpeoplemove@tin.it
Website: www.letpeoplemove.com

Note:
Submissions, including papers, photographs, illustrations, etc. submitted will not be returned unless a self-address stamped envelope is included.

Members of the research groups of the Award Committee are not eligible.

Honorary Life Membership awarded to Professor Savio L-Y Woo

Professor Savio Lau-Yen Woo, Ph.D. recently ended his tenure on the Board of Directors of STMS. Savio is considered one of America’s leading Bioengineers, being W.K. Whiteford Professor of Bioengineering at the University of Pittsburgh, where he established the world renowned biomechanical research laboratories and pioneered the application of engineering science in understanding the causes and healing mechanisms of ligamentous injuries. His development and application of robotic/universal force-moment sensor testing system has revolutionized the study of ligament and soft tissue injuries.

Savio was one of the early supporters of STMS and has brought his extensive scientific expertise to our understanding of the musculoskeletal aspects of tennis medicine and science.

At the most recent STMS meeting in Indian Wells, Savio presented his latest area of study using antisense gene therapy to guide and enhance ligament healing. Savio’s prestige, guidance and support have helped STMS develop into an internationally recognized tennis related medical and scientific organization. In addition to being an avid tennis player, his leadership and council has greatly contributed to the growth of STMS as a resource for validated clinical and scientific information.

For his services to the Society and continued work in tennis medicine and science, Savio was awarded our Honorary Life Membership at the recent World Congress in Tennis Medicine and Science dinner. STMS looks forward to continue to benefit from Savio’s knowledge, leadership and guidance.

The Journal Medicine and Science in Tennis is endorsed by: