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medicine and science in tennis

number 2

How the tennis scoreboard affects player performance

Tristan Barnett and Rod Cross

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Journal of the STMS in co-operation with: the ITF | the ATP | the Sony Ericsson WTA Tour

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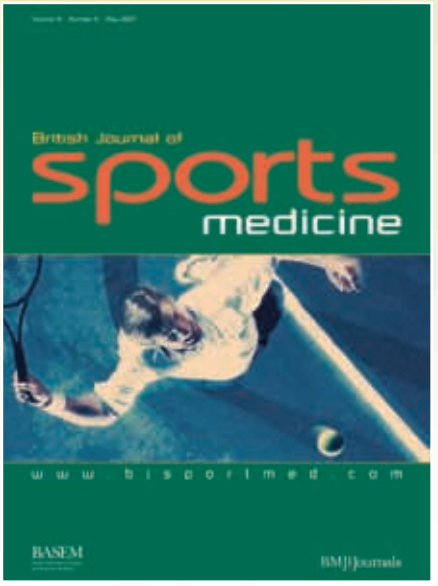
The November 2007 issue of the British Journal of Sports Medicine (BJSM) will be dedicated to tennis science and medicine. This issue will be FREE to members of the STMS, as is access to the online version via the STMS website.

Including contributions from members of the STMS, the ITF Sport Science and Medicine Commission, the ATP and the Sony Ericsson WTA Tour; this edition promises to be a must read.



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- Lateral epicondylitis in tennis: update on aetiology, biomechanics and treatment *Thomas De Smedt, Andy de Jong, Lieven Dossche, Wim van Leemput, and Francis Van Glabbeek*
- MRI findings in the lumbar spine of asymptomatic adolescent elite tennis players *Faisal Alyas, Michael Turner, and David Connell*
- Shoulder joint kinetics of the elite wheelchair tennis serve *Machar Reid, Bruce Elliott, and Jacque Alderson*
- Pre- and post-impact muscle activation in the tennis volley: effects of ball speed, ball size, and side of the body *John W Chow, Duane V Knudson, Mark D Tillman, and Damon P S Andrew*
- Short term effects of light and heavy load interventions on service velocity and precision in elite young tennis players *Alexander Ferrauti and Kenneth Bastians*

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Editorial office
PO Box 302
6800 AH Arnhem
The Netherlands
Phone: +31-26-4834440
Fax: +31-26-4834439
E-mail: editor@stms.nl

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Message from the President

2007 has been a year of change for the STMS with many exciting things happening for the society, boding well for our future. 2007 has seen the rotation of the board. Babette Pluims great stewardship has carried us well and set the stage for more growth. She will continue as Editor-in-Chief for Medicine and Science in Tennis. This edition is a tribute to her hard work, as she has been able to solicit some excellent articles that are included in this edition while working on another project of scientific articles, noted below. The STMS website has undergone some exciting changes that include a new look, news items and past issues of our journal Medicine and Science in Tennis. Ben Kibler and Peter Jokl, founding members of the STMS, have included the history of our society from its inception to current state. All this allows us to continue with our mission, to be a forum for the sharing of knowledge of medicine and science as it relates to tennis by allowing a permanent, accessible record of the information to our members.

Along this theme of disseminating tennis-related research and current thoughts, Babette Pluim and Mike Turner have recently served as guest editors of a second tennis-specific edition of the British Journal of Sports Medicine, to be published in November. A copy of this exciting publication will be available to each fully paid up member of STMS. It will be double the normal size! There will be more than 20 articles included, with additional articles available in the on-line edition of the journal. The international group of authors, many of whom are STMS members, have made significant contributions to the journal and our mission.

A new board has rotated in place and we have met via conference call a few times already this year. Our new Vice President is Javier Maquirriain from Buenos Aires. Our Treasurer is Bill Durney, A.T.C., M.B.A., of San Francisco, who formerly coordinated the medical care for the Indian Wells tournament for many years. Todd Ellenbecker, P.T., of Scottsdale, Arizona, the Chairman of the Sports Science Committee of the USTA, is our new Membership Chairman, and Neeru Jayanthi, M.D. of Chicago, Illinois, is our new Education Committee Chairman. Other board members include our Past-Presidents, W. Benjamin Kibler, of Lexington Kentucky, our first president, Per Renström of Stockholm, Sweden, our second president, and Babette Pluim, of Ede, Netherlands, our most recent Past-President. Additional board members are Peter Jokl of New Haven, Connecticut, and Bernard Montalvan, of Paris, France. There are several new ideas on the table for our society that have come from our board conference calls, that will be brought before the society for a vote during the next meeting, to be held in Tokyo, Japan, October 2-4, 2008.

Upcoming tennis meetings include the ATP tournament physicians conference in December 7- 9, 2007 at the Sawgrass Marriott in Ponte Vedra. Depending on the number of STMS board members present, we may have a small board meeting there. The next international meeting of the STMS will take place in Tokyo, Japan, during the AIG Tennis Tournament, October 2-4, 2008. This meeting will be hosted by Moroe Beppu. Stay tuned for more details and please visit our new upgraded website for information about this meeting. It will be an outstanding meeting and a great venue with an opportunity to watch excellent tennis.

I would encourage you to visit our website for the newest information about tennis medicine, our future meetings and other latest tennis medicine information.

Hope to see you in Ponte Vedra and Tokyo!!!

Marc Safran, M.D.
President

2007 ATP Tournament Physicians Conference

7 - 8 December 2007

Sawgrass Marriott Resort and Spa

Ponte Vedra Beach, Florida, USA

Dear Colleagues and Friends,

The 2007 ATP Tournament Physicians Conference will take place in Ponte Vedra Beach, Florida, home of the ATP's U.S. headquarters, on December 7th-8th.

This interactive meeting will include the latest information in tennis medicine and important updates for tournament physicians. A social program will include a dinner reception and golf and tennis outings at the beautiful facilities in the area.

All ATP Tournament Physicians are encouraged to attend. Please save the dates on your calendar. For more information on the conference program, travel and accommodations or to reserve your space*, please contact Bill Norris (bnorris@atptennis.com) or Erika Kegler (ekegler@atptennis.com).

We look forward to seeing you in Ponte Vedra Beach in December.

ATP Medical Services Committee

David Dines, M.D.
Per Renstrom, M.D., Ph.D.
Gary Windler, M.D.
Bill Norris, SMT, Medical Services Administrator
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* Reservations must be made no later than October 31, 2007

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number 2

How the tennis scoreboard affects player performance

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Further>

How the tennis scoreboard

Tristan Barnett and Rod Cross

Pollard et al.[1] analysed men's Grand Slam set scores over a ten-year period and found that the scores depend to some extent on progress during a match. They fitted a model to account for this dependency in the data and concluded the following. The better player lifts his probability of winning a set in certain situations. These situations are:

1. The player is behind in the set score, needs to lift his game, and lifts his probability of winning the next set by (on average) 0.035;
2. The player has just won a set, is 'on-a-run', and lifts his probability of winning the next set by (on average) 0.035;
3. The player has just lost two sets in a row, desperately needs to lift his game, and lifts his probability of winning each remaining set by (on average) 0.110, a substantial amount.

In this article, the above results are used to determine what proportion of a match win can be attributed to a player's ability (by assuming no memory of the scoreboard) and what proportion of a match win can be attributed to the psychological affects when a scoreboard is present. Further analysis is carried out to determine how the percentages of points won on serve vary as the match progresses from set to set. These results could be used in the training and coaching of players.

"If coaches were aware of the psychological affects, then they could use this information in their coaching"

Match winning percentages

Suppose two players, player A and player B meet in a tennis match. Player A (the better player) is predicted to win 68% of points on serve in the first set and player B is predicted to win 60% of points on serve in the first set. By assuming independence of both players winning points on serve in the first set, player A has a 87.5% chance of winning a game on serve, and player B has a 73.6% chance of winning a game on serve.[2] These percentages equate to player A having a 74.7% chance of winning the first tiebreak set. This percentage of 74.7% is comparable with the predictive modelling obtained in Pollard et al.[1]

affects player performance

If the percentage of points won on serve were independent for the entire match, then player A would have a 89.3% chance of winning a best-of-5 set tiebreak match. However, it has been noted from above that the better player lifts his probability of winning a set in certain situations, both when ahead or behind in the match score. As a result of this dependency (in matches where the player takes notice of the scoreboard) player A now has a 93.2% chance of winning the match.

The current rankings may be used by players to recognise the better player prior to the start of a match. As a result of the scoreboard being present, player A has increased his chances of winning the match by 93.2 - 89.3 = 3.9%. If we were to interpret this increase in probability of winning the match as a result of psychological affects when the scoreboard is present, then 0.893 / 0.932 = 95.8% of the match is attributed to the players' ability, whilst 4.2% of the match is attributed to psychological affects.

Serving percentages

Tables 1, 2 and 3 represent the total number of games won in men's singles from 1995-2004 conditioned by the number of sets played. Games (W) and Games (L) represent the total number of games won by winners and losers respectively. S1 represents the first set, S2 represents the second set and so on for each set being played.

From Table 1, there is a decrease in the number of games from the first to the third set for the winner, due to more tiebreaker games being played in the first set than in the second or third sets. There is a decrease in the number of games from the first to the third set for the loser. This implies that there is a decrease in probability of winning points on serve for the loser of the match, as the match progresses from the first to last set. From the results presented in the introduction, this suggests a decrease in probability of winning points on serve for the weaker player of the match, as the match progresses from the first to the third set.

From Table 2, there is an increase in the number of games from the first to the second set for the winner and a decrease in the number of games from the first to the second set for the loser. Pollard et al.[1] show that in a 4-set match the winner is most likely to lose the first set. This suggests an increase in probability of winning points on serve for the winner of the match, as the match progresses from the first to the second set, given that the winner lost the first set. From the results presented in the introduction, this suggests an increase in probability of winning points on serve for the better player of the match, as the match progresses from the first to the second set, given that the better player lost the first set. The data represented in Table 3 gives similar conclusions.

The following is now concluded: If the better player wins a set, then the increase in probability of the better player winning the next set is likely to be from a decrease in probability of winning points on serve for the weaker player. If the better player loses a set and is either behind in the scoreboard or has just lost two sets in a row, then the increase in probability of the better player winning the next set is likely to be from both a decrease in probability of winning points on serve for the weaker player and an increase in probability of winning points on serve for the better player.

About the authors

Dr. Tristan Barnett was awarded a Ph.D. from Swinburne University for mathematical modelling of tennis in 2006. He has written several published papers, given presentations at international conferences and was awarded the Denise Lievesley student award to attend the 55th Session of the International Statistical Institute. He has appeared on many occasions in the media including SEN sports radio and 3RRR sports segment "Run Like You Stole Something".

Professor Rod Cross works in the physics Department at Sydney University, where his main research interest is the physics of tennis. He has written two books on the subject with co-authors Professor Howard Brody and Crawford Lindsay, called *The Physics and Technology of Tennis and Technical Tennis*. He discovered, by looking at pre and post 1980 Grand Slam statistics, that the two main causes of tennis injuries are modern racquets and modern tennis courts.

Address for correspondence:
Dr. Tristan Barnett
Swinburne University of Technology
strategicgames@hotmail.com
www.strategicgames.com.au

Table 1 Total number of games won in 2,330 3-set matches

	S1	S2	S3
Games (W)	14,563	14,444	14,418
Games (L)	7,917	7,657	7,303
Ratio = W / L	1.839	1.886	1.974

Table 2 Total number of games won in 1,599 4-set matches

	S1	S2	S3	S4
Games (W)	8,521	8,785	8,738	9,960
Games (L)	7,260	6,985	6,900	5,385
Ratio = W / L	1.174	1.258	1.266	1.850

Table 3 Total number of games won in 954 5-set matches

	S1	S2	S3	S4	S5
Games (W)	4,812	4,583	4,744	4,898	6,312
Games (L)	4,790	4,783	4,808	4,494	3,541
Ratio = W / L	1.005	0.958	0.987	1.090	1.783

Discussion

Another way of interpreting the results presented above, is that the weaker player does not have a strong belief that he can beat the better player. When the better player is ahead on the scoreboard, the better player gains momentum for the remaining sets. This momentum may contribute to the fact that the weaker player has lost confidence in being able to win the match and is simply going through the motions rather than fighting for every point. When the better player is behind on the scoreboard, the better player has the back-to-the wall effect. This effect may contribute to the fact that the weaker player does not believe that he can beat the better player, and is unable to close out the match. If players and coaches were aware of these psychological affects, then coaches could use this information in their coaching routines.

Conclusion

As a result of dependency in the data, it has been shown that the better player gains an increase in the chances of winning the match, compared to a match where players winning points on serve are independent. The results are used to determine what proportion of a match win is contributed to a player's ability (by assuming no memory of the scoreboard) and what proportion of a match win is contributed to the psychological affects when a scoreboard is present. Further analysis is carried out to determine how the percentages of points won on serve vary as the match progresses from set to set. These findings could be used in the training and coaching of players.

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Biomechanical issues of abdominal and groin injuries in tennis

Duane Knudson

Many kinds of evidence must be integrated to determine the mechanism of common injuries in sport.[8] One of the most important areas of research comes from biomechanics. Knowledge of the normal motion of the body, the kinetics that create that motion, as well as pathomechanics, allows sports medicine professionals to diagnose and treat sport injuries more accurately. There are many kinds of biomechanics research that provide this indirect evidence about the likely mechanisms of sport injury (Table 1). This paper will summarise biomechanical loading and some of these lines of evidence that have focused on the biomechanics of the hip and lower trunk motion in tennis.

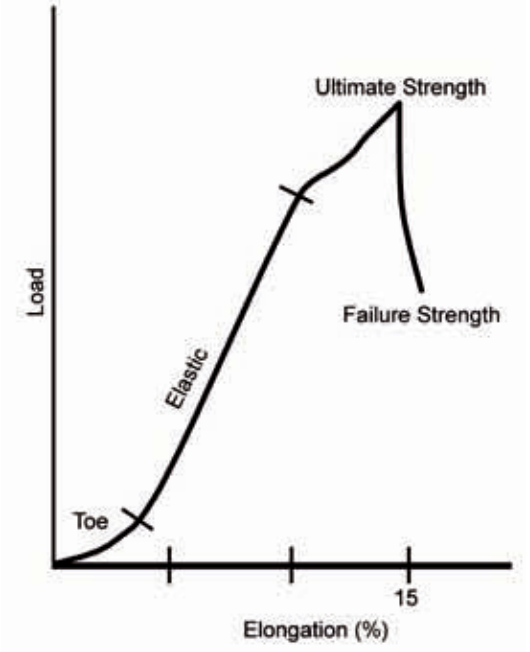
Safety factor

Forces applied to biological tissues create mechanical stress (force per unit area within the tissue) and strain (deformation). Often the small dimensional changes in materials are ignored, so loading is studied by plotting force and deformation. Figure 1 illustrates the various regions of a load-deformation graph for a tendon pulled to failure. How close tissue loads in sporting competition are to their mechanical strength, as a rough percentage of maximal, determines the safety factor.

Table 1 Biomechanics research methodologies for examining sport injury

- Electromyography (EMG): measures relative activation of muscles
- Kinematics: measures motion variables
- Kinetics (inverse dynamics): net forces & torques estimated from images
- Dynamometry: direct measurement of force
- Simulation: theoretical calculations based on modelling
- Ultrasound & MRI: measure muscle fibre and tendon movement

Figure 1 Schematic of the load-deformation graph of a tendon pulled to failure. Most normal movements load the tendon in the toe and early elastic region of the curve (<5% strain). The end of the elastic region is the yield point, where there will be clear damage in the material, which cannot be immediately reversed, as the force is unloaded. The mechanical strength of the material is usually defined as the largest force or energy (area under curve) absorbed by the material before complete rupture.[6]



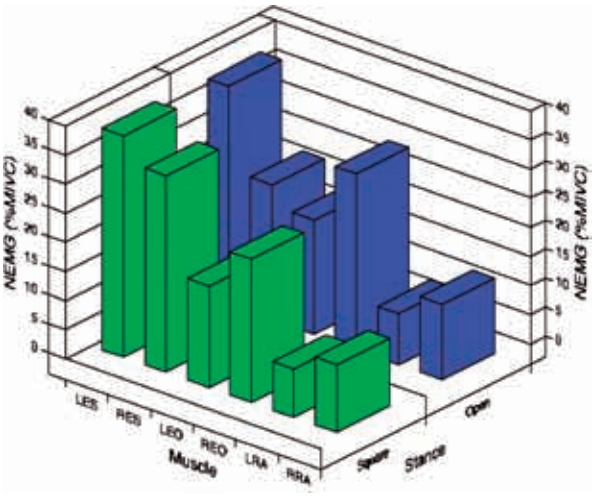
While the safety factor provides a general picture of how close typical play is to a catastrophic injury, it provides less information about overuse injuries and does not take into account the many other factors important in sports injuries. For example, the safety factor does not account for individual variation in mechanical strength, anatomy, fatigue, or the actual biomechanical factors of a particular acute injury event. The in vitro cadaver data on the mechanical properties of human tissues are usually from older, inactive persons while most sporting injuries are in younger athletes. This paper will focus on less precise, but in vivo "muscular" strength, inverse dynamics, and EMG data to examine the safety factor in the hip and lower trunk motion in tennis play.

Abdominal and lower-back strains

Lower trunk injuries in tennis are most commonly lower-back strains, but recently there have also been case studies reporting abdominal injuries.[9] A typical forehand drive creates 60 Nm of peak axial torque between the pelvis and lower back,[4] which is about 30% of maximum muscular strength. The EMG data also support the theory that abdominal muscle loading is fairly low in a forehand. Figure 2 shows the mean normalised EMG of the abdominal and lower back muscles in an open and square stance forehand drive. Notice that the abdominal muscles are activated at a lower percentage of maximal isometric voluntary contraction than the erector spinae.[7] This combined with the patient history of an unusual, awkward swing,[9] suggests that abdominal strains in tennis have a good safety factor and are likely to be rare events related to some unforeseen event.

Lower back injuries in tennis are believed to be related to overuse of the serve because of the combined motions of lumbar flexion/hyperextenstion, lateral bending, and axial rotation. Biomechanical research on the serve has shown that the predominant source of angular impulse to drive the racket comes from somersaulting angular momentum,[1] and a major source of this because of inertia is trunk flexion. It is likely that lower back muscular strain comes from the isometric and eccentric loadings on the lumbar musculature that are required to stabilise and transfer energy from the legs and hips to the upper extremity.

Figure 2 Mean normalised EMG of trunk muscles in a forehand, and follow-through of open and square stance forehands of advanced players. Trunk extensor activation was significantly greater than flexor activation.[7]



EMG data of the trunk musculature in tennis serves supports this hypothesis. Normalised electromyography (NEMG) of the back extensors is significantly greater than the abdominal muscles in all kinds of tennis serves.[3] Chow and co-workers[3] reported back extensor activation between 40 and 100% of maximal voluntary contraction (MVC) levels. Unfortunately, it is not uncommon to have NEMG in dynamic movements well over 100% of MVC, so a precise safety factor cannot be typically identified with NEMG alone. Nevertheless, the great demands on the trunk extensors in the serve, and the forehand noted earlier, could account for the greater than normal trunk extensor strength observed in tennis players.[13, 14]

In summary, preliminary biomechanical evidence suggests that the levels of stress placed on the trunk flexors during tennis play are considerably safe, however these stress levels are less safe for the trunk extensors. These results are consistent with the clinical observations of unusual events in abdominal strains, and more frequent acute and overuse injuries of the trunk extensors.

Hip strains

The numerous sprints, quick lateral movements, and strokes in tennis play may contribute to strength imbalances and injuries to the hip musculature. A common debilitating injury in tennis and other athletes are hip adductor strains.[11]

Normal hip adductor strength for male athletes is between 140 and 220 Nm, with hip abductors about 30% weaker. Typical tennis strokes like the forehand create peak hip extensor and abductor torques that are only about 20 to 40% of these maximal strength values.[5] This data show a good safety factor for tennis strokes, so the largest risk of injury to the hip musculature may be related to vigorous lateral court movements.

The majority of the biomechanical data on lateral movements tends to be electromyographic data from lab-based studies on cutting movements. There is kinetic data in these studies, but it often focuses on the knee and not the hip. A large NEMG study of lower extremity muscles in lateral movement reported mean NEMG of the adductor magnus of 50% MVC.[10] While this is not very high activation, other studies have noted significant differences in activation and loading between pre-planned and unanticipated lateral cutting movements.[2, 12] Muscles are often pre-activated at higher levels in anticipation of creating movement and reducing bone or ligament strain in the upcoming motion. Lower muscle activation from an unexpected movement, (e.g. slipping on clay or a shoe catching on a hard court), combined with other factors such as fatigue could explain how loadings increase to dangerous levels in unusual lateral court movements in tennis.

In summary, the typical loads experienced by the hip abductors/adductors in tennis strokes and the lateral movements on court are considerably safe. These results are also consistent with the clinical observations of unusual events related to fatigue, slipping, or some event contributing to an acute injury. More data on this subject is needed, since the predominance of biomechanical research on tennis strokes and movements has not focused on the hip, trunk, and transverse plane variables.

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About the author

Dr. D. Knudson earned his Ph.D. in biomechanics from the University of Wisconsin-Madison. His primary area of research is the biomechanics of tennis and he has published over 70 peer-reviewed papers and three books. Dr. Knudson has pioneered innovative force measuring technology and data smoothing techniques for research on tennis performance and injury. Dr. Knudson is internationally known as an expert on the biomechanics of tennis, stretching, and the qualitative analysis of human movement. He has served on the USTA Sport Science and Technical Committees.

Address for correspondence:
Duane Knudson
Department of Kinesiology
Associate Dean
College of Communication and Education
California State University, Chicago USA

Imaging sports lesions of the groin

Pieter van Dyck, Jan Gielen, Filip Vanhoenacker and Paul Parizel

Most athletes with groin pain attend an imaging department if symptoms persist. Therefore, most patients referred by the clinician for further imaging evaluation present with chronic groin injury. In daily radiological practice, acute groin injury is rare. Differential diagnosis of groin pain is broad and clinical diagnosis of groin lesions may be confusing, reflecting the fact that the causes of groin pain are protean.[1,2] Moreover, combined pathology is often present in chronic groin pain and these different groin conditions are often interlinked. Medical imaging may play a crucial role to narrow differential diagnosis and to better display the interlinked nature of different groin conditions.

We know, for example, the anatomical and functional relationship of tendon attachments at the level of the pubic bone, the so-called "rectus abdominis and common adductor origin (RA-CAO)", providing a unifying concept for groin injuries in athletes.[3] Chronic (or acute) stresses applied at these tendon attachments, will shear off the RA-CAO from the pubic bone and this will have an effect on proper function of the conjoint tendon and superficial inguinal ring, leading to a so-called "sports-hernia". This is the reason why symptomatic relief of groin pain may occur after hernia repair, rectusplasty or adductor tenotomy.[4]

So what are the imaging modalities available and is there an "ideal" imaging strategy? We believe an ideal imaging strategy does not exist. In daily practice, the imaging pathway to be followed is tailored to individual cases and depends mainly on local expertise (of both clinician and radiologist), equipment available and financial costs.

Should we perform plain films in every patient with chronic groin injury? Probably not. Plain radiographs are valuable for detection of acute bone lesions, e.g. avulsion fracture in the immature skeleton, but may also detect chronic bone injury, e.g. sclerotic marginated erosions at the pubic bone ("gracilis syndrome").

For chronic groin injury, multidetector CT scan is not routinely used in our institution. It may be useful for acute bone injury or biometric views, e.g. measurement of femoral neck anteversion.

If good equipment (high frequency probe) and local expertise is available, ultrasound should be the imaging modality of first choice to evaluate patients with groin pain. The most important advantage of this technique is the possibility for dynamic assessment, e.g. detection of inguinofemoral hernia or "snapping hip". It is an accurate technique for assessment of the posterior wall of the inguinal canal and conjoint tendon to detect "sports hernia". Peritoneography is another accurate technique for these purposes, but its invasiveness is a major disadvantage.

When these imaging modalities only reveal normal or equivocal findings, patients may be referred for magnetic resonance imaging (MRI). MRI is mainly used as a "water map". We specifically look for both bone-marrow and soft tissue oedema on fat-suppressed images. We prefer spectral

fat saturation because of its better spatial resolution and signal-to-noise ratio compared with inversion recovery techniques. In patients with clinical suspicion of intra-articular disease (cartilage or labral tear), gadolinium may used either to perform direct or indirect MR arthrography. In our opinion, the indirect technique (after intravenous contrast administration) is an accurate technique for detection of labral or chondral pathology, and importantly, it is less invasive. Another advantage of the indirect technique is the enhancement of peri-articular soft tissues, which may be important for obtaining correct diagnosis, e.g. snapping hip due to illiopsoas tendinitis.

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About the authors

Photo: P. van Dyck

P. van Dyck, M.D., is a musculoskeletal radiologist and staff member at the Department of Medical Imaging of the University Hospital Antwerp, Belgium. Imaging diagnosis of sports injuries is one of his main topics in daily clinical practice.

J. Gielen, M.D., Ph.D., is Associate Professor at the Department of Medical Imaging of the University Hospital Antwerp, Belgium.

F.M. Vanhoenacker, M.D., Ph.D., is consultant musculoskeletal radiologist at the Department of Medical Imaging of the University Hospital Antwerp, Belgium. He is staff member at the Department of Radiology, AZ St-Maarten, Duffel/Mechelen, Belgium.

P.M Parizel, M.D., Ph.D., is Professor of Radiology and Head of the Department of Medical Imaging of the University Hospital Antwerp, Belgium.

Address for correspondence:
Pieter Van Dyck
University Hospital Antwerp
Wilrijkstraat 10
B-2650 Edegem
Belgium

Running speed loads on clay and hard courts in world class tennis

Sven Pieper, Thomas Exler and Karl Weber

Abstract

Background

Tennis is a complex sport which is characterised by quick starts and stops as well as the involvement of several muscle groups during the different strokes. At elite level, there is a huge number of tournaments on different surfaces each year. So that the players can master the requirements of the game, they must be prepared physically as well as psychologically optimally for the running speed demands of tennis and to protect themselves against overloading damages and injuries. This study shows some important results about the characteristics of running speed demands in elite level tennis, and the implications for training a player's physical working capacity as well as for preventing injuries.

Methods

For the study thirteen clay court and seven hard court men's singles matches were analysed by means of a systematic criterion catalogue. In the foreground this shows all of the playing situations in which a player prepares his next stroke with a running movement under "time pressure". To categorise the running demand profile, several definitions were identified for different match situations. The results of this analysis were taken from a total of 24 ranking list players (ATP 1-50) aged between 20 and 33 years.

Results and conclusions

On hard courts, a top player at international level must operate at approx. 45% (n=1306), as opposed to 29% on clay courts, in all match situations under time pressure, i.e. under a raised running demand. Also the characteristics of the running demand on both these surfaces differ considerably. The rate of stroke errors differs between both tournaments with regard to the runs to each field side (forehand and backhand) as well as to each stroke (forehand and backhand). In the Australian Open substantially longer running ways are evident under high time pressure than, for example, on clay (5.1 ± 2.7 m versus 4.7 ± 1.6 m). We conclude that a match on a hard court is substantially more incriminating and can be therefore more injury-intensive for the tendons and joints. Therefore, it is necessary to train for these particularly high running demands so that adaptations can result in optimum performance and injury prevention.

Key words: running speed loads, time pressure, court surfaces, injury prevention.

Introduction

Tennis is characterised by diverse performance factors. In competitive tennis there are multiple tournaments on various surfaces every year. For players to be able to handle the huge amount of competitions on various surfaces, they have to be properly prepared, physically as well as mentally, and need to protect themselves from overload damages or chronic injuries. This article highlights the changes of the running speed loads in tennis on different surfaces for an optimal injury prophylaxis and an efficient training composition.

Methods

The main goal was to gather all the game constellations, where a player was forced to prepare and perform his next stroke under time pressure, whilst in motion. To categorise the physical running load, several definitions were identified for different game situations within the match. The results of

the game analysis came from an overall sample of 24 ATP players, aged between 20 and 33 (age 25.8 ± 2.7 years; height 183.9 ± 5.8 cm; BMI 23.4 ± 1.2 kg/m²) and ranked between 1 and 63. The arithmetic mean and standard deviation of the anthropometric data as well as the ranking position can be seen in Table 1.

With one exception all of the observed players were right-handed. The different tactical orientation of the players ranged from defence-orientated baseliner, to all-round player, to offensive player with dominant serve.[1] According to this test, the standard of the players was representative of world class tennis.

Using systematic video analysis, some up to date findings could be acquired concerning the demands on running speed abilities in world class tennis on clay (C) as well as on hard courts (H). The game analysis contained every rally of 327 (C) and 287 (H) typical service games, as well as eight (C) and three (H) tie-breaks respectively, during the World Team Cup 2004 and the Australian Open 2006. The acquired game situations were sorted into two main categories, "strokes without time pressure" and "strokes under time pressure", and were further differentiated.[2] In a second research section, running distances were measured. This evaluation analysed the running performance of each player under "time pressure". In each "time pressure" situation within the match, the dislocation of the body focus was recorded while hitting the ball, or immediately after it, and the amount of steps needed to reach the stroke position.[3] The data was processed with the programme SIMI SCOUT as well as the spreadsheet analysis programme Excel 2003. There was no statistical analysis of the obtained data because of the different player samples and the varying importance of the different tournaments.

Results and conclusion

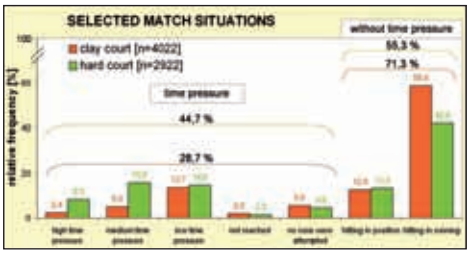
On hard courts, a top player at international level will be forced to operate at approx. 45% (n=1306), as opposed to 29% on clay courts, in all match situations under time pressure, i.e. under a raised running demand. Whilst the count of strokes conducted while hitting in position differ only slightly between hard and clay courts in the category "strokes without time pressure" (H: 13,3% and C: 12,6%), the value on hard courts is more than 28% over the value on clay courts with regard to strokes under medium and high time pressure (Figure 1).

Table 1 Personal data of the tested tennis players regarding participation in each particular tournament (Player data at the time of the particular tournament)

Clay court tournament 2004						
Player data*	**Nation**	**Age [years]**	**Height [cm]**	**Weight [kg]**	**BMI [kg/m²]**	**Ranking**
Albert Costa	ESP	28	180	78	24,1	25
Gaston Gaudio	ARG	25	175	70	22,9	34
Fernando Gonzalez	CHI	23	183	81	24,2	35
Tommy Haas	GER	26	187	88	25,2	43
Lleyton Hewitt	AUS	23	180	77	23,8	17
Nicolas Kiefer	GER	26	182	80	24,2	58
Feliciano Lopez	ESP	22	187	85	24,3	28
Nicolas Massu	CHI	24	182	80	24,2	12
Jiri Novak	CZE	29	190	86	23,8	13
Mark Philipoussis	AUS	27	195	98	25,8	9
Sjeng Schalken	NED	27	193	82	22,0	18
Rainer Schüttler	GER	28	180	70	21,6	6
Vincent Spadea	USA	29	182	77	23,2	29
Radek Stepanek	CZE	25	185	75	21,9	46
Martin Verkerk	NED	25	195	89	23,4	19
Mariano Zabaleta	ARG	26	182	77	23,2	27
x̄		25,8	184,9	80,8	23,6	26,2
±s		2,1	5,8	7,2	1,1	14,4
Hard court tournament 2006						
Player data*	**Nation**	**Age [years]**	**Height [cm]**	**Weight [kg]**	**BMI [kg/m]**	**Ranking**
Roger Federer	SUI	24	185	80,5	23,5	1
Marcos Baghdatis	ZYP	20	182	80,0	24,2	52
Nicolas Kiefer	GER	28	183	80,5	24,0	24
David Nalbandian	ARG	24	180	79,5	24,5	5
Nikolay Davydenko	RUS	24	180	69,1	21,3	6
Sebastian Grosjean	FRA	27	175	66,8	21,8	28
Fabrice Santoro	FRA	33	178	72,7	23,0	63
Ivan Ljubicic	CRO	26	193	82,7	22,2	9
x̄		25,8	182,0	76,5	23,1	23,5
±s		3,8	5,4	6,0	1,2	23,2
Total						
x̄		25,79	183,92	79,37	23,4	25,29
±s		2,72	5,75	7,03	1,2	17,34
maximum		33	175	66,8	21,3	1
minimum		20	195	98	25,8	63

* Player data at the time of that particular tournament

Figure 1 Frequency distribution of all observed criteria under time pressure on clay (orange) and hard courts (green)



The characteristics of the running speed loads also differ substantially according to the two different surfaces. In 1172 game situations on a hard court, an average of 3.83 ± 1.94 m is covered under time pressure, which is a mean of 20 additional centimetres compared to clay (3.65 ± 1.32 m). Except for those under high time pressure, the average running distance in time pressure situations is shorter on hard court than on clay court (Figure 2).

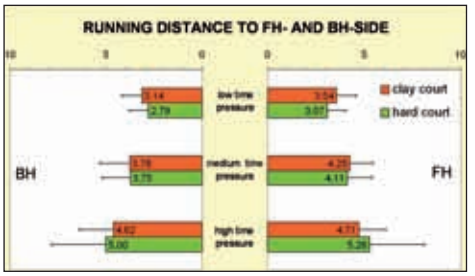
Figure 2 Average values and standard deviations to the running distance in time pressure situations in clay and hard court tennis

The results not only show a dominance in running sidewards, but also demonstrate clearly that on average in all time pressure situations especially to the forehand (FH) side, longer distances have to be covered when compared to the backhand (BH) corner. Particularly in the observation category of medium and high time pressure, a mean running distance of four to five metres to the forehand can be determined (Figure 3).

Figure 3 Running distance to the FH and BH sides. Average values and standard deviations to the running distance differentiated for the forehand (FH) and backhand (BH)

The error ratio differs between the two tournaments, concerning runs to the court side as well as to the stroke. In clay court tennis, the error ratio under time pressure (net and out) is higher than one fifth (n=184), whilst on hard courts, the amount of faults lies at about 19%. The differentiated analyses regarding the three time pressure situations, as well as the court and stroke side, also show that clay court tennis has a higher error ratio than hard court tennis (Figure 4).

Figure 4 Error rate in selected match situations. Progress of the error ratio in selected match situations



It has to be emphasised that the percentile amount of errors on the forehand side as well as the forehand stroke, with the exception of the results under medium time pressure, preponderates. In the match situations under medium time pressure the error ratios of the backhand (28.2% versus 16.3%) and in the backhand corner (27.0% versus 16.8%) in clay court tennis differs substantially compared to those of hard court tennis (Tables 2 and 3). The relative frequency of the runs to the forehand side and to the forehand stroke, however, remains almost the same.

The present game analysis supplies fundamental details of current running speed loads in the elite tennis-specific demand profile. The results not only show the necessity to train this performance-limiting factor, but also describe the characteristics of the running speed loads (e.g. running distances) in world class tennis on different surfaces. Especially realising that the maximum running performance mainly takes place in sideward movements plays an essential role in the injury prevention of the lower extremities.

In connection with the findings and the resulting amount of stopping movements, a competition on a fast surface (hard court) seems to be substantially more incriminating and thus produces more injuries in tendons and joints when compared to clay. It is necessary for injury prevention, as well as for the control and regulation of training, to prepare the player for those high and specific loads. To achieve these goals, strengthening of the concerned muscle areas, as well as technical education of the running technique and co-ordination is essential.

Table 2 Percentile error ratio regarding the three time pressure situations for runs to the forehand (FH) and backhand (BH) sides. Error ratio-runs to the side. Low time pressure. Medium time pressure. High time pressure

ERROR RATIO - RUNS TO SIDE													
Surface		Low time pressure				Medium time pressure				High time pressure			
		Out		In		Out		In		Out		In	
		FH	BH	FH	BH	FH	BH	FH	BH	FH	BH	FH	BH
[n]	Clay court	61	49	202	240	28	20	98	54	16	10	40	29
	Hard court	17	41	107	262	50	38	188	188	32	31	89	90
[%]	Clay court	23,2	17,0	76,8	83,0	22,2	27,0	77,8	73,0	28,6	25,6	71,4	74,4
	Hard court	13,7	13,5	86,3	86,5	21,0	16,8	79,0	83,2	26,4	25,6	73,6	74,4

Table 3 Percentile error ratio regarding the three time pressure situations for runs to the forehand (FH) and backhand (BH) strokes

ERROR RATIO - RUNS TO STROKE													
Surface		Low time pressure				Medium time pressure				High time pressure			
		out		in		out		in		out		in	
		FH	BH	FH	BH	FH	BH	FH	BH	FH	BH	FH	BH
[n]	Clay court	69	41	267	175	28	20	101	51	17	9	40	29
	Hard court	26	32	163	206	54	34	201	175	34	29	92	87
[%]	Clay court	20,5	19,0	79,5	81,0	21,7	28,2	78,3	71,8	29,8	23,7	70,2	76,3
	Hard court	13,8	13,5	86,2	86,5	21,2	16,3	78,8	83,7	27,0	25,0	73,0	75,0

For tournament practice, not only a basic running speed training, but also game situations under time pressure should deliberately be integrated into training, where strokes should be executed in combination with one or more quick changes of direction. The improvement of the tennis-specific quickness should not only result in a minimisation of the amount of time pressure situations - more balls can be reached -, but also in a reduction of the intensity level (low < medium < high time pressure). If the player must hit less balls under time pressure, because he disposes a good running speed and quickness, as well as footwork, the stroke quality (precision and velocity) does not decrease. Thereby the opponent is forced to make more mistakes. The high ratio of direct errors in all situations of time pressure (Figure 4) on clay and hard court in men's tennis confirms the increased importance of running speed. These findings are elementarily for the training practice as well as for the development of valid tennis-specific running tests. The main focus on one hand is to increase the explosive start and acceleration abilities for the first few metres, and on the other hand to optimise the tennis-specific running technique and co-ordination (footwork) immediately before and after the stroke. Start and sprint speed have to be practised for running distances from three to eight metres to the side, especially to the forehand as well as backhand side (Figure 3), with or without subsequently changing direction (including strokes) on the baseline.

To reach an optimal adaptation and performance increase, as well as injury prophylaxis, an accompanying strength training of specific structures is recommended. Speed and agility training must be considered the temporal adaptation process of muscles, tendons and ligaments.

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About the authors

Sven Pieper, Ph.D., has a degree in Sport Science as well as the B-Licence for Tennis Coaches of the German Tennis Federation. He is currently employed as a scientist at the Institute of Movement Science for Team and Racket Sports at the German Sport University Cologne. He completed his Doctor of Sport Sciences with the doctoral thesis: Diagnostic of the Running Speed in Tennis – Empirical study for development and evaluation of several tests.

Thomas Exler works at the Institute of Movement Science for Team and Racket Sports at the German Sport University Cologne as a student assistant. Shortly he will finish his degree in Sport Science.

Karl Weber, Ph.D., M.D., is the Director of the Institute of Movement Science for Team and Racket Sports at the German Sport University Cologne and has been since 1986. He holds an A-Licence for Tennis Coaches of the German Tennis Federation and in 1998 he became German Vice Champion (Men 55) in Team Tennis.

Address for correspondence:
Sven Pieper
Institute of Movement Science for Team and Racket Sports
German Sport University Cologne
Carl-Diem-Weg 6
50000 Cologne 41
Germany

Prognostic value of ultrasonography

ESWT as treatment of the extensor tendinopathy of the elbow

Mathieu Maroy, Els van den Eede and Koen Peers

Extensor tendinopathy of the elbow, formerly known as tennis elbow, is a common complaint in medical practice. It affects 1 to 3% of the population. It is not an inflammatory process, but histologically there is collagen disarray with proliferation of fibroblasts as a result of repetitive microtrauma. This tendinopathy is often a problem in occupations requiring repetitive wrist flexion and extension, and commonly occurs in persons who play racket sports. Suggested causal factors in tennis players are a high string tension, a wrong grip, overtraining, and bad technique on the one-handed backhand (hitting the ball too late and often 'framing' the ball).

The problem is self-limited, but nevertheless, it becomes often a chronic condition, difficult to treat. More then 40 conservative treatment options are known including corticosteroid injections, a brace or tape, laser therapy, stretching and strengthening exercises and friction massage. Extracorporal ShockWave Therapy (ESWT) is one of the newer treatment options: there is growing evidence for the effectiveness of ESWT in the treatment of the extensor tendinopathy of the elbow.

Objective

To determine if ultrasonography has a prognostic value for the outcome of ESWT in the treatment of the extensor tendinopathy of the elbow.

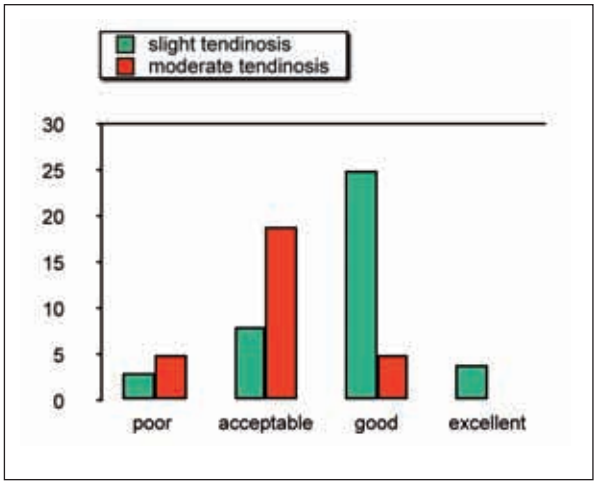
Materials and methods

Retrospectively, the records of 74 patients (38 women, 36 men) who attended the outpatient Sports Clinic of the University Hospital Leuven between March 2005 and February 2005 were re-assessed. All patients were clinically diagnosed with extensor tendinopathy of the elbow and they all received ESWT as treatment. An ultrasound scan was performed before starting ESWT. Four ultrasonographic entities were defined: a) normal tendon on ultrasound scan; b) slight tendinosis - swelling of the tendon maximum 5 mm; c) moderate tendinosis - swelling of the tendon maximum 7 mm, hypo-echogenicity; d) severe tendinosis - swelling of the tendon more than 7 mm, severe hypo-echogenicity, mucoid degeneration and calcifications.

Table 1 Roles and Maudsley score for the different ultrasound subgroups

Ultrasonography/R&M score	Poor	Acceptable	Good	Excellent	Total
Normal	2	0	0	0	2
Slight tendinosis	3	8	25*	4	40
Moderate tendinosis	5	19*	5	0	29
Severe tendinosis	4	2	0	0	6
Total	14	29	30	4	77
* statistically significant (Cohen's Kappa 0,412)					

Figure 1 Roles and Maudsley score of slight and moderate tendinosis: bar diagram



Treatment consisted of three sessions, with a one week interval. Shock waves were applied using a mobile treatment unit especially designed for orthopaedic use (Sonocur Plus, Siemens AF, Erlangen, Germany, 1000 pulses, frequency 4 Hz, energy-flux density 0,2mJ/mm). In addition to ESWT patients had to perform an exercise programme, consisting of eccentric tendon training and stretching of the tendon. Six weeks after the last ESWT session all patients were examined and asked about their complaints.

Results

Patients were subjectively asked about their complaints and clinical outcome was then assessed with the Roles and Maudsley score. This is an established score-system to determine the performance of ESWT and comprises four categories: a) excellent - no complaints anymore; b) good - only occasional discomfort; c) acceptable - still complaints but significantly better; d) poor - symptoms equal or deteriorated. Patients who had a normal ultrasound scan had poor results after ESWT. 72% of the patients with slight tendinosis on ultrasound scan had good to excellent results. Patients with moderate tendinosis were more prone to have acceptable results after ESWT (66%). Patients with severe tendinosis on ultrasound had poor results after ESWT. This association between especially slight and moderate tendinosis was proven statistically by the Cohen's Kappa test (Kappa= 0,412, 95%CI (0,257; 0,567).

Conclusions

Ultrasonography has potential prognostic value to predict the outcome of ESWT treatment in patients with extensor tendinopathy of the elbow. More prospective studies should be done, with larger patient subgroups, to confirm this statement.

About the authors

Photo: M. Maroy

Dr. M. F.Y.P. Maroy works at the Physical Medicine and Rehabilitation Department at the KU Leuven, Belgium.
Dr. E. van den Eede is a physician at the Physical Medicine and Rehabliitation Department at the KU Leuven, Belgium.

Prof. Dr. K.H.E. Peers is Professor of Physical Medicine and Rehablitation at KU Leuven, Belgium.

Address for correspondence:
Mathieu Maroy
St Pietersweg 31
8510 Bellegem
Belgium

Surgery | Ruben van Veen, Paul de Baat, Geert Kazemier, Rien Heijboer, Bas Punt and Casper van Eijck

Endoscopic total extraperitoneal mesh placement in elite athletes

Chronic groin pain, especially in professional sportsmen, is a difficult clinical problem. 55 (semi) professional sportsmen (53 male, 25 ± 4.5 year, range, 17-36) with undiagnosed chronic groin pain were followed prospectively from January 1999 to August 2005. All patients underwent an endoscopic total extraperitoneal (TEP) mesh placement. An incipient hernia was diagnosed 15 (27%) times on the right, 12 (22%) times on the left, and 9 (16%) times bilaterally.

In 20 (36%) patients an inguinal hernia was found of which 3 (5%) were direct inguinal hernias and 17 (31%) indirect hernias. All athletes returned to their normal sports level within three months after operation. It was concluded that an endoscopic total extraperitoneal mesh repair must be proposed to patients with prolonged groin pain who are unresponsive to conservative treatment. If no clear pathology is identified, reinforcement of the wall using a mesh offers good clinical results in athletes with idiopathic groin pain.

An unloading tape technique for rectus abdominus strains

Kathleen Stroia, Melissa Baudo and Kathy Martin

The application of tape has been widely used for many years by athletic trainers and physiotherapists in the rehabilitation, prevention, and management of a wide variety of neuro-musculoskeletal sports injuries and disorders.[1,2] The basic rationale for using tape is to provide protection and support for a joint, tendon, or muscle while permitting optimal functional movement and facilitating a safe return to sport. The effectiveness of tape application is dependant upon two critical factors:

1. **The taping method is appropriate for the clinical purpose and desired outcome of treatment to be met;**
2. **The skill of the Physiotherapist or Certified Athletic Trainer applying the tape, to apply the appropriate amount of tension and accurate direction of pull of the tape.**

Current research about taping effects

Although taping techniques are commonly used in rehabilitation and the management of sports injuries, there is a paucity of good research that demonstrates how tape works. The effects of taping are reported to include[1]:

- Provide mechanical stability;
- Optimise joint alignment;
- Reduce pain;
- Neuro-musclular effects such as inhibition of overactive muscles and facilitation of under active movement synergists;
- Enhance proprioception;
- Unload irritable neural tissue.

There is little evidence to support the underlying mechanisms by which taping effects are achieved. However, Alexander et al suggest that taping along the length of a muscle shortens the muscle, thereby unloading the intrafusal muscle fibers of the muscle spindle, resulting in muscle inhibition.[1] Further support for the neuromuscular effects of taping have been described in the literature.[2] Morin et al (1997) and McConnell (1999) examined the influence of tape application on the upper and middle trapezius muscle activity by EMG analysis and found that tape application decreased the muscle activity in the upper trapezius muscle and increased muscle activity in the middle trapezius muscle.[2]

Lohrer et al (1999) investigated the neuromuscular properties and functional aspects of ankle taping and found that taping caused changes in muscle latency times, in addition to the mechanical restriction of movement.[2] Neptune et al (2000) proposed that a delay in vastus medialis obliquus (VMO) onset may result in a significant increase in patellofemoral pain.[4] Many researchers have explored this theory and have reported a change in timing in vastii muscle activity with the application of tape. With tape, the onset of VMO activity occurred earlier relative to the vastus lateralis.[4, 5, 6]

Anti-pronation taping in the foot has been associated with marked improvement in jogging distance and time.[7] A temporary carry-over effect from the anti-pronation taping was demonstrated with the improved jogging distance and time maintained after the tape was removed.[7] This is a common clinical finding and maybe due to short-lived adaptations in the neuro-motor system, pain systems, and/or soft tissue properties. Various authors have reported that the support function of taping is lost within a relatively short time after application.[2] However, cutaneous and mechanical effects of tape may persist and may enhance sensorimotor variables such as proprioception.[3, 4] This latter effect may help explain why objective improvements continue to be evident even after the removal of the tape.[7] Reinforcement after taping, in the form of continued taping, therapeutic exercise and further physical therapy are advised to maximise the positive effects and increase the chance of a more desirable long-term outcome.[7]

A common tennis injury

Abdominal muscle injuries are common in tennis players at all levels of competition.[8, 9] They are typically caused by an indirect trauma, such as an overstretch injury of the muscle; they may also present as overuse syndromes.[8, 9] These injuries may become debilitating and result in prolonged periods of time away from competition. Most lesions affect the non-dominant rectus abdominus muscle; however, the internal or external oblique muscles can also be injured depending on the mechanism of injury.[8, 9] Most often, the cocking phase of the tennis serve causes injury. During the cocking phase of a tennis serve, the athlete brings the racket overhead by shoulder abduction and external rotation and lumbar spine hyperextension.[9] The non-dominant rectus abdominus shows high electromyographic (EMG) activity during this phase, predisposing it to strain.[9]

Following a diagnosis of abdominal muscle strain, tennis players are advised to avoid practice, and the initial treatment consists of rest, trunk compression, cryotherapy, oral non-steroidal anti-inflammatory drugs, and physiotherapy. Following a consistent course of rehabilitation including isometric, concentric, eccentric muscle strengthening, core stabilization, followed by sports specific training, the tennis athlete may return to high level competition at approximately four to six weeks depending on the severity of the injury.[9] When an athlete has completed a rehabilitation program and returned to competition, the risk of re-injuring the abdominal muscle is relatively common. Issues that will affect the recovery and rehabilitation at the professional level include the pro player's desire to get safely back on court in a shorter time period which may be motivated by pressure to protect her ranking and finances. Players who get back to competition too early or not fully rehabilitated are most likely to account for many in the re-injury group.

Unloading tape for rectus abdominus strains

It is the responsibility of the Sony Ericsson WTA Tour's Primary Health Care Providers (PHCPs) to initially manage a new or recurrent abdominal injury. The PHCPs use tape as an adjunct to the usual treatment protocol discussed above. The aim of taping is to reduce healing time, and to protect and facilitate the function of the healing rectus abdominus muscle. Conventional taping techniques would apply a girdle compression tape which encompasses the trunk and so restricts movement and supports the injured area. This style of taping was trialed by the PHCPs in the late 1980's and early 1990's for professional women players. It was observed to be non-specific to the injured abdominal muscle; too cumbersome and often described by players as uncomfortable and restrictive; provided at best variable pain relief; and possibly inhibited on-court agility and performance.[10] Clearly, a new method of tape for rectus abdominus strains was required.

The 1986 work of McConnell and patellofemoral taping, did much to stimulate the physiotherapy profession to reconsider taping and its beneficial clinical effects.[11]

McConnell has published specific unloading/deloading taping techniques for the infrapatellar fat pad in the treatment of patellofemoral pain syndrome, the elbow in the treatment of lateral epicondylalgia, the buttock and lower leg in the management of chronic low back and leg pain and the thoracic spine prior to mobilisation treatment.[12-16] "The principle of unloading is based on the premise that inflamed soft tissue does not respond to stretch."[13] Unloading tape involves lifting of soft tissues towards the painful area, essentially shortening the tissue. It is suggested that his technique unloads the neural tissues especially and hence minimises their exposure to

painful stretch during activity and treatment and in turn decreases pain.[13] Tape produces mechanical, tensile and compressive forces on the skin and then alters the skin tension, which changes the afferent information from cutaneous mechanoreceptors.[12] Tropp et al (1985) postulated that because cutaneous mechanoreceptors detect pressure, taping may alter the perception of an applied external pressure over skin and may influence pressure pain thresholds.[12] O'Leary et al (2002) adapted the McConnell unloading tape and studied its effects on the treatment of the mid-thoracic spine in asymptomatic subjects and showed a trend towards a change in pressure pain thresholds. Further study is required using symptomatic, painful subjects as it is expected the effect would be significantly larger with this group.[12]

In the late 1980's and early 1990's there were limited effective taping options for abdominal muscle strains which provided both support to the injured area and allowed the athlete to continue play.[10] In the early 1990's, Kathleen Stroia and Kathy Martin applied the McConnell principles of "unloading"[12-15] to the abdominal muscles. Stroia and Martin experimented with various tape applications and created a clinically effective "Unloading Technique" suitable for use with players who sustain rectus abdominus strains.[10] The technique meets the desired goal of allowing a player to play with improved function, less pain and without jeopardizing muscle healing.[10] It is designed to consider the anatomy and patho-physiology of the injury and the biomechanics of the tennis serve and is described below.

Unload tape for rectus abdominus

Step 1: Identify the area of the injured muscle. Place a layer of Coverall® or Fixomull® directly over the area on the skin so that the center of the Coverall® coincides with the center of the injury (see Photo 1).

Step 2: With brown tape, two anchor strips are placed on either side of the Coverall® (Photo 2).

Step 3: Diagonal strips are placed from anchor to anchor, and the soft tissue structures are lifted up, shortening the underlying tissues. This can be seen as soft tissue wrinkling between the anchors. Anchor the starting part of the tape with your thumb. With the other hand, apply a tensing force along the direction of the tape. Before laying the tape down, make sure that the underlying skin is moved in towards the painful region. Do this by using the index finger of the hand that is anchoring the tape to the skin (Photos 3 and 4).

Step 4: Once all the diagonal strips are in place, place two more anchors to help hold the diagonal strips (Photo 5).

Step 5: Functional test: There should be an immediate decrease in symptoms seen on manual muscle or other functional testing (Photo 6).

This unload taping may be universally applied to all muscle injuries and is currently a key taping strategy in the management of muscle injuries for the professional women tennis players on the Sony Ericsson WTA Tour. The mechanism for the observed positive effect of Unload Tape needs further investigation. Clinically it works. The unloading tape enables the athlete to continue tennis safely with minimal to no pain, with firm support and protection of the muscle that prevents further injury. Unloading tape allows the athlete to continue treatment, rehabilitation and strengthening and functional re-training without any increase in symptoms.[10]

Conclusion

The purpose and effect of tape in the management of musculoskeletal injuries in professional sports is fairly well established. Conventional athletic taping strategies are highly effective and used today; however limited taping strategies available in the management of abdominal muscle injuries in the late 1980's and early 1990's inspired Stroia and Martin, at that time both PHCPs with the Sony Ericsson WTA Tour, to develop the "Unloading Technique" for abdominal muscle strains, an injury common to tennis. The use of tape is an adjunct in the overall rehabilitation of the injury, which includes a stabilisation program of the back and abdomen, manual therapy, modalities, and when necessary, biomechanical stroke analysis to correct the underlying cause.


Photo 1


Photo 2


Photo 3


Photo 4


Photo 5

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Photo 6

About the authors

Kathleen Stroia is a sports physiotherapist with 20 years experience in sports therapy. Kathleen earned her Bachelor of Arts in Sports Sciences with an emphasis in Athletic Training from Purdue University, a Master of Science degree in Athletic Training from West Virginia University and a Bachelor of Science degree in Physical Therapy from Chicago Medical School. Kathleen is Vice President of the Sony Ericsson WTA Tour Sports Sciences & Medicine and PRO U™ Departments and is responsible for the supervision and direction of the Sports Sciences & Medicine and PRO U™ departments and staff. Kathleen currently oversees all health and medical services for the Sony Ericsson WTA Tour, and coordinated those of International Tennis Federation Women's Circuit between 1995 through end of 2003. Kathleen serves on the ITF Medical Commission and the United States Tennis Association Sport Sciences Committee and has served on the Special Olympics Committee, Tennis Anti-Doping Committee and the National Athletic Trainers Association (NATA) in previous years. She is the 2007 recipient of the prestigious "Most Distinguished Athletic Trainer Award" presented by the NATA.

Melissa Baudo is a sports physiotherapist with 5 years experience in sports and manual physical therapy. Melissa earned her Bachelor of Science degree with an emphasis in cardiac rehabilitation and wellness at The Ohio State University and later gained her Masters and Doctor of Physical Therapy Degrees from Emory University. Melissa is certified in Pilates through Polestar Pilates Rehabilitation. Melissa is certified in Manual Therapy from the University of St. Augustine and is preparing for Board Certification as a Sports Clinical Specialist. She has completed a variety of articles and is currently awaiting publication. Melissa has been a medical services team member at a variety of pro/amateur sports events including the Pro Beach Volleyball Tour (AVP) in Atlanta, Georgia. Melissa joined the Tour in 2006 as a Primary Health Care Provider.

Kathy Martin is a sports physiotherapist with 23 years experience in sports therapy. She was awarded the Australian Physiotherapy Association Sports Physiotherapist title in 1999. She received her Bachelor of Arts (1991) and Graduate Diploma in Adolescent Health & Welfare (2004) from Melbourne University. She is currently completing her Masters degree in Counseling at Monash University. Kathy Martin was the Australian Olympic Team physiotherapist in 2000, the Australian Fed Cup Team physiotherapist from 1994 to 2000, and sports medicine consultant to Tennis Australia from 1998 to 2003. She joined the Sony Ericsson WTA Tour as a Primary Health Care Provider in 1991. She is currently the director, athlete assistance, for the Sony Ericsson WTA Tour.

Tennis players in flow

Csikszentmihalyi's and reversal theory's approaches to flow

Janet Young

Abstract

Complementing a paper on factors influencing tennis flow[1], this paper examines tennis flow states for correspondence with flow descriptions from Csikszentmihalyi[2,3] and reversal theory.[4,5] In a study supported by Tennis Australia, 31 Australian professional female tennis players related their experiences of a time that stood out from average, one involving total absorption and which was rewarding in and of itself. Qualitative content analyses of participants' narratives of flow states revealed a correspondence of narratives with Csikszentmihalyi's and reversal theory's descriptions. In light of the study's findings, a model of flow is proposed which integrates key psychological parameters underpinning Csikszentmihalyi's and reversal theory's approaches to flow. Practical implications of the study's findings for players and coaches are highlighted.

Key words: flow, professional tennis player, reversal theory and optimal tennis experience

Introduction

Given sport psychologists' fascination, and even obsession, with optimal and peak performance, it is not surprising the concept of flow commands a central focus in the literature. Defined as "enjoyment, an intrinsically rewarding, or autotelic (self-rewarding) experience"[6], flow describes a general feeling of being totally in tune with oneself, and one's abilities, to produce a focused, memorable, fun and very high standard performance.

Numerous anecdotal accounts of tennis players (including Roger Federer, Rafael Nadal and Serena Williams) support the experience of flow states (which are sometimes referred to as 'in the zone'). While flow states have been examined in athletes representing several sports (including figure skating, track and field, rowing, swimming, cycling, triathlon, rugby and field hockey),[7,8] this is, to the author's knowledge, the first known study of flow in tennis.

Theoretical frameworks for understanding flow

Explanations of flow can be gleaned from two theoretical approaches, namely Csikszentmihalyi's[2,3] flow construct and reversal theory.[4,5]

In brief, Csikszentmihalyi's[2,3] flow construct denotes flow as a holistic sensation when an individual acts with total and

enjoyable involvement in an activity. This self-rewarding experience is thought to be a function of two subjective experiential variables:

1. The perceived challenges (or intrinsic demands) of an activity;
2. The perceived skills (or capacity) of the individual to meet the demands.

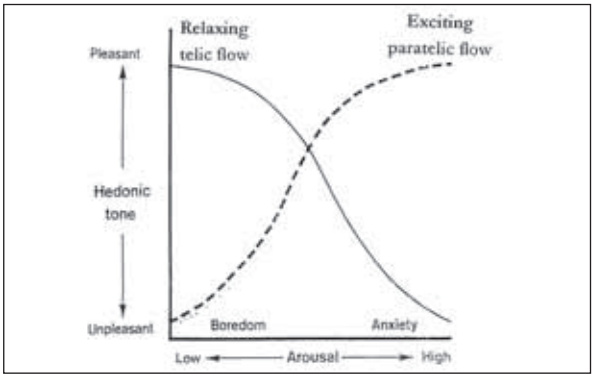
Csikszentmihalyi posits that flow is optimised in situations characterised by:

a. A match between high perceived challenges and high perceived skills;
b. Clear goals and feedback;
c. Action and awareness merged;
d. Concentration on task;
e. Sense of control;
f. Loss of self-consciousness;
g. Altered sense of time;
h. Autotelic (self-rewarding) experience.

In an alternative conceptualisation, reversal theory posits an explanation of flow in terms of metamotivational states (modes or mental states in which an individual's motives are structured, interpreted and organised within experience) and reversals (switches between states). Specifically, individuals are thought to experience flow as an optimal relaxing telic (from the Greek word "telos" meaning goal or end) or exciting paratelic ("para" being the Greek word for beside or alongside) metamotivational state.[9] In telic flow, low arousal is preferred and experienced as pleasant /high hedonic tone (relaxing).

In contrast, in paratelic flow, high arousal is preferred and experienced as pleasant/high hedonic tone (exciting). These alternative categorisations of flow as telic and paratelic states are illustrated in Figure 1.

Figure 1 Model of telic and paratelic flow (adapted from Apter[5] and Rea[9])



Aim of the study

The aim of the study was to explore the correspondence of tennis flow experiences in elite professional female player with Csikszentmihalyi's[2,3] and reversal theory's'[4,5] conceptualisations of flow.

Method

Data were collected from 31 of 38 (return rate = 82%) Australian professional female tennis players competing in the Tennis Australia summer circuit. Participants had played tennis and competed professionally for a mean number of 12.2 years (SD = 3.8) and 2.2 years (SD = 1.9) respectively, had a mean singles ranking of 456 (SD = 250) and a mean age of 22.7 years (SD = 2.8).

Materials

A self-report instrument (questionnaire) was developed in which participants were asked to describe an experience in tennis, either in competition or training, that stood out as being better than average in some way, an experience in which they were totally absorbed and which was very rewarding in and of itself. This definition of flow presented to participants was adapted from Jackson's[8] sport-specific definition of flow to reflect this study's focus on tennis. Participants were also asked to rate challenges and skills (on a ten-point Likert scale) of the experience they had reported. A copy of the questionnaire adopted in this study is available from the author on request.

Data collection and analysis

Data were collected throughout the eight-week summer circuit of tournaments after participants had completed the questionnaire at times convenient to their training and matches. To analyse the qualitative data, four sport psychology researchers (who were knowledgeable in qualitative research methods and the literature on flow and reversal theory) conducted a content analysis of participants' narratives of a flow experience. In a popular procedure adopted by qualitative researchers[8,10] key words, phrases or statements (referred to as "raw data themes") were identified in participants' narratives. The raw data themes were then examined, in two separate procedures, for a match with (a) Csikszentmihalyi's[2,3] flow dimensions and (b) reversal theory's[4,5] telic and paratelic states. To examine for differences in the frequency of telic and paratelic flow, a chi-square good-of-fit test was conducted.

Results

Csikszentmihalyi's flow approach

31 participants (100%) reported a flow experience, with accounts varying from several sentences to two full pages

in length. Two narratives representative of the clear and concise descriptions of flow experiences in tennis were:

"Before I play my mind is very relaxed, visualising the balls I hit going perfectly into place. I'm a little nervous but confident in myself. As soon as I step onto the court, everything outside and including the fence is a blur. I'm aware of people watching and the surroundings and am completely relaxed with this. Between points, my thoughts are only with my breathing and my blood circulating through every muscle in my body from head to toe. During points, the ball is huge; it's the only thing I see although I'm completely aware of where my opponent is and what she's doing. When I'm playing like this, it is like a complete escape from the outside world and its problems."

"I was so focused in the match all I could see was the tennis court. I did not hear anything or anybody on the outside. I felt I was one with my body, racquet and tennis court."

The results of the matching of raw data themes (245) derived from participants' narratives with theoretical flow dimensions are reported in Table 1.

In terms of reported challenges and skills in flow, these were closely matched at a high level with a mean challenge rating of 8 (SD = 1.84) and a mean skill rating of 8.45 (SD = 1.17).

Reversal theory's flow approach

A second analysis of participant's narratives of flow generated 15 narratives classified as paratelic experiences, with the remaining 16 classified as telic experiences.

Participants' accounts of flow classified as paratelic experiences were characterised as spontaneous, automatic, exciting and with 'a here-and-now' orientation. Some of these features are illustrated in the following descriptions:

"... I am in full concentration, which is automatic ... My adrenaline is pumping. I feel on top of the world."

"I guess I felt nervous but it was more an adrenalin rush; a feeling of excitement that culminated into complete focus on my objective..."

Participants' descriptive reports of flow classified as telic experiences were characterised as calm, relaxing, serious, and goal-orientated. Some of these features are illustrated in the following descriptions:

"My body is totally relaxed. I can't hear or see anyone else, I am fully concentrating on myself. I'm not worried about what my opponent is doing or saying. I am totally at ease."

"... I am playing well above my standard at the time, and it was at the time when I enjoyed my tennis (that) I was the most relaxed on the court. (I was) totally at ease."

A chi-square goodness-of-fit test revealed no significant differences in the frequencies of telic and paratelic flow [χ^2 (1, N = 31) = 0.3, p >.05].

Discussion

This study found evidence to support principle tenets of both Csikszentmihalyi's[2,3] and reversal theory's[4,5] approaches to flow.

It was expected that tennis players' flow experiences would display a close correspondence with Csikszentmihalyi's[2,3]

Table 1 Theoretical dimensions of flow and miscellaneous category, number and percentage of tennis players citing themes within each dimension and frequency and percentage of all raw data themes represented by each dimension.

	Flow dimension	Number of tennis players	Percentage of tennis players	Number of all tennis players theme	Percentage of all raw data themes
1	Challenge-skill balance	11	36	13	5
2	Action-awarness merging	20	65	39	16
3	Clear goals and feedback	16	52	30	12
4	Concentration	22	71	53	22
5	Loss self-consciousness	9	29	11	5
6	Paradox of control	21	68	57	23
7	Transformation of time	5	16	5	2
8	Autotelic (self-rewarding) expercience	7	24	10	16
9	Miscellaneous	9	29	13	5

Note: Participants could contribute more than one theme in each narrative.

flow construct. Such is the correspondence of data from tennis players with theoretical flow dimensions (as illustrated in Table 1 with 95% of raw data themes matching a flow dimension) that, together with the study's findings of flow characterised by the simultaneous presence of both high challenges and skills, tennis flow appears to be representative of a universal flow sport experience, and as such, one type of Csikszentmihalyi's generic flow phenomenon.

This study also investigated flow in a different approach to the traditional application of Csikszentmihalyi's[2, 3] conceptualisation. In doing so, this study illustrates how flow experiences can be plausibly described in an alternative way where a player is alerted to the significance of her experience of arousal.

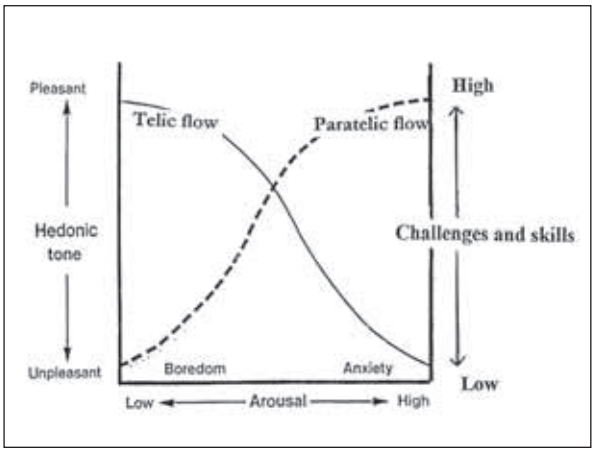
In instances when flow is not experienced by a tennis player at the commencement of a performance, the critical consideration for achieving a flow state is the tennis player's interpretation of arousal *during*, rather than *prior* to, performance. While this distinction is phenomenologically real in the sense of its intuitive appeal, the significance of the distinction has not been generally acknowledged in the literature. While this insight into tennis flow provided by reversal theory of the significance of a player's experience, and timing, of her arousal for understanding flow might appear simplistic, it has the potential to become a new focus of research in sport psychology. No longer is the traditional strategy to feel calm and relaxed appropriate as a blanket approach for tennis players in pursuit of the optimal sport experience.[11, 12] The study's finding of evidence of paratelic flow states suggest some players need to feel energised, 'hyped-up' or excited to attain, and maintain, flow.

This is entirely consistent with theoretical notions that feeling aroused does not mean the individual is anxious.[13, 14] It is this insight of the significance of a tennis player's interpretation of her arousal prior to, and during, performance which validates the adoption of reversal theory's conceptualisation of flow for understanding tennis flow.

Proposed integrated model of flow

In light of this study's findings, and the theoretical compatibility between Csikszentmihalyi's flow construct and reversal theory,[9] a conceptual model of flow (Figure 2) is proposed which integrates key psychological variables underpinning both Csikszentmihalyi's and reversal theory's approaches to flow.[15]

Figure 2 Model of flow illustrating the relationships between arousal (sense of feeling 'worked up/stirred up'), hedonic tone (degree of pleasantness), challenges and skills in telic and paratelic flow.[15]



In Figure 2, flow is denoted as one of two stable optimal states with regard to arousal. In the first state, flow is experienced as calm or relaxing, while in the second, flow is experienced as exciting or exhilarating. The former state is denoted as telic flow, and the latter, paratelic flow. In an addition to Figure 1 above, both telic and paratelic flow states are associated with the simultaneous presence of high challenges and high skills.

It is anticipated future research will extend evaluations of the proposed model and the relationships of key psychological variables underpinning flow in tennis and other sports. Interested researchers may wish to refer to sport studies which have adopted a reversal theory framework[13, 14] for a fuller description of reversal theory than could be practically presented in this paper.

Conclusion

The significance of this study is to challenge the traditional approach of researchers to exclusively adopt Csikszentmihalyi's[2,3] approach in investigations of flow. While this study provides clear evidence to support Csikszentmihalyi's flow construct, it also highlights a value in adopting a reversal theory perspective for understanding flow experiences of Australian professional female tennis players.

In capturing narrative accounts of flow from tennis players at the peak of their profession, the study provides clues for aspiring players, and their coaches, to foster and nurture flow experiences. These clues – including balance of high challenge and skill, experience and control of arousal, full involvement and concentration, clarity of goals and

feedback, loss of self-consciousness and sense of time and merging of action and awareness – suggest tennis flow experiences may be more readily achievable than previously thought.

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About the author

Dr. Janet A. Young, B.Com., B.A. (Hons), Ph.D., MAPS, is a lecturer in the School of Human Movement, Recreation and Performance at Victoria University and also conducts a sport psychology practice based in Melbourne, Australia. Her research interests include optimal performance and experiential states, talent development, mental toughness and retirement from sport.
Dr. Young has had a long involvement in tennis both at a National and International level in roles including Head of Women's Tennis at Tennis Australia, Tour Director for the Women's Tennis Association, Australian Fed Cup Manager, Tournament Director of the Richard Luton Properties Canberra Women's Classic and member of the ITF Women's Pro Circuit Committee. As a former Australian representative, Dr. Young was a member of two winning Fed Cup Teams. Tennis Australia and the International Hall of Fame recently honoured Dr. Young for her contributions to Australian Tennis.

Address for correspondence:
Janet Young
Sport, Recreation and Fitness
School of Sport and Science
Victoria University
P.O. Box 14428
Melbourne Vic 8001
Australia

Sports medicine | Anne Karelse and Joe de Beer

Internal impingement – the pathological cascade

Scapular dyskinesia due to repetitive overhead movements is among the common problems of the tennis playing shoulder. The resulting ante-tilting of the glenoid together with the anteroinferior laxity and posterior tightness of the capsule causes a shift of the centre of rotation of the shoulder. Abduction-external rotation movements will induce a posterosuperior shift of the humeral head resulting in a posterior SLAP lesion, possibly progressing to an articular side rotator cuff tear which can evolve to a full thickness tear.

It is important to identify the 'shoulder at risk' to prevent the development of this pathological cascade. This demands awareness of this phenomenon by coaches, physiotherapists and sports physicians. Efficient rehabilitation can prevent progression of damage to the shoulder joint and so, avoid surgery.

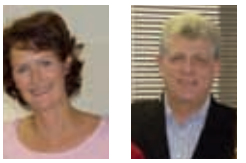


Photo: A. Karelse and J. de Beer

About the authors

A. Karelse, M.D., is an orthopaedic surgeon at the University of Gent, Belgium.

J. F. de Beer, M.D., is an orthopaedic surgeon at the Cape Shoulder Institute, Cape Town, South Africa.

Address for correspondence:
A. Karelse
Department of Orthopaedic Surgery
University of Gent
De Pintelaan 8
9000 Gent
Belgium

The additional value of a night splint to eccentric exercises in chronic midportion Achilles tendinopathy

In previous studies good clinical results for pain were found with eccentric calf muscle training on patients with painful Achilles tendinopathy. Functional outcome scores are lacking. It was hypothesised that the addition of a night splint to eccentric calf muscle exercises is beneficial for patient suffering from chronic Achilles tendinopathy. The study was designed as a randomised controlled single blinded clinical trial with one year follow-up.

62 tendons from 50 patients were included and randomised into one of two treatment groups. Both groups completed a 12 week heavy load eccentric training programme. One group received a night splint in addition to eccentric exercises. Outcome scores were: patient satisfaction, VISA-A score and VAS-score.

The results were as follows. After one year follow-up, patient satisfaction in the eccentric group was excellent or good in 53%, compared to 70% in the night splint group. This difference was not statistically significant. No significant differences were found in decrease in mean VAS-score and increase in VISA-A between the groups.

In both groups VAS-scores reduced significantly; from 56.3 to 27.9 (P <0.001) in the eccentric group and from 55.2 to 25.4 (P <0.001) in the night splint group. VISA-A increased significantly from 50.1 to 78.1 (P <0.001) in the eccentric group and from 49.2 to 78.0 (P <0.001) in the night splint group.

It was concluded that an additional night splint to eccentric exercises in the treatment of chronic midportion Achilles tendinopathy is not beneficial compared to eccentric exercises alone.

About the authors

S. de Jonge is a 5th year medical student at the Leiden University Medical Centre and co-ordinated a follow-up study at the Department of Sports Medicine in The Hague Medical Centre, the Netherlands.

R.J. de Vos is a Ph.D. student on Achilles tendinopathy research at the Erasmus Medical Centre in Rotterdam, the Netherlands and co-ordinated a randomised clinical trial at the Department of Sports Medicine in The Hague Medical Centre, the Netherlands.

Dr. J.L. Tol, M.D., Ph.D., is sports medicine physician at the Department of Sports Medicine in The Hague Medical Centre, the Netherlands.

Address for correspondence:
J.L.Tol
The Hague Medical Centre
Antoniushoeve
Department of Sports Medicine
Burgemeester Banninglaan 1
2262 BA Leidschendam
P.O. Box 411

Internal impingement

Long-term results of capsular shoulder shrinking and up-to-date treatment anno 2007

Nick Jansen and Geert Declercq

The underlying pathophysiology of internal impingement has been a subject of debate. Walch et al.[1,2] first described the pathophysiology of internal impingement. They found that all shoulders exhibit internal impingement in the abducted and externally rotated position, but that repetitive contact between greater tuberosity and the posterosuperior glenoid could lead to labral and rotator cuff damage in the throwing athlete. Jobe and Davidson et al.[3] attributed the pathologic findings to acquired anteroinferior instability. In order to eliminate this instability, some authors therefore advocated the use of arthroscopic thermal capsulorraphy.

Burkhart and Morgan[4] believe that the pathological cascade starts with a tight posteroinferior capsule. This leads to a glenohumeral internal rotation deficit and a shift in the glenohumeral rotation point. The created shear forces lead to a "peelback" and posterosuperior labral tearing. In their "circle concept theory", arthroscopic selective repair of the peel back lesion is the key to successful surgery if conservative treatment with posteroinferior capsular stretching fails.

We evaluated the long-term results of arthroscopic electrothermal shrinkage of internal impingement in competition athletes. In our study we only included high level, overhead athletes with a history of longstanding pain in their dominant shoulder due to internal impingement.

In this series, ten men and two women were included. All patients were high level overhead athletes who performed in different sports (volleyball, baseball, tennis and swimming). Age at the time of surgery ranged from 23 to 34 years old (mean 27 years).

Patients were included if clinical examination showed posterior shoulder pain in 90° of abduction, hyperextension and external rotation and a positive Jobe relocation test. A conservative treatment of intense physiotherapy for at least six months was initiated for all patients who presented with internal impingement. Twelve patients failed to respond to physical therapy and were treated with arthroscopic thermal capsulorraphy.

The study with a 7-year follow up shows the results of electrothermal capsulorraphy. Traditional treatment of internal impingement consisted of debridement of labral and/or undersurface cuff lesions. The use of concomitant electrothermal capsulorraphy, based on the concept of antero-inferior laxity, was advocated.

At the time of surgery, glenohumeral laxity was confirmed by external rotation greater than 100 degrees, at least 50% anterior translation and a positive drive-through sign. If necessary, debridement of labral fraying and articular sided partial rotator cuff tears was performed. Additionally all patients had thermal shrinking performed using a monopolar radiofrequency probe.

This probe produces a constant temperature of 65°Celsius at the tip of the probe. Our technique of capsulorraphy consisted of slowly painting the complete shoulder capsule (Figure 1 and 2).

Figure 1 Example of shoulder capsule before capsular shrinkage

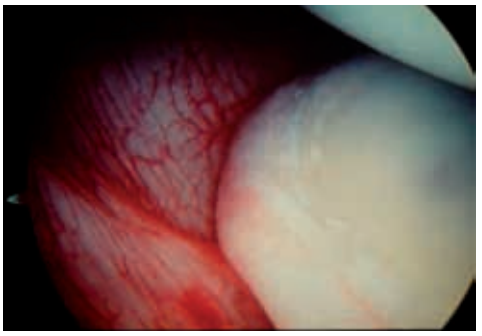
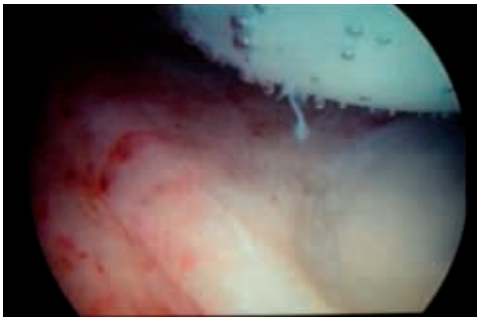


Figure 2 Example of shoulder capsule after capsular shrinkage



Rehabilitation consisted of immobilisation of the affected arm in a sling for four weeks. Then passive range of motion exercises were initiated, avoiding the last 15° of external rotation. Intensive physiotherapy leaded to a return to full sport activity at four months postoperatively. Twelve patients underwent traditional arthroscopic treatment for internal impingement and had a thermal shrinkage of their shoulder capsule. All patients were evaluated at 1, 2 and 7 years postoperatively using a questionnaire and the Modified Rowe score. The modified scoring system assesses pain (15/100), stability (30/100), motion (10/100) and function (50/100) of the shoulder. The maximum score is 100/100, meaning a painless shoulder, that experiences no apprehension, has a full range of motion and does not limit sport. Data showed a decline in long-term results. At 2 and 3 years postoperatively the results were excellent. The 7-year follow up, however, showed a significant deterioration of the initial results, and only 25% of the patients were able to perform at their preoperative level of sport.

Preoperatively the modified Rowe score was 45.83. At 1 and 2 years postoperatively the average scores were 89.48 and 90.42, respectively. The average modified Rowe score at 7 year postoperatively was 70.42. This is significantly worse than after 1 and 2 years follow up, but still significantly better when compared to the preoperative scores. At the time of final follow up, 3 of 12 athletes (25%) had returned to their pre-injury level of competition, 3 (25%) played at a lower level and 6 (50%) had retired because of their shoulder pain. Nine athletes (75%) would choose to have the surgery again, but 3 (25%) were not satisfied with the final outcome and regretting having had surgery.

We concluded that thermal capsulorrhaphy, in addition to traditional arthroscopic treatment did not address the pathology of internal impingement to a full extent. Recently Burkhart and Morgan[4] proposed the circle concept theory where they describe peel back of the posterosuperior labrum as the most important finding in internal impingement. These authors therefore advocate repair of the labral lesion with an anchor to neutralise torsional peel-back and thus eliminating the pseudolaxity.

Our personal experience confirms the above mentioned findings and we therefore now routinely fix the postero-superior labrum in athletes with internal impingement (Figure 3,4 and 5). We believe that in this matter the pathology is better addressed and this is the reason why we stopped using thermal capsulorraphy in these athletes. Since we started repairing the labrum defect results got much better. Obviously again these are only short term results, but addressing the posterosuperior labrum defect during arthroscopy seems to be the way to go.

About the authors

Photo: G. Declercq

N. Jansen, M.D. and **G. Declercq,** M.D., orthopedic surgeons, are based in the OLV Middelares Hospital, Deurne, Belgium. Dr. Declerq is chairman of the Medical Committee of the Flemish Tennis Federation.

Address for correspondence:
G. Declercq
OLV Middelares Ziekenhuis
Florent Pauwelslei 1
2100 Deurne
Belgium

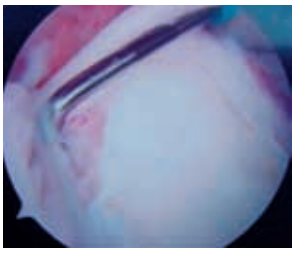


Figure 3
Peel-back of the postero-superior labrum

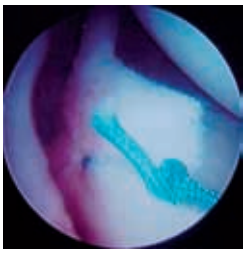


Figure 4
Fixation of the postero-superior labrum

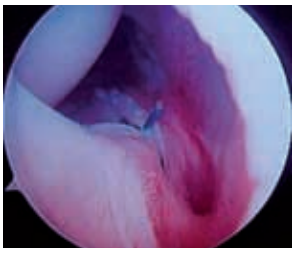


Figure 5
The postero-superior labrum after fixation

Our study confirms the good short-term results for thermal capsulorraphy in athletes with internal impingement. To our knowledge this study is the first that reports on the long-term results. Our data show that there is a marked deterioration of the results in time. We can not exclude that antero-inferior capsular laxity plays a role in the pathophysiology of internal impingement, but our study does not support the concept that treating this laxity by thermal capsular shrinkage will provide satisfying long-term results. Because there is still some doubt about the primary cause of internal impingement, it would be interesting to compare the results of capsulorraphy with those of the repair of the posterosuperior labrum..

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The value of ultrasound in assessment of chronic midportion Achilles tendinopathy

Neovascularisation, detected with Power Doppler Ultrasonography (PDU), is thought by some to play a central role in pathogenesis of Achilles tendinopathy. Our hypothesis was that the PDU neovascularisation score is correlated with clinical severity at baseline and after conservative treatment.

The study was designed as a prospective clinical trial. 70 tendons from 58 patients with chronic midportion Achilles tendinopathy were included. All patients were prescribed a 12-week heavy load eccentric training programme and evaluated with PDU at baseline, 12 weeks and one year. Patient satisfaction, Victorian Institute of Sports Assessment-Achilles (VISA-A) score and mean Visual Analogue Scale (VAS) score were correlated with degree of neovascularisation (five-grade scale).

In total, 63 tendons could be analysed after 12 weeks. 52 tendons were analysed after one year. Of the 63 symptomatic tendons at baseline neovascularisation scores were: 23 grade 0 (37% no neovessels), 18 grade 1, 8 grade 2, 8 grade 3 and 6 grade 4 (63% neovascularisation grade 1-4). At baseline there was no significant correlation between mean VAS scores (P=0.131) or VISA-A score (P=0.074) and neovascularisation score. At the 12-week follow-up, the neovascularisation score significantly correlated with the mean VAS score (r=0.43, P <0.001) and VISA-A score (r=-0.46, P <0.001). At the 52-week follow-up, the neovascularisation score significantly correlated with the mean VAS score (r=0.62, P <0.001) and VISA-A score (r=-0.56, P <0.001).

No significant differences were found in improvement of the VISA-A score at 12 (P=0.865) and 52 (P=0.222) weeks, between patients with (grade 1-4) or without (grade 0) neovessels at baseline.

In conclusion, 63% of the symptomatic tendons were found to have neovessels at baseline. There was no significant correlation between neovascularisation score and clinical severity at baseline, but at follow-up there was a significant correlation. Neovascularisation at baseline did not predict clinical outcome after conservative treatment and at the one-year follow-up.

About the authors

Photo: R.J. de Vos

R.J. de Vos is a Ph.D. student on Achilles tendinopathy research at the Erasmus Medical Centre in Rotterdam, the Netherlands and co-ordinated a randomised clinical trial at the Department of Sports Medicine in The Hague Medical Centre, the Netherlands.

S. de Jonge is a 5th year medical student at the Leiden University Medical Centre and co-ordinated a follow-up study at the Department of Sports Medicine in The Hague Medical Centre, the Netherlands.

Dr. A. Weir is a sports medicine physician at the Department of Sports Medicine at Medisch Centrum Haaglanden in The Hague, the Netherlands.

Dr. L.P.J. Cobben is a radiologist at the Department of Radiology at Medisch Centrum Haaglanden in The Hague, the Netherlands.

Dr. J.L. Tol, M.D., Ph.D., is sports medicine physician at the Department of Sports Medicine in The Hague Medical Centre, the Netherlands.

Foot muscles preventing inversion traumatisms

Koos Jaap van Zwieten, Inge Robeyns, Marjan Vandersteen, Peter Lippens, Roberto Mahabier and Kenneth Lamur

An inversion traumatism of the ankle usually occurs when, for example, a tennis player lands on one foot, while it is turned inward. The resulting ankle sprain causes swelling and pain on the outside of the ankle. As stated by Pallis[1] this is the most common of all tennis injuries.

The normal human step cycle of each leg is divided into a stance phase and a swing phase. The end of each stance phase is preceded by take-off of the heel. Subsequently, the medial side of the foot looses contact with the substratum. The lateral side of the foot initially stays in contact with the ground, while the sole of the foot increasingly faces medially. This movement is called inversion of the foot.[2]

Following toe-off, the foot starts its swing phase more or less in inversion, to be actively repositioned into eversion during the rest of the swing phase. Hereby the medial side of the foot is lowered, a process which continues after landing of the foot, from touchdown until mid-stance.[3]

Lowering the medial side of the right foot during sway consists of an anticlockwise rotation of this foot, as seen from the rear, around the longitudinal axis of the transverse tarsal joint (Chopart's joint). This axis of inversion and eversion was recently defined[4] as an oblique line passing through the lateral tubercle of the tuber calcanei of the heel bone and the calcaneal process of the cuboid up to the first interdigital space of the foot.

In the present study, the role of foot muscles in preventing inversion traumatisms was examined. We investigated if, during the swing phase of normal gait, some of the intrinsic foot muscles in particular may be active in everting the freely moving foot.

Examples of such intrinsic foot muscles are the m. extensor hallucis brevis and m. adductor hallucis, the latter being composed of a caput obliquum and a caput transversum.

After dissecting the anatomical specimens of ten normal human legs, measurements from these specimens were taken on tracings of radiographs. For each muscle, the angle between the muscle and the axis of inversion mentioned above, was determined.

This angle renders information about the effectiveness of the muscle with respect to the inversion axis. In the radiographs the bony structures mentioned above, served as landmarks. The direction of each muscle was identified in the radiographs by means of metal wires, wound around the muscle at origin and insertion. The axis of inversion and eversion were introduced to the tracings.

The length of each muscle's moment arm, with respect to the inversion axis, was also measured. This parameter was correlated with the efficiency of movement of the muscle.

The same procedure was applied to the tendons of two extrinsic foot muscles inserting on the foot (m. tibialis anterior and m. peroneus longus). Our analyses confirm that m. tibialis anterior is a strong invertor, while m. peroneus longus is a strong evertor.[5]

Furthermore, our analyses indicate that, theoretically, caput transversum of m. adductor hallucis may also be involved in preventing inversion traumatisms, by lowering the foot's medial side, thus everting the foot during the swing phase of gait. In this concept it is explicitly presumed, however, that the foot's medial side is more mobile than its lateral side.

Remarkably in this study, this caput transversum was absent in three out of ten human legs. Persons with m. adductor hallucis consisting of caput obliquum only, would theoretically be more sensitive for inversion traumatisms. Further research is necessary to support this hypothesis.

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About the authors

Photo: K.J. van Zwieten

K.J. van Zwieten, M.D., Ph.D., is responsible for the Functional Morphology Research Group at the University of Hasselt, Belgium, BioMed, and teaches Functional Anatomy and Embryology.

I. Robeyns M.Sc. did research in Functional Morphology, as a part of her Master's Thesis in Biomedical Sciences at the University of Hasselt, Belgium. Currently she works at Trenker Pharma Laboratories. As accredited representative, she keeps in touch with the latest developments in scientific research to keep people mobile.

M. Vandersteen, M.D., Ph.D., teaches Anatomy at the University of Hasselt, Belgium. She is Head of the Department of Basic Medical Sciences at this University, and a member of the Functional Morphology Research Group, BioMed, University of Hasselt, Belgium

P.L. Lippens, Ph.D., teaches Histology and Functional Morphology at the University of Hasselt, Belgium and is a member of the Functional Morphology Research Group, BioMed, University of Hasselt, Belgium.

R.V. Mahabier, M.D., teaches Functional Anatomy at the Medical Faculty of the University of Suriname, Paramaribo, Suriname. He currently prepares a Ph.D. thesis in Functional Anatomy.

K.S. Lamur, Ph.D., is Head of the Department of

Internal impingement instability of the shoulder

Imaging features focused on MR imaging

Henk-Jan van der Woude and Jaap Willems

In shoulder pathology, impingement can be classified as external impingement (primary or secondary) and internal impingement. Primary external impingement is secondary to contact between the rotator cuff and coracoacromial arch. Secondary external impingement reflects rotator cuff tendinosis and tears as a result of accentuated glenohumeral (micro) instability. This is typically seen in sports that require overhead or throwing motions. As a result of weakened static stabilisers, more load is placed on dynamic stabilisers including the rotator cuff muscles, resulting in fatigue of muscles, superior migration of humeral head and impingement of the rotator cuff.

Symptomatic internal impingement of the shoulder is a mechanism of injury that has been described in various types of (throwing) sports, including tennis. It may occur without (primary) or with (secondary) glenohumeral instability and capsular laxity. It may be classified as anterosuperior or posterosuperior impingement. In posterosuperior impingement, due to extreme combined ABduction and ExoRotation (ABER) of the shoulder (during the late cocking phase of throwing motions), the humeral head posteriorly translates on the glenoid and posterosuperior glenoid, and labrum may contact the deep undersurface of the rotator cuff. Contact between supra- and infraspinatus can be a physiological finding during overhead motion. However, as a result of repetitive impaction, this may result in glenohumeral joint lesions at that particular site, including labral degeneration, fraying and tears, paralabral cyst formation, articular-sided partial cuff tears, articular cartilage lesions and (reversible) posterosuperior humeral head cyst formation.

Plain radiographs may show abnormalities of the greater tuberosity, including irregular margin, reactive sclerosis and/or geode formation. In this respect, a glenoid profile view, compared with the contralateral side may add to the diagnosis.

Magnetic resonance (MR) imaging, particularly MR arthrography after intra-articular injection of a diluted mixture of contrast medium (Gd-DTPA), is very useful to detect these lesions that can be very subtle and it assists in differentiation from other shoulder problems including rotator cuff injuries. Identifying the most likely cause of shoulder pain may have serious consequences for further treatment. MR arthrography is considerably more sensitive than conventional MRI for the detection of partial thickness cuff tears and labral tears. Imaging the shoulder in ABER apprehension position simulates the mechanism of injury and as such optimally depicts the posterosuperior glenohumeral joint. Besides the ABER position, the entire scan protocol includes T1-weighted TSE sequences with fat

saturation in oblique coronal and sagittal directions, axial T1-weighted gradient echo sequence and coronal proton-density, and T2-weighed series.

Rotator cuff tears in internal impingement are usually found on the deep surface of the posterior supraspinatus or supraspinatus-infraspinatus junction at about 1 cm from the greater tuberosity insertion. Tears are articular sided and typically small, depicted as small linear contrast extensions in the tendon. These tears can be easily missed without ABER positioning, which allows contrast imbibition into a relaxed posterior superior rotator cuff.

Frequently, subtle posterosuperior labral abnormalities can be appreciated, demonstrated as contour irregularities and/or signal increase and impaction deformities at the posterior greater tuberosity. It has been suggested that glenohumeral internal rotation deficit and tightening of the posterior shoulder elements (capsule, cuff) may contribute to impingement. As such, thickening and scarring of the posterior capsule can be seen on MR images as well.

MR signs of posterosuperior impingement can be seen in approximately one third of throwing shoulders, but is not a consistent predictor for pain. Similarly, a high incidence of partial or full thickness rotator cuff abnormalities can be appreciated in dominant asymptomatic shoulders of overhead throwing athletes.

In contrast to posterosuperior internal impingement, anterosuperior impingement is less frequently described. In these patients, shoulder pain is provoked by internal rotation and elevation. In anterosuperior internal impingement, MR arthrography may demonstrate partial thickness articular-sided subscapularis tears, secondary to impingement along the anterior superior glenoid rim. At arthroscopy, partial subscapularis lesions can be encountered with or without pulley lesion, which reflects the combined humeral insertion of the superior glenohumeral ligament and coracohumeral ligaments.

In conclusion: abnormalities related to internal impingement of the shoulder are optimally depicted using MR arthrography. Including a sequence in abduction-exorotation position is strongly advocated. Under any circumstances, however, close correlation with clinical findings is pivotal.

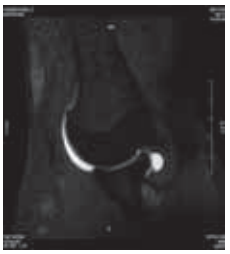

Figure 1 T1-weighted fat-saturated MR arthrogram in ABER position. Physiologic narrow contact between the deep undersurface of the rotator cuff and the postero-superior glenoid and labrum in a young elite gymnast.

Figure 2 T1-weighted fat-saturated MR arthrogram in ABER position. There is branching contrast extension within rotator cuff on the articular side reflecting partial tear and subtle posterosuperior labrum abnormality (arrow). American football player with complaints consistent with PSI.

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About the authors

H.J. van der Woude, M.D., Ph.D., is a member of staff at the radiology department, Onze Lieve Vrouwe Gasthuis, Amsterdam, the Netherlands. His main field of interest in diagnostic imaging is MR imaging and orthopaedics.

W.J. Willems, M.D., Ph.D., is an orthopaedic surgeon in the same hospital with principal experience in shoulder pathology.

Address for correspondence:
H.J. van der Woude
Department of Radiology
Onze Lieve Vrouwe Gasthuis
P.O. Box 95500
1090 HM Amsterdam
The Netherlands
h.jvanderwoude@olvg.nl

Fast MR arthrography of the shoulder joint using VIBE to evaluate the rotator cuff

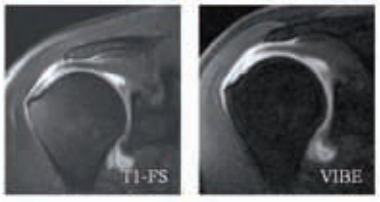
Jan Vandevenne, Filip Vanhoenacker, Geert Gelin, Bie Velghe, Yvan Palmers, Arthur de Schepper and Paul Parizel

Concerning the radiologist dealing with tennis players, the demand is high for immediate and accurate diagnosis after a shoulder joint injury. Until recently, diagnostic imaging in the acute phase after injury mostly relied on radiography and ultrasound examinations. Ultrasonography is readily available and cheap, but has its limitations because the accuracy is operator-dependent and ultrasonography does not show all shoulder joint structures. In recent years, both professional and recreational tennis players are increasingly seeking magnetic resonance (MR) imaging soon after trauma. MR arthrography (MRA) is a well established and accurate imaging modality for diagnosis of internal derangements of the shoulder joint. However, immediately following trauma patients are often in pain during the MR examination and can only be immobilised for a short time. Applying the standard MR sequences, mainly spin echo T1-weighted fast saturated (T1-FS) with acquisition times of five minutes for each imaging plane, often results in degraded MR images due to movement artefacts.

VIBE (volumetric interpolated breathhold examination) is a gradient echo sequence that only lasts a few seconds, and nevertheless demonstrates a high contrast-to-noise ratio between gadolinium contrast and the rotator cuff. If the accuracy of VIBE to diagnose internal derangements of the shoulder joint is comparable to the accuracy of the standard sequences, VIBE may become the preferred MR arthrography sequence in athletes who cannot immobilise the shoulder for a prolonged time because of pain after recent trauma.

As a first project, we performed a study to evaluate the accuracy of fast MRA with VIBE sequences for diagnosing tears of the rotator cuff using the T1-FS sequence as the imaging gold standard. 82 athletes, mainly tennis players, underwent direct MRA of the shoulder joint with both VIBE and T1-FS sequences in the axial and paracoronal plane. The T1-FS sequence took five minutes for each imaging plane; the VIBE sequence lasted only 13 seconds. To identify and evaluate rotator cuff tears, two radiologists independently performed separate blind scorings of VIBE and T1-FS images. Scores were defined as normal, fraying or small partial thickness undersurface rotator cuff tears, large partial thickness undersurface rotator cuff tears, and full thickness tears with or without extension to the acromioclavicular joint. Accuracy of VIBE was calculated per score, using the T1-FS sequence as the imaging gold standard. Calculating the results, sensitivity and specificity values over 90% were found for large partial thickness undersurface tears and for full thickness tears with or without contrast extension in the acromioclavicular joint. However, for fraying and small partial thickness tears at the undersurface of the rotator cuff, the sensitivity was only 55%. This was felt to be related to the lower spatial resolution obtained using the VIBE sequence, and was mainly a consequence of the very short acquisition time.

Figure 1 The full thickness tear of the rotator cuff (infraspinatus tendon) is equally well demonstrated by the standard T1-FS sequence as by the VIBE sequence which lasts only 13 seconds.



In conclusion, MR arthrography using VIBE sequences was found to be an accurate tool for diagnosing large partial thickness undersurface tears and full thickness tears of the rotator cuff. Due to its short acquisition time, VIBE may be the preferred MR sequence for evaluating the rotator cuff of patients who cannot lie still because of pain after recent injury, or patients suffering from claustrophobia.

About the authors

Dr. J. Vandevenne is a young radiologist with special interests in MR imaging and musculoskeletal imaging. He was trained at the University Hospital of Antwerp where he received a two-year research grant for studying MR imaging of soft tissue tumours under the guidance of Prof. A. de Schepper. Via a Schering Research Fellowship and a Radiology Research and Education Foundation grant, he completed 1.5 years of research and training at the Lucas MRI and MRS Centre in Stanford University, San Francisco. Currently, Dr. Vandevenne is working as a radiologist at the Ziekenhuizen-Oost-Limburg in Genk, Belgium.

Drs. G. Gelin, B. Velghe and **Y. Palmers** are radiologists in the same hospital. **Dr. Filip Vanhoenacker** is a consultant radiologist at the University Hospital Antwerp and also a radiologist at the St.-Maarten hospital in Duffel-Mechelen. **Prof. Parizel** is Head of Department of Radiology at the University Hospital Antwerp, and **Prof. De Schepper** is a professor emeritus of the same department.

Address for correspondence:
J. Vandevenne
Department of Radiology
Ziekenhuizen Oost-Limburg
Schiepse Bos 6
B-3600 Genk
Belgium

Photo: J. Vandevenne

Treatment of long-standing groin pain in athletes

A systematic review

Jaap Jansen, Jan Mens, Frank Backx, Nikki Kolfschoten and Henk Stam

The treatment of longstanding groin pain in athletes is a challenging problem in sports medicine. The possibility of multiple co-existing pathologies complicate the diagnostic process.[1,2] A second complicating factor is the poor validity of diagnostic tests.[3] As a consequence, it is hard to choose the optimal treatment strategy.

The aims of this study were to determine 1) what kinds of treatments are applied in practice for longstanding groin pain in athletes; 2) what are the results of these interventions; and 3) to determine the levels of evidence of the studies describing these interventions.

A literature search using the following combination of keywords:

"("groin pain" OR "groin injury" OR "sportsman's hernia" OR "sports hernia" OR "osteitis pubis" OR "symphysis syndrome" OR "athletic pubalgia" OR "adductor tendinitis" OR "adduction-related") AND ("treatment" OR "surgery" OR "tenotomy" OR "physical therapy" OR "physiotherapy") AND (athletes OR sportsmen OR soccer OR hockey OR football)"

was performed in the digital databases Pubmed, Embase, Science Direct, Scopus, Doconline and Cochrane from 1966 till 1 April 2006.

The search retrieved 135 relevant titles. A total of 92 were excluded because they were reviews, small case reports, comments or letters, or not written in English, German or Dutch. Of the resulting 43 articles evidence levels were determined using the method described by the North American Spine Society (available through the website of the North American Spine Society; www.spine.org) and the Delphi list by Verhagen et al.[4]

Treatment for longstanding groin pain in athletes consists mostly of conservative measures like rest or restricted activity, physical therapy. If this does not give the desired effects, steroid injections or dextrose prolotherapy can be applied. When this remains unsuccessful, explorative surgery is the next option. A reinforcement of the abdominal wall (sometimes in combination with adductor tenotomy) is applied in most cases, using an open or laparoscopic approach.

There is high quality evidence that physical therapy aiming at the strength and coordination of the muscles stabilizing the pelvis has positive effects compared with passive therapy.[5] Based on one moderate quality study, there are indications that surgery will result in earlier return to sport compared with conservative therapy in patients with positive herniography and/or positive ilioinguinal or iliohypogastric nerve block tests.[6] In surgery, laparoscopic intervention

results in earlier return to sport compared with an open approach (Level III).[7] 36 studies were retrospective case series (Level IV) and no valid conclusions can be drawn based on these studies.

It was concluded that there is lack of high quality research in international literature considering treatment of longstanding groin pain in athletes. Reinforcement of the abdominal wall by means of a mesh is performed in most studies, since migration of the content of the abdominal cavity into the pre-peritoneal space is thought to be the underlying mechanism. However, it is noticeable, that several authors agree on the causal mechanism of some kind of imbalance over the anterior pelvis, which causes the weakest link in the kinetic chain (abdominal wall, symphysis, adductor muscle) to give complaints.[6, 8, 9] Therefore, the interventions performed in these studies, whether conservative by physical therapy,[6] surgical by reattachment of the tendon of the straight oblique for abdominal wall problems,[8] or mesh placement for osteitis pubis,[9] interventions are always focused at balancing forces acting on the pelvis, and are reported to be successful. However, quality research in terms of large-scale randomized clinical trials is needed in this field.

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About the authors

Photo: J.A.C.G Jansen

A.C.G. Jansen is a Ph.D. student at the Department of Rehabilitation and Sports Medicine at the UMC in Utrecht.

Prof. Dr. F.J.G. Backx is head of this department.

J. M.A. Mens, M.D, Ph.D., is researcher at the Department of Rehabilitation at the Erasmus Medical Centre in Roterdam.

N. J. Kolfschoten is a medical student at the Erasmus University in Rotterdam.

Prof. Dr. H.J. Stam, is Head of the Dept of Rehabilitation at the Erasmus Medical Centre in Roterdam.

Address for correspondence:
J.A.C.G. Jansen
Department of Rehabilitation and Sports Medicine
UMC Utrecht
P.O. Box 85500
3508 GA Utrecht
The Netherlands

Monitoring of load in young tennis players

Paul Ponnet

In youth sports it is known that performance improvement is often a combined result of growth and maturation with training effects. Sports training in young athletes has thus to consider that the energy cost, and therewith the stress of effort, is most probably higher than it is in well trained adult top athletes. And if not higher, it has at least to be considered as different from that in adults. Consequently, training planners should be aware that "load", defined as the cumulative training stress for a certain period, needs particular attention. The balance between session contents, session density, session stress and optimal recovery, within and between sessions, needs proper individual follow-up.

Nearly every sport has its own specific performance structure. However, sports mainly rely on general capacities. There is always a merge between technical and physical fitness elements. The quality of most of the sports motor actions depends on the neuromuscular and/or cardiovascular capacities of the athlete. In children and youngsters both capacities are constantly growing, maturing and developing. So it is important that the separate strain on the muscles and the cardiovascular system are well organised within the planning and follow-up of training.

Training planning

Motor development studies show that the acquisition of new skills, and consequently new sports skills, put a high stress on the neuromuscular system. This is mainly due to the energy cost of coordinative adaptations. The coordination of the different intra- and inter-muscular motor units has to economise. The younger the athlete, the more new motor answers have to be installed for the acquisition of a wide range of motor actions and handling. The more novice the athlete, the less economic these motor performances are. Thus it could be expected that the economy of training response depends on calendar age, maturity status, training age, and probably talent.

Pilot study

At the training centre of the Flemish Tennis Federation (Belgium), a pilot study was set up for a better understanding of the individual response on training strain between the youth elite squads. Heart rate monitoring was used to register the individual cardio-respiratory response to a set of standard on-court exercises, each of a well defined duration, and separated by a defined recovery phase.

Subjects

The study groups consisted of 4 girls and 4 boys, subdivided as follows: 2 girls and 2 boys aged 13 years, and 2 boys and 2 girls aged 15 years. All players were members of the national talent squad. Data samplings were done in the spring of 2002. Since this time, 1 girl and 2 boys from this group have been highly ranked on the final world junior rankings in the year that they became 18 years of age.

Data sampling and evaluation method

Prior to the session at which the heart rate response to a defined set of standard on-court exercises was registered, the players underwent, on separate days, 2 incremental running tests to define VO_2 and heart rate dynamics in relation to running speed. These tests were a standard treadmill protocol, and a field shuttle run over 20 meter to

exhaustion (Légertest). Afterwards test results were matched to define the individual heart rate zones. A few days later a set of 9 classic tennis training exercises was performed, and at the end a high intensity ball game was played as a control for the maximum attainable heart rate.

Results

Heart rate data was analysed using Intensiogram® software, allowing a visual comparison of the chronological alternation of five individually defined heart rate zones (Figure 1). Due to individual profiles, the heart rate response showed individual intensity alternations per exercise. However the differences were always larger between age groups, and between both sexes, than between the age peers per group. In the major part of the exercises the girls' heart rates tended to be lower at effort, but remained higher during the in-between repetition intervals. The recovery heart rates between the separate exercises showed no visual differences between both sexes. In the exercise sets that combined the need for a higher technical mastering with larger replacement distances, the younger players' heart rates were generally lower. Thus we concluded that there is definitely a different exercise stress per age and between sexes. However, heart rate monitoring can only explain a part of the exercise strain, since muscle activity strain does not always cause reliable heart rate responses.

Discussion

Since there were only 4 players observed per age group, 2 girls and 2 boys, and the characteristics of the players were certainly not average, the findings should be interpreted with caution. It can be expected that less skilled young players show different heart rate answers to the exercise stress. The better the skill, the longer lasting the ball exchanges, and thus, the higher the intermittent intensity efforts.

Conclusions

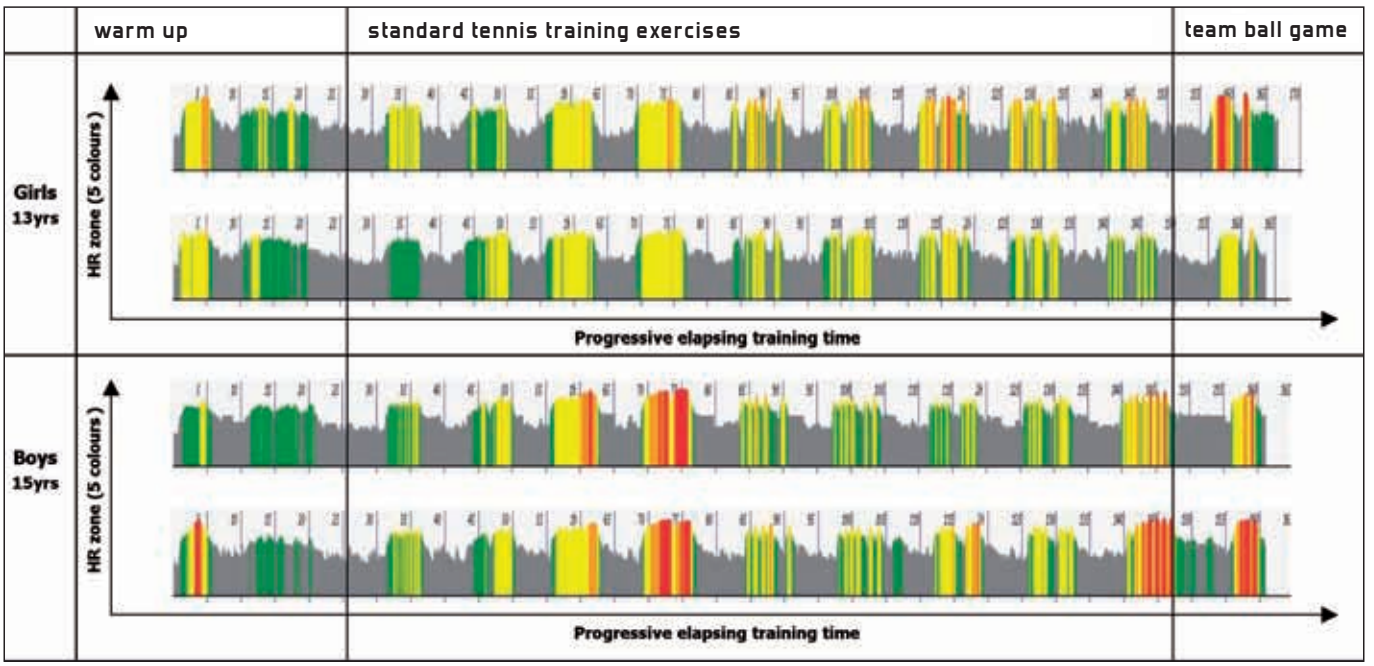
Heart rate monitoring is a valid method to monitor exercise stress in tennis. Data however has to be interpreted regarding training age, talent, kind of exercise, and most of all in relation to a personal profile. For deeper conclusions, it would be of interest to use heart rate monitoring in combination with movement tracking systems, such as accelerometers, for a better understanding of muscle power output, and eventual energy expenditure per training session. Visual interpretation of heart rate monitoring can contribute to a fast and useful analysis of training load tendency.

About the author

Paul Ponnet, Ph.D., is a specialist in talent development. He advises federations, teams and individual athletes. At the Flemish Tennis Federation he advises the federal coaching staff from the talent groups in the planning and the follow-up of training response.

Address for correspondence:
Paul Ponnet
www.sportconsultancy.com
pponnet@sportconsultancy.com

Figure 1 Heart rate response in pubertal girls and boys during tennis drills



Dr. Javier Maquirriain

Javier Maquirriain, M.D., Ph.D., is an orthopaedic surgeon, specialising in Sports Medicine and Arthroscopic Surgery. He has been the Medical Director of the Argentine Tennis Association since 1998.

1 How did you develop in sports yourself?

I was introduced to sport by my parents. My father Eulogio was an excellent tennis player and an enthusiastic car racer, and my mother Susy plays tennis and golf. I started playing tennis at the age of seven. I was the top ranked junior player in Argentina and have played some professional tournaments. I then started playing paddle-tennis; a novel racquet sport which has became very popular in South America and Spain. I was Paddle-Tennis World Champion between 1988 and 1993 and played with several partners including my brother Gustavo.

2 Why did you choose to become an orthopaedic surgeon?

My passion for sports was a determining factor for choosing orthopaedics and sports medicine.

3 Your Ph.D. was on endoscopic surgery of Achilles tendon injuries. Why did you choose that topic and what did you learn from it?

I was interested in Achilles tendon problems because I suffered from chronic Achilles tendinopathy myself during my paddle-tennis career. The idea of performing endoscopic surgery on the Achilles tendon came to mind during a car trip! My thesis included a cadaveric study carried out at the San Isidro Hospital's morgue and I "almost died" from an electric-shock caused by a damaged cable.

4 You are currently the Vice-President of the Society for Tennis Medicine and Science. Where would you like to see the STMS ten years from now?

The STMS was founded by the "Fathers of Sports Medicine" - Ben Kibler, Per Renstrom and Peter Jokl, among others. I was elected to the STMS Board in 2001 and I'm really proud to be a member. Dr. Babette Pluim has done a terrific job in recent years and the members have also contributed to expand the society. The STMS has made significant contributions to tennis medicine in the past decade and I am sure that it will continue to provide a source of knowledge and expertise for health professional involved in our sport. I would hope that tennis related companies and organisations (ATP, WTA and ITF) can be persuaded to give financial support to continue this work.

5 What is the main goal of the Argentine Medical Committee?

The mission of our Medical Department is "to provide scientific care to tennis players in order to help them reach their maximal performance". We provide full medical cover for approximately 200 players, including juniors and professionals. Last year we launched an ambitious Anti-doping Program which includes testing (in- and out-competition) and an intensive education programme.

6 You have written two (Spanish) books on "Sports Medicine Applied to Tennis" and you are the editor of "Medicine & Tennis On-Line". What does it mean to you?

I was honoured to be Editor-in-Chief of these books and to have the support of so many several international experts in the field of tennis medicine. I know that the Spanish version was a really useful way to disseminate high quality information to our Latin American doctors. I am now working with Todd Ellenbecker (USTA Director Sports Medicine) on the third volume which will update many of the current "hot topics" such as core-stability, stress fractures and motor learning.

We also have an e-mail newsletter that has been bimonthly edited since 2001. It is a useful educational tool to keep in touch with the Argentine regional federations and with all the tennis associations in Latin America. Last week, during the Pan-American Games in Rio de Janeiro (Brazil), I met the President of the Cuban Tennis Federation and he assured me that he greatly enjoys the Newsletter and forwards it on to all the Cuban coaches and regional academies.

7 You have conducted several research projects in tennis. Which one are you most proud of and why?

We consider research as an essential part of our Medical Department commitment. We have published a number of articles regarding the present injury pattern in competitive tennis players. In my opinion, the analysis of the incidence and distribution of stress fractures in tennis has proved to be of particular interest and relevance.

8 What are the major challenges facing tennis at the moment?

Tennis has received increasing interest in the scientific literature over the last decade. Consequently, most tennis-related injuries and medical problems are now better understood and can be treated on the basis of good medical evidence. In my opinion, there is a marked lack of understanding of the psychosocial effects on professional tennis players. In our country, we have just formed a study group with the objective "to set guidelines that will help attenuate the costs of a professional tennis career".

9 What is your opinion on the doping cases in tennis in Argentina?

Doping is a very complex issue and seven Argentine tennis players tested positive between 2001 and 2005. The substances found were anabolics, stimulants and masking agents. Fortunately, we have not had any positive cases in the AAT representative teams (Davis Cup, Fed Cup, Olympics).

We know that drug use is a common problem of highly competitive sports and that there is a major issue with supplement abuse among tennis players. Another big problem is self-medication and drugs issued by coaches and trainers. From a social perspective, there is also a potentially self-destructive characteristic in Argentine society that may influence our athletes´ behaviour. In my opinion, sports federations (national and international) should adopt a more proactive approach to doping problems and should listen and react to positive criticism regarding the present WADA Code.

Kathleen Stroia awarded Most Distinguished Athletic Trainer

Pictured in the photo to Kathleen's left is Mary Donahue, chair of the Most Distinguished Athletic Trainer Subcommittee. To her right, Chuck Kimmel, MA, LAT, ATC - NATA President.

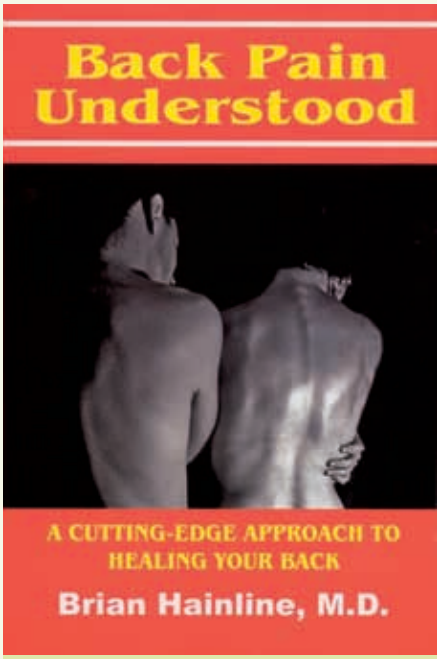
Kathleen Ann Stroia, M.S., P.T., ATC., a Vice President of Sports Medicine for the WTA Tour, has been selected as one of the National Athletic Trainers' Association's 2007 Most Distinguished Athletic Trainer (MDAT) award recipients. The MDAT presentation was made on June 29, 2007, at NATA's 58th Annual Meeting & Clinical Symposia in Anaheim, California.

Kathleen has worked for the professional women's tennis tour since 1989 and became Director of the Sports Medicine Department in 1992. She has contributed to the international exposure of the athletic training profession and continues the Tour's most valuable commodity, athlete health.

The MDAT award recognizes outstanding dedication and service to the athletic training profession. Candidates for the award must have held the certified athletic trainer (ATC) credential, conferred by the Board of Certification, for at least 20 years; have been recognized for service to the profession of athletic training at the local, state, national and/or international level; exhibited distinguished service as a certified athletic trainer; and been recognized for unique contributions to the profession of athletic training not acknowledged elsewhere. Kathleen is one of nine nationwide recipients of the award in 2007.

"Dedication, innovation, loyalty and leadership are common traits among MDAT recipients", said National Athletic Trainers' Association (NATA) Executive Director Eve Becker-Doyle, CAE. "Those who receive the honour serve as an inspiration to their peers and as role models to the next generation of certified athletic trainers."

Back Pain Understood: A Cutting-Edge Approach to Healing Your Back



Babette Pluim

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ISBN: 0-9787727-0-9
Price: 17.95 US$

It has been estimated that back pain affects 80% of the population at some time in their lives. Back pain is one of humanity's most frequent complaints. In the United States, acute low back pain is the fifth most common reason for all physician visits. About nine out of ten adults experience back pain at some point in their life, and five out of ten working adults have back pain every year.

Thus, Dr. Hainline's book *Back Pain Understood: A Cutting-Edge Approach to Healing Your Back*, is much needed. In this book Dr. Hainline has combined his years of clinical experience with his knowledge of emerging pain medicine, mind-body medicine, and the multitude of treatment paradigms offered to patients who suffer with chronic back pain. From the most elite tennis player to the most sedentary layperson, this writing provides insight into understanding the essential meaning of back pain.

The first section of the book provides very clear and essential information on the causes of low back pain, the anatomy of the back, type of clinicians who treat low back pain, imaging and diagnostic studies, medications and surgical and non-surgical treatments. It is amazing to see how many therapists and treatments there are!

This is followed by a very interesting chapter on 'Mind-body and integrative strategies'. This chapter brings a unique and refreshing approach to understanding the nagging problem of back pain, whereby not only the physical aspects of low back pain, but also the non-conscious and emotional processing of pain are taken into account.

This holistic approach is also followed in the second section of the book, in which the various low back syndromes are discussed: lumbar strain, lumbar disc herniation, lumbar degenerative disc disease and lumbar spondylosis, facet pain, lumbar stenosis, sacroiliac pain, myofascial pain, failed back syndrome (post-laminectomy syndrome) and chronic pain syndrome. Various case reports provide good illustrations of the way the mind and body interact. A rich glossary of terms ensures easy reference.

This book is a great resource not only for patients, but also for physicians and clinicians who need to better understand the complexities of back pain. The illustrations are outstanding, and the discussions about anatomy, the meaning of pain, treatment approaches and the different back syndromes are interesting, informative and easy to follow.

About the author
B. Hainline, M.D., is Chief of Neurology and Integrative Pain Medicine at ProHEALTH Care Associates in Lake Success, NY, and Clinical Associate Professor of Neurology at New York University School of Medicine.

At ProHEALTH, he has developed a comprehensive, multi-disciplinary Pain Center that embraces a rigorous scientific approach with compassionate holistic medicine.
In addition to his daily work in pain medicine, Dr. Hainline – an avid tennis player and tennis advocate – has raised the standard of care for tennis medicine worldwide. He is Chief Medical Officer of the US Open Tennis Championships, and Chair of the International Tennis Federation Sport Science and Medicine Commission. In recognition of his medical contributions to the sport of tennis, he is the recipient of the prestigious 2001 International Tennis Hall of Fame Tennis Education Merit Award, and the 2004 WTA Tour Irving Glick Award.

Society for Tennis Medicine and Science

Join us now!

The Society for Tennis Medicine and Science (STMS) is an international organization of sports medicine and science experts aiming to serve as an international forum for the generation and dissemination of knowledge of tennis medicine and science.

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Medicine and Science in Tennis is a Journal produced by the Society in co-operation with the ITF, the ATP and the Sony Ericsson WTA tour. Arko Sports Media in the Netherlands is the delegated publisher. The Journal is issued twice a year. Medicine and Science in Tennis is listed in Altis, Free Medical Journals, MedNets, NewJour, Sponet and SIRC Sports Discus.

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The Society is proud to introduce a completely new website for the STMS, www.stms.nl. The site has been totally redesigned and now includes our extensive library, background information on the STMS, our conference calendar and the latest news items. The Members Area, with full access to the current issue of Medicine and Science in Tennis, Injury Cards, the Tennis-editions of the British Journal of Sports Medicine and Member Profiles, is only available for members. We strongly encourage you to put it on your Favourites List immediately.

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