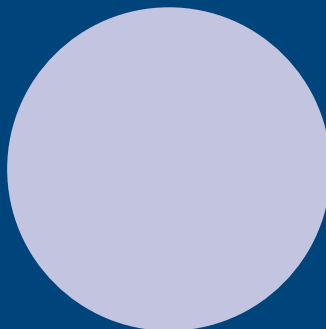
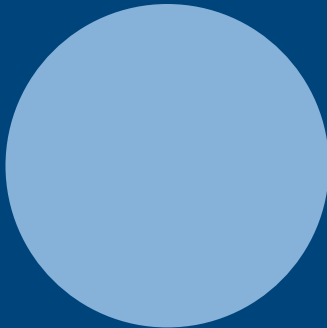
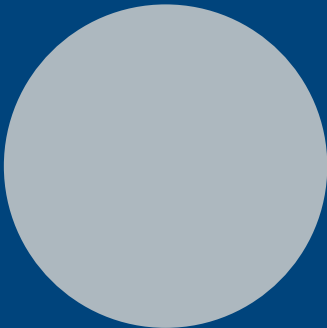
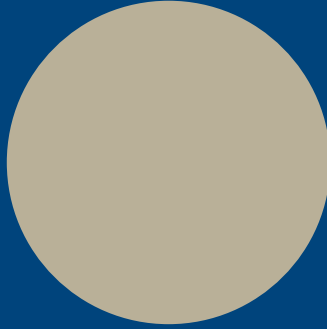




RECOVERY IN TENNIS



A GUIDE TO IMPROVING PERFORMANCE AND
LIMITING INJURY THROUGH IMPROVED RECOVERY



INTRODUCTION

This *Recovery in Tennis* booklet is a culmination of a multi-year project undertaken by the Sport Science Committee of the United States Tennis Association (USTA). Recovery is a complex paradigm focusing on recovery from training — session to session, day to day and week to week. Recovery is also vitally important during training as well as in competition between matches and between days during multi-day tournaments. As more information is needed in the area of tennis specific recovery, the Sport Science Committee of the USTA sponsored an extensive evidence-based review of the available literature on tennis-specific recovery and this booklet is a summary of a larger document (approximately 400 pages) which has been compiled into a book titled *TENNIS RECOVERY: A Comprehensive Review of Research*. This book is focused on eight areas of tennis specific recovery, and below are the chapter topics and authors (who are all world leading experts in their specific areas of tennis and/or recovery).

*Please see the following link for access to the full electronic version of the book
- [TENNIS RECOVERY: A Comprehensive Review of Research](#)*

TABLE OF CONTENTS

And authors of original chapters

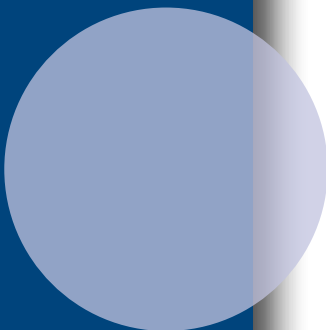
A NORMAL MATCH		4
FATIGUE		6
PERIODIZATION		8
HEAT & HYDRATION	Mark Kovacs, PhD <i>(USTA Sport Science)</i>	9
PSYCHOLOGY	Kristen Dieffenbach, PhD <i>(West Virginia University)</i>	11
PHYSIOLOGICAL	William J. Kraemer, PhD Shawn D. Flanagan, BA Gwendolyn A. Thomas, MA <i>(University of Connecticut)</i>	13
NUTRITION	Susie Parker-Simmons, RD <i>(USOC Nutritionist)</i>	14
COACHING ASPECTS	Angela Calder, MA (Hons) <i>(Australian Institute of Sport and The University of the Sunshine Coast)</i>	17
MUSCULOSKELETAL	W. Ben Kibler, MD <i>(Lexington Sports Medicine Center & the USTA Sport Science Committee)</i> Aaron Sciascia, MS <i>(Lexington Sports Medicine Center)</i> Todd Ellenbecker, DPT <i>(Physiotherapy Associates, ATP Tour & the USTA Sport Science Committee)</i>	20
YOUNG ATHLETE	Ellen Rome, MD <i>(Adolescent Medicine, Cleveland Clinic & the USTA Sport Science Committee)</i> Gordon Blackburn, PhD <i>(Cleveland Clinic)</i>	21
MEDICAL	Margo Putukian, MD <i>(Head of Athletic Medicine, Princeton University)</i>	22

A NORMAL MATCH

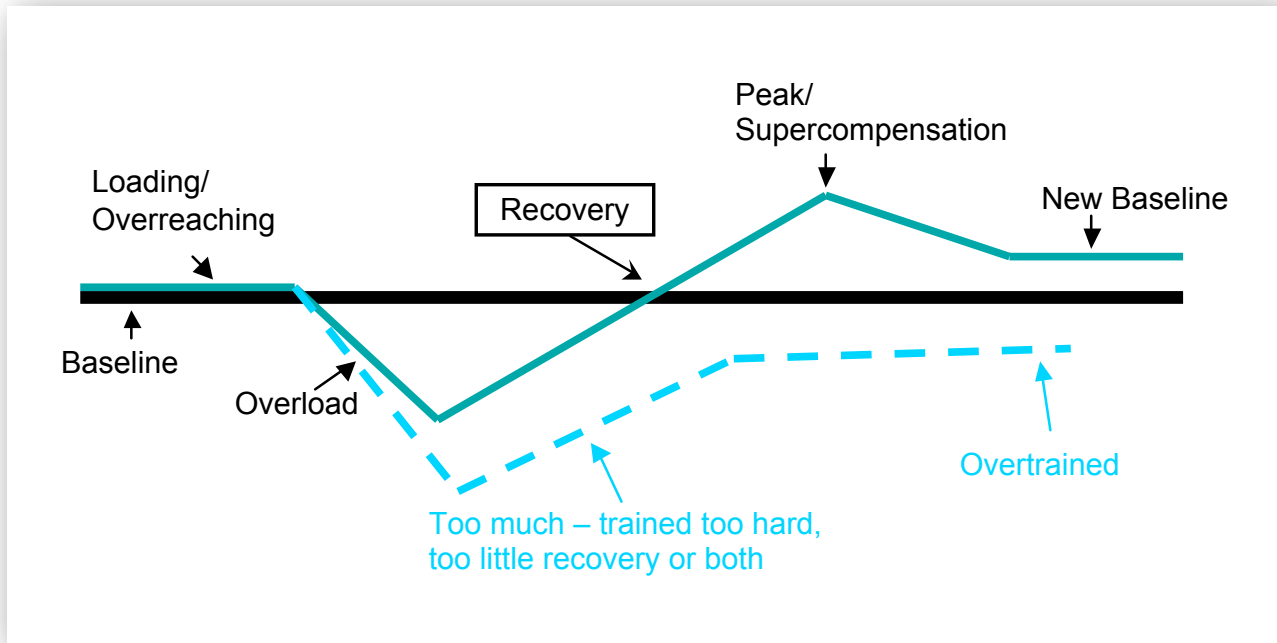
- *45 minutes to 5 hours!*
- *Exercise to rest ratios range between 1:2 – 1:4*
- *20-25 seconds rest between points and 60-90 seconds every change of ends*
- *An average point encompasses 2-5 strokes with an average of 4 directional changes.*
- *Elite players run an average of 3 meters per shot, with 8-12 meters per point*
- *300-500 high-intensity efforts per “best of 3 set” match*
- *Point duration typically last less than 10 seconds*

Competitive players usually compete in between 15-30 tournaments per year, which results in 50-150 competitive singles matches and the possibility of more than 50 doubles matches per year.

Recovery is often overlooked, or worse taken for granted. Time alone may provide recovery, but most of the time tennis athletes do not have enough time to recover sufficiently. The purpose of this booklet is to provide both information and tips on recovery for the tennis player.



Training alone does not result in improved performance. It is only achieved when matched with proper recovery.



Training, Recovery and Overtraining Diagram

FATIGUE

Fatigue – sensation of tiredness associated with decrements in muscular and nervous system performance and function. In tennis this fatigue presents itself as a decrease in stroke accuracy, stroke mechanics, serve velocity, court movement, increase in errors, poor shot selection, increased mental frustration and mental errors.



TYPE OF FATIGUE	MAIN CAUSES FOR FATIGUE
<p>METABOLIC FATIGUE</p> <p>(Energy Stores)</p>	<ul style="list-style-type: none"> ▶ Long training sessions (> 60 minutes) ▶ Playing several matches a day (e.g. singles and doubles) ▶ Cumulative fatigue from training or competing over many days
<p>NEUROLOGICAL FATIGUE</p> <p>PERIPHERAL NERVOUS SYSTEM FATIGUE (PNS)</p> <p>(muscles)</p>	<ul style="list-style-type: none"> ▶ After short, high intensity sessions, (e.g. weights, plyometrics, complex skill execution, etc.) ▶ After long training sessions ▶ Several matches over consecutive days
<p>NEUROLOGICAL FATIGUE</p> <p>CENTRAL NERVOUS SYSTEM FATIGUE (CNS)</p> <p>(brain)</p>	<ul style="list-style-type: none"> ▶ Low blood glucose levels ▶ High pressured training session – especially involving rapid decision making and reactions ▶ Poor motivation (e.g. monotony of training, emotional factors, injury etc.)
<p>PSYCHOLOGICAL FATIGUE</p> <p>(emotional, social, cultural)</p>	<ul style="list-style-type: none"> ▶ Personality conflicts ▶ Competition pressures, event venue, residential conditions, parents, coach, media, etc. ▶ Other lifestyle stresses – home, school exams, personal relationships
<p>ENVIRONMENTAL & TRAVEL FATIGUE</p>	<ul style="list-style-type: none"> ▶ Weather (e.g. wind, heat and sun) may increase fatigue ▶ Disruption of normal routines (e.g. sleep, waking and meal times) ▶ Sedentary and restricted body movement on long journeys ▶ Adapting to different climates and time zones

EXPRESSION OF THIS FATIGUE

TENNIS EXAMPLES

- ▶ Player fatigues sooner than is normal
- ▶ Player struggles to complete a session or event

- ▶ Lethargic body language
- ▶ Walking slower than normal
- ▶ Slower response to chasing balls

- ▶ Reduced localized force production (e.g. slower responses, reduced power)

- ▶ Slow feet
- ▶ Reduced acceleration
- ▶ Poor technique and coordination.
- ▶ Abnormal number of technical mistakes
- ▶ Reduced power in shots & strokes

- ▶ Lack of drive
- ▶ Slower at processing visual cues

- ▶ Loses concentration quickly
- ▶ Slower at decision making
- ▶ Slower anticipation timing (e.g. speed and placement of opponents serve or return)

- ▶ Player loses self-confidence or self esteem
- ▶ Increased signs of anxiety, negative attitudes, etc.

- ▶ Player shows a definite lack in confidence during play and also off court
- ▶ More negative than usual, especially in self-talk and body language
- ▶ Change in player communication

- ▶ Players are slower to start
- ▶ Fatigue sooner than normal
- ▶ Visual fatigue from bright or glaring sunlight

- ▶ Player takes longer than usual to get rhythm on court.
- ▶ Unforced errors in the first 15 min. are well above normal
- ▶ Tired eyes and eye strain
- ▶ Poor tracking of the ball

PERIODIZATION

More than 200 potential physical and psychological symptoms are connected with overtraining and ineffective recovery.

Periodization is the cyclical pattern of alternating progressive training loads with appropriate recovery to improve an athlete's performance. The focus on improved training has led to great increases in performance, yet without appropriate focus on recovery, athletes will never reach their potential which could result in minor and major negative consequences such as injury, apathy and burnout.

Researchers have found that, in junior competitive tennis, there are high levels of burnout due to combination of factors, but one major factor is excessive physical and mental volume without adequate recovery.

Numerous recovery modalities are available, and coaches and players have tried hundreds of different techniques to improve recovery; however, very few have been subjected to rigorous scientific examination.

More than 25% of all Olympians report being overtrained for the Olympics – even the best athletes in the world struggle to find the fine-line between pushing themselves to the limit without overstepping to the point of overtraining and negative performance.



HEAT AND HYDRATION

RISK FACTORS FOR EXERCISE ASSOCIATED HYPONATREMIA

Athlete Risk Factors

- *Excessive drinking of plain water with little/no consumption of salty drinks or food*
- *Weight gain during exercise*
- *Lower body weight individuals*

Environmental or Match Risk Factors

- *> 4 hours of exercise*
- *Unusually hot conditions*

As little as a 2% loss in body weight, due to dehydration, can have a major negative effect on muscle strength and power.

Post-training or match hydration has three major purposes:

- *Replace fluid volume to an equal or slightly greater extent than the volume lost while sweating*
- *Drink liquid carbohydrates to aid in glucose uptake to the muscles*
- *Replace electrolytes lost during sweating*

Many tennis players go into practice and/or competition already dehydrated. This results in the possibility of problems during play, but it also slows recovery.

It is recommended to consume smaller volumes of fluid in a more regular basis during recovery. An example would be if you were to drink 32oz of fluid in the 60 minutes following a two hour match, it would be recommended to consume 4-8oz every 10 minutes, rather than consume one or two larger doses of fluid.

Athletes drink more fluid if it is flavored. Studies have shown as much as 30% more fluid is consumed with flavored drinks as opposed to plain water. Flavored, carbohydrate-electrolyte drinks are more effective in promoting post-exercise re hydration than plain water, or low-electrolyte diet cola.

Many athletes do not consume enough sodium in their regular diet to support strenuous physical activity, especially in early stages of training and in hot and/or humid environments. Having recovery drinks and food that contain sufficient levels of sodium is helpful for a number of purposes:

- *Replaces the sodium that is lost in sweat*
- *Stimulates glucose (energy) absorption by the muscles*
- *Increases the athletes drive to drink*
- *May reduce the symptoms of exertional heat cramps, exertional heat exhaustions and exertional hyponatremia.*



During multi-day tournaments or practice, it is common for players to experience a subtle but gradual sodium deficit and this can result in heat and hydration related problems (exhaustion, cramping etc) towards the later rounds of tournament.

HYPONATREMIA

Athletes may be susceptible to a rare but dangerous condition called hyponatremia if recovery following single or repetitive exhaustive tennis matches does not take into account proper fluid and salt intake. Hyponatremia exists when sodium levels are below a normal range in the body and is typically the result of sweating out sodium, while drinking high volumes of plain water. This results in a dilution of the sodium in the blood and can cause serious health problems.

PRACTICAL SUMMARIES

If a tennis player has to follow-up a practice or match within one to two hours, it is recommended that a sports drink be consumed with between 600-900mg of sodium per 32oz of fluid.

To prevent post match hydration problems, it is recommended that pre and post-match hydration is appropriate (see USTA Heat and Hydration Booklet for more information)

Heart rate, body temperature and hydration level are interrelated, and it is important to reduce core temperature and lower heart rate during recovery to help speed the recovery process along with the hydration components.

HEAT AND HYDRATION RECOVERY BEST PRACTICES

AFTER PRACTICE OR MATCH

Consume approximately one regular size bottle (20oz) of fluid per pound of bodyweight lost within the previous match. Adding carbohydrates and protein in the recovery fluid can also aid in recovery (see nutrition section).

AT THE END OF A TOURNAMENT DAY

Continue to hydrate and check your urine color to ensure you have color in the range of 1, 2 or 3.

AFTER A TOURNAMENT

Check urine color the day proceeding the tournament and make sure that urine color is appropriate.

To improve recovery aspects, hydration strategies should seek to optimize hydration status continuously, and not solely around competition schedules.

AM I HYDRATED? URINE COLOR CHART

1		<p>If your urine matches the colors 1, 2, or 3, you are likely properly hydrated. Continue to consume fluids at the recommended amounts. Nice job!</p>
2		
3		
4		<p>If your urine color is below the RED line, you may be DEHYDRATED and at greater risk for heat illness!!</p>
5		
6		<p><u>YOU NEED TO DRINK MORE!</u></p>
7		
8		<p>Speak to a Health Care Provider if Your Urine is this Dark and is Not Clearing Despite Drinking Fluids</p>

Overtraining is rarely the problem. The typical limiting factor in tennis training is inadequate recovery.

PSYCHOLOGICAL ASPECTS OF RECOVERY

FACTORS THAT ARE CORRELATED WITH HIGHER RISK OF BURNOUT:

- *Individuals with perfectionist tendencies*
- *Negative parental involvement*
- *Individuals who feel they have less input in training*
- *Perceived high expectations from key individuals*
- *Less likely to use planning strategies such as goal setting*



STALENESS

is a good cue that the current training plan may need to be altered. Staleness is associated with lower levels of performance, mood changes, psychological fatigue, inability to maintain focus, lower sense of enjoyment, higher frustration and sleep disturbances. These symptoms may appear even before physical symptoms are present.

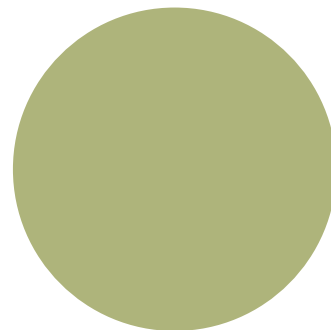
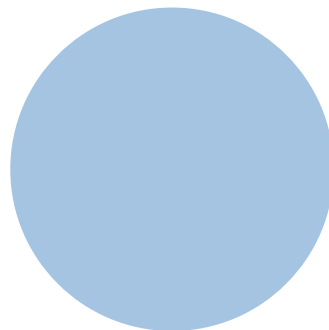
BURNOUT

may manifest as psychological, emotional or physical withdrawal from sport occurs. The obvious cases of burnout are individuals who stop playing or competing. However, more prevalent are individuals who continue to practice and compete in tournaments, but they have less than optimal mind-set, high levels of stress and as a result often play less than effective tennis.

COMMON PSYCHOLOGICAL SIGNS AND SYMPTOMS OF OVERTRAINING

- *Increased anger*
- *Increased irritability*
- *Increased depression*
- *Reduced motivation*
- *Mental exhaustion*
- *Emotional exhaustion*
- *Decreased self-esteem*
- *Sadness*

The greater the distance between the demands of training and the resources for recovery, the greater the risk of overtraining.



THE FOLLOWING SEVEN CATEGORIES CAN HELP REDUCE STRESS DURING RECOVERY.

LISTENING SUPPORT	perception that one is listening without giving unrequested advice or being judgmental
EMOTIONAL SUPPORT	perceptions of unconditional care and comfort
EMOTIONAL CHALLENGE SUPPORT	perception of being challenged to evaluate individual attitudes, values and feelings for the purpose of positive growth
REALITY CONFIRMATION SUPPORT	perception that someone else sees things in a similar manner or has had a similar experience
TASK APPRECIATION SUPPORT	acknowledgement of efforts
TASK CHALLENGE SUPPORT	perceived motivational guidance and support to help the athlete improve a skill or effort
PERSONAL ASSISTANCE SUPPORT	perceptions of financial or tangible support such as funds or transportation



Psychological overtraining is difficult to measure as the lines between hard training and working through adverse conditions to achieve a goal may be blurred.

Early detection of changes in mood, self-confidence, energy level and sleep all can help prevent training slumps. One of the best methods of improving recovery habits and reducing the likelihood of overtraining is appropriate athlete education. Empowering athletes with symptom awareness and self-monitoring will help.

PHYSIOLOGICAL ASPECTS OF RECOVERY

DELAYED ONSET MUSCLE SORENESS (DOMS)

Largely eccentric focused exercise requires greater recovery.

Physiological fatigue occurs when power output cannot be maintained or physiological homeostasis cannot be achieved in a given set of physiological systems. Although research is still limited on physiological fatigue and recovery, it is apparent that it is a combination of both central and peripheral factors.

Emphasis should be placed on training that develops physiological resistance to fatigue and improves the physiological ability to repair damage to tissues. Training attempts to avoid major muscle problems (strains) while inducing enough muscular stress - if provided the appropriate recovery - will result in positive adaptations, but does try to induce enough muscular stress that, if provided the appropriate recovery, will result in positive adaptations.

DOMS arises from the damage and repair processes that result from unaccustomed exercise with a high eccentric focus. The duration of DOMS is directly related to the exercise overload, amount of tissue damage and the fitness level of the athlete. Typically pain is at its peak between 24-72 hours, but it can last as long as 10 days.

There is a constant balance between body and muscle protein breakdown and rebuilding. During exercise — especially exercise involving a high eccentric component, such as starting and stopping frequently, changing directions, decelerating, and strength training — this balance is shifted to muscle breakdown whereas during recovery the balance needs to shift to expedited muscle rebuilding.

Neurological Demands

Neurological fatigue is difficult to measure but is in direct response to stressful activities involving large volumes of high power and force activities. Neurological fatigue could occur at both the central nervous system (CNS) and peripheral nervous system (PNS). PNS fatigue can be monitored by muscle contraction rates at the muscle. Muscle activation should be higher in non-fatigued muscles than fatigued muscles, thus creating an objective assessment of recovery state.

Performance tests that measure explosive exercise — vertical jump, long jump, single-effort medicine ball throw for distance — are a great method of monitoring neurological fatigue. Although these are indirect measurements, such tests do provide a coach with an immediate snapshot of an athlete's recovery status from a nervous system fatigue perspective.

Intervention strategies

To reduce DOMS while protecting against muscle damage, athletes should engage in exercises that provide different ranges of tennis-relevant motions with progressive eccentric loading. Heavy resistance training should be followed by 1-2 days of rest for the involved muscles and joints.



NUTRITIONAL ASPECTS OF RECOVERY

The major goals of nutritional recovery include:

- *Replenish glycogen (muscle and liver energy) stores*
- *Restore appropriate fluid and electrolyte levels*
- *Create new muscle proteins*
- *Restoration of the immune system*

As little as 10 grams of essential amino acids before and after physical training may help jump start protein synthesis and repair. In prolonged exercise, such as tennis play greater than 90 minutes, fatigue is closely associated with low muscle glycogen and blood glucose levels.

The American College of Sport Medicine position statement on nutritional requirements for athletes suggests consuming between 30-60 grams (120-240 calories) of carbohydrates per hour of exercise. If consuming a standard carbohydrate/electrolyte sport drink, this would equate to between 600-1200ml/hour (20-40oz/hour), or this amount could also be consumed with a combination of fluid and solid food such as nutritional bars. The timing of on-court nutrition during practice or competition should be in small regular intervals every 10-20 minutes at changeovers.



Consuming high glycemic carbohydrates (simple sugars) during recovery can result in a 50% greater rate of muscle glycogen resynthesis than the ingestion of low glycemic carbohydrates.

Nutrient Timing

Researchers have shown a nutritional window of opportunity where glycogen resynthesis and protein repair occurs at a greater rate. This window is within 45 minutes of completing physical training or competition; during this time frame it is vital that tennis players consume high glycemic carbohydrate fuels with a reasonable amount of protein (including essential amino acids) to help speed glycogen resynthesis, as well as protein rebuilding. Research has shown that replacing fuel within this window, as opposed to waiting two or three hours after physical activity, reduces recovery time and improved fuel stores. This difference could be as high as 47%.

Ingesting between 6-20 grams of protein is recommended during this recovery window. A 4:1 carbohydrate to protein ratio is also a good general recommendation for the food/fuel source during the recovery period.



ERGOGENIC AIDS VERSUS SUPPLEMENTS

Ergogenic aids are external additions that may improve performance. Nutritional ergogenic aids are referred to as supplements. There are several problems with sport supplements: there is a lack of research that supports marketing claims; the supplement industry is poorly regulated, thereby allowing misleading claims; up to 30% of sport supplements may contain substances that are not listed in the ingredients, and that may be banned by various anti-doping agencies. At the higher levels of junior, collegiate and professional tennis, tainted supplementation could result in a positive drug test. Players are 100% responsible for any products that are consumed, and a tainted supplement is not a defense for a failed drug test.

Although thousands of products are marketed as potentially performance enhancing for athletes, there are five supplements (creatine, caffeine, electrolyte drinks, sodium bicarbonate, protein) that have enough scientific evidence and longevity to discuss. Supplements do not replace proper training and recovery, but may be incorporated into a well-developed program. Coaches, parents and players should consult with a physician or sport nutritionist prior to beginning a supplement. Athletes who may be drug tested (national and international junior, collegiate or professional athletes) need to understand that the Tennis Anti-Doping Program, World Anti-Doping Agency, and US Anti-Doping Program assume that all athletes are responsible for what they have consumed, even a tainted supplement that contains a banned substance. For more information see the following websites:

US Anti-Doping Agency
www.usada.org

ITF Tennis Anti-Doping Program
www.itftennis.com/antidoping/

World Anti-Doping Agency
www.wada-ama.org

CAFFEINE

Caffeine is a naturally occurring stimulant that can be found in coffee, tea, caffeinated soda, and chocolate in dosages typically between 30-200mg of caffeine. A large strong coffee could have more than 200mg of caffeine. Although caffeine has been studied extensively in many sports, showing a multitude of physical improvements in strength, power, speed and endurance, the data is limited in tennis players. The few studies that have been conducted have not shown positive performance improvements in tennis players. Recent research on caffeine and dehydration show limited evidence of caffeine having a negative response to thermoregulation or hydration status in dosages between 300-400mg per day. However, caffeine is not a supplement that is recommended for tennis play or competition, but under appropriate guidance, may have some positive effects for off-court training for adult players. Large dosages (>500mg per day) need to be discouraged, as this could have detrimental effects on heart rate, fine motor control, technique, over-arousal and hydration level. Not enough data is available on children and thus caffeine should not be a supplement used by junior tennis players.

CREATINE

Creatine is a naturally occurring compound found in skeletal muscle and is found in dietary sources of meat and fish. Short-term creatine supplementation has been shown to enhance the performance of exercise involving repeated sprints or bouts of high intensity exercise, separated by short recovery times. However, studies specifically in tennis have not shown an improvement in stroke quality. The long-term consequences of creatine use are still unknown, but it is not recommended for individuals under the age of 18, and adult players should check with qualified personal (physicians, exercise physiologists or nutritionists) to see whether creatine may be a suitable addition to their training and competition arsenal. From a recovery standpoint, creatine may provide faster recovery from short high intensity workouts such as strength training or sprint workouts.

NUTRITION RECOVERY BEST PRACTICES

1. Optimize Nutritional Status

Regularly checking nutritional status via blood, body composition and urine analysis by a trained professional is recommended at least once per year.

2. Carbohydrate Intake

Consume 30-60 grams of carbohydrates per hour of play.

3. Protein Intake

Consume 6-20 grams of protein immediately post-training or competition.

4. Timing is Important

Start your nutritional recovery within 45 minutes of finishing your training session or tournament match.

5. Hydrate Appropriately and Often

6. Extremely Cautious

With Ergogenic Aids or Supplements.

7. Seek Professional Assistance

As a qualified tennis coach it is important to provide knowledgeable instruction about technique and tactics. A qualified physician, sport scientist or sport nutritionist with a strong tennis-specific nutritional background should aid in providing of individual nutritional advice.

AFTER PRACTICE OR MATCH

Consume approximately 200-400 calories of a carbohydrate:protein drink or snack with an approximate 4:1 carbohydrate to protein ratio. Good sources of this are chocolate milk, a commercial recovery shake, or a 6-inch sandwich with meat/fish. Follow this recovery snack within three hours with a more substantial meal (i.e. chicken, rice and salad, pasta with chicken/fish and vegetables)

AT THE END OF A TOURNAMENT DAY

Continue to hydrate and check your urine color to ensure you have adequately hydrated. Consume a good dinner with a high carbohydrate, medium protein, low-medium fat meal. Some good examples include pasta with chicken/fish and vegetables, steak/chicken/fish and potatoes, rice, beans and salad, eggs and potatoes.

After dinner and before bed, it may be important to consume a light snack of slow releasing carbohydrate and a moderate amount of protein. Some good examples include a commercial low sugar shake, some tuna and crackers, a glass of milk.

AFTER A TOURNAMENT

Consume similar foods to during a tournament scenario, but it is advisable to increase the fruit content of the diet. Specifically foods that contain high amounts of vitamin C and antioxidants (oranges and variety of berries).

FOOD SOURCE

GRAMS OF CARBOHYDRATES

SPORT DRINK – 16oz

30 grams

SPORT GEL – 1 pack

20-38 grams

SPORT BAR – 1

25-55 grams

SPORT BEANS/SHOTS – 1oz

25 grams

BANANA – 1 medium

28 grams



PRACTICAL COACHING ASPECTS OF RECOVERY

SLEEP

Although sleep is an area that is not yet well understood, it could be the most important form of recovery. A good night sleep between 7-9 hours provides invaluable adaptation time to adjust the physical, neurological, immunological and emotional stressors that are experienced during the day. Some athletes, especially during major growth spurts, may need 10 hours or more of sleep. However, too much sleep can be detrimental to performance, as it can slow down the central nervous system. Short naps during the day of 15-30 minutes are beneficial and can improve alertness, perception and performance. Longer naps are not as beneficial and can result in the player feeling sluggish and groggy.

REST DAYS

Athletes require a rest day at least once weekly, and sometimes twice weekly. A rest day should not include sitting for the majority of the day. It is important for the athlete to be mobile during the day. It could be a good time to socialize with friends, go to the mall, play another sport (that is not physically as taxing – i.e. golf), walk, cycle or swim at a pool or the beach. However, limiting excessive sun exposure would be encouraged (hat, sunglasses and sun-screen should be used).



HYDROTHERAPIES

WARM-WATER

Taking a warm/hot bath in body-temperature neutral (34°C - 36°C / 93°F - 97°F) water results in marked changes in the circulatory, pulmonary, renal and musculoskeletal systems. The effects have been shown to be most pronounced for whole body (head out) immersion rather than partial immersion (a single limb or lower body immersion). Studies have indicated that increased hydrostatic pressure leads to a shift of blood from the lower regions of the body to the thoracic region during immersion. The net result is an increase in muscular blood flow without an increase in heart rate. Alternating from cool to warm water immersion can accelerate metabolic activity, as indicated by faster clearance of blood lactate and creatine kinase (which is a marker of muscle damage) through an increase in muscle blood flow.

SHOWERING

Showering within 5-10 minutes after the end of the training session can accelerate recovery. If pool access is available, performing active and static stretching (5-20 minutes) is also beneficial.

SPAS

Spa use has had little scientific investigation and most reports are anecdotal. No definitive guidelines for time or even water temperature have been set, but excessive time-periods in hot water can leave the athlete feeling lethargic and "flat"

COLD-WATER

It is recommended that a range of 10°C – 15°C for cold water is the optimal range for cooling soft tissues. Colder temperatures used for long periods risk damage to soft tissues and are not recommended for sporting contexts. Cold water immersion reduces the sensations of DOMS in trained athletes. Typically 10-15 minutes is recommended.

SAUNAS

Sauna use (hot and dry heat) is not well understood and can be misused by athletes. The traditional protocol involves a warm shower followed by a sauna for 5 minutes (40°C) with cold plunge (10°C) for 30-60 seconds, repeated 3-5 times. The aim is to depress activity in the central nervous system to prevent over-stimulation following high intensity training. There is a lack of published research on the performance benefits of sauna use, and such use is not recommended for use by young athletes. Certain national training centers restrict the use of saunas to athletes over 15 years of age.

SPORT MASSAGE

Although massage does feel good and provides a sensation of reducing tight muscles, little scientific evidence is available to support claims such as improved blood flow, improved muscle strength, or significant reductions in muscle soreness. However, many studies have shown an improvement in psychological factors such as mood and well-being.

COMPRESSIVE CLOTHING

Compressive garments have been shown in certain circumstances to reduce injuries, benefit performance and enhance recovery. The benefits stem from graduated pressures which extend from the limbs to the core of the body. Studies have shown reductions in post-exercise muscle damage following eccentric work (stop and start movements, deceleration activities), muscle soreness, and aid recovery of soft-tissue injuries. There is also a reduced perception of fatigue. These compression garments aid in recovery, but do not improve performance if worn during practice or matches – they may even reduce performance during play.



Player's responsibility – listen to your body and look after your body.

PLAYER SELF MONITORING AND SELF MANAGEMENT RESPONSIBILITIES

DAILY

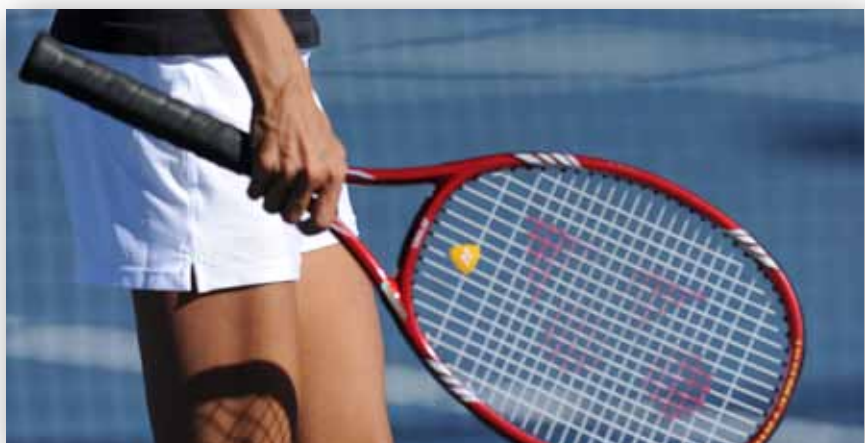
- ▶ Keep a daily record or log book recording adaptation to stress
- ▶ Eat a balanced diet and plan appropriate meals and post training snacks
- ▶ Use a shower/spa/bath after training with some cold immersion for legs after training
- ▶ Stretch and self massage before bed
- ▶ Practice some relaxation strategies before bed and learn to "switch off" from the day

WEEKLY

- ▶ Have at least one rest day a week (e.g. a light non-training activity)
- ▶ Plan some active rest (e.g. yoga)
- ▶ Organize a massage from a professional, parent, partner, or do some self massage on legs and shoulders

WEEKLY TIME MANAGEMENT PLANNING – PLAN IN ADVANCE

- ▶ Prioritize all weekly commitments in advance (e.g. school, work, training, domestic chores, social events, appointments etc.)
- ▶ Add a few varied recovery activities to fit in around these commitments (e.g. movie, spa, or night out with friends)



MUSCULOSKELETAL ASPECTS OF RECOVERY FOR TENNIS

The elite adult tennis player must generate approximately 4,000 watts of energy (1.2hp) in each serve. Competitive junior tennis players could have serves that require more than 3,000 watts of energy.

Overuse injuries account for an estimated 50% of all injuries in young athletes. Overuse injuries are more common during peak growth spurts, especially if underlying biomechanical/technical problems are present.

The major intrinsic musculoskeletal factors to address in recovery protocols include: joint and muscle flexibility, strength, power, endurance, balance and kinetic chain activation.



MUSCLE FUNCTION

Optimum muscle function is required to generate the forces required in tennis and to protect against the loads applied to the body as a result of tennis play. Recovery needs to focus on the upper back, hip abductors and the muscles of the core.

STRATEGIES FOR IMPROVED RECOVERY FOR MUSCULOSKELETAL FUNCTION

FLEXIBILITY

Areas of particular risk include hip and shoulder. Flexibility must be addressed in athletes who develop more than five degrees of hip or shoulder rotation limitation, or more than 2cm restriction in sit and reach score before the next practice or tennis match.

Muscles respond to eccentric loads by becoming "stiff." Appropriate stretching reduces muscle stiffness and increases range of motion in the affected area.

The sleeper stretch is one of the best stretches to improve internal rotation flexibility at the shoulder joint.

PAIN RATING SCALE & RECOMMENDATIONS

A pain rating scale can help determine the severity of an athlete's situation and his/her participation capabilities for upcoming training or competition. An athlete should not continue training or competing if swelling, range of motion limitations (above normal) or muscle weakness (above normal) is present. The pain scale can also be used to assess the degree of recovery from any type of injury. Return to play may be allowed if pain levels are 1 or 2.

ICE

Cryotherapy (ice treatments) has an analgesic effect (numbing and immediate pain reduction), but it has not been shown to reduce the symptoms of DOMS. However, more research is still needed for definitive guidelines or recommendations. If ice is applied after training, it should be restricted to 20 minutes or less.

PAIN RATING	COMPLAINT	DETERMINATION
1	Pain after match or next day	May play – athlete should warm-up well
2	Pain during match with normal stroke mechanics and no loss of performance	May play – place emphasis on stretching and watch mechanics
3	Pain during match with change in mechanics and performance loss	No Play
4	Pain during play with minimal playing ability	No Play

RECOVERY AND THE YOUNG TENNIS ATHLETE

HERE IS SOME INFORMATION ADAPTED FROM THE AMERICAN ACADEMY OF PEDIATRICS COUNCIL ON SPORTS MEDICINE AND FITNESS CLINICAL REPORT ON "OVERUSE INJURIES, OVERTRAINING AND BURNOUT IN CHILD AND ADOLESCENT ATHLETES":

- 1. Young athletes should strive to have one or two days off per week from competitive athletics or sport-specific training to allow for physical and psychological recovery.*
- 2. Weekly training time or volume should not increase by more than 10%.*
- 3. Ideally young athletes should take 2-3 months off per year from the specific sport.*
- 4. Emphasize that the focus of sports participation should be on fun, skill acquisition, safety and sportsmanship.*
- 5. If the athlete complains of nonspecific muscle or joint problems, fatigue or poor academic performance, be alert to the possibility of burnout.*
- 6. Advocate for a medical advisory board for multi-day tournaments to help educate players, parents and coaches about important areas of nutrition, heat illness, hydration, sport safety, overtraining, burnout, optimal performance and health.*
- 7. Convey a special caution to parents with younger athletes who participate in multi-match tournaments with limited rest and recovery periods.*

Although these are good general guidelines, most young tennis players—with the full knowledge and approval of their coaches and parents—train and compete more than recommended. Therefore, it is vital to improve the recovery activities to attempt to offset the increase in training and competition.

Many young athletes do not realize that if they increase their training volume and/or intensity, their daily energy requirements also need to be increased. They should increase their nutrition and hydration volume in response to an increased workload. During hot and/or humid conditions, young athletes have a more challenging time to control core body temperature. Young athletes may also underestimate the time needed for physiologic recovery.

When environmental conditions change, children may need longer acclimatization periods than adults.



MEDICAL ISSUES AND RECOVERY IN THE TENNIS ATHLETE

IMMUNE FUNCTION

With moderate levels of exertion, the risk of infection is decreased compared to a sedentary lifestyle, but at significant levels of exertion, there is an increased risk of infection. This is referred to as a J-shaped curve.

Low glutamine levels (the most abundant amino acid in the bloodstream) develop following heavy, frequent, repetitive exercise, and with an increased risk of upper respiratory tract infections. Therefore, supplementation with glutamine may be a consideration during heavy training segments of a tennis player's periodized program only after consultation with a qualified healthcare provider who is trained in nutrition.

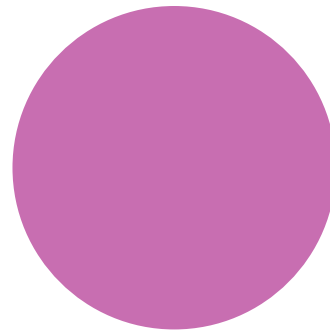
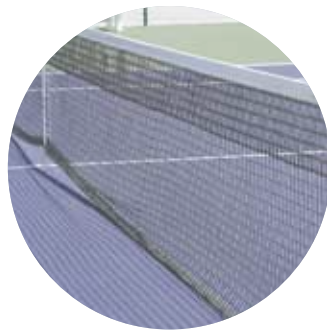
OVERTRAINING SYNDROME

Overtraining syndrome has been defined as "a condition of fatigue and underperformance, often associated with frequent infections and depression which occurs following hard training and competition. The symptoms do not resolve despite two weeks of adequate rest and there is no other identifiable cause." Overtraining syndrome is the endpoint of planned overreaching and inadequate recovery.

If overtraining syndrome is not treated with appropriate rest, a more severe condition—chronic fatigue syndrome—may develop. Chronic fatigue syndrome has similar symptoms to overtraining syndrome, except that the symptoms must be present for more than 6 months. It includes fatigue that is not alleviated by rest, leading to severe decrease in work, education or personal activities plus at least four of the following symptoms: impaired memory or concentration; multijoint pain; sore throat; new headaches; tender cervical or axillary lymph nodes; unrefreshing sleep; muscle pain; post exertional malaise. It has been estimated that as much as 20% of all elite athletes will be affected by overtraining syndrome.



The depressive effect of intense exercise on immune function is only temporary, assuming there is adequate recovery time.



CLINICAL SYMPTOMS OF OVERTRAINING

- *Increased resting HR*
- *Weight loss*
- *Poor healing*
- *Sleep disturbance*
- *Loss of appetite*
- *Depression*
- *Sore throat*
- *Legs feel heavy*
- *Excessive sweating*
- *Decreased drive or competition*
- *Decreased Performance*
- *Irritability*
- *Restlessness*
- *Decreased concentration*
- *Frequent Upper Respiratory Infections*
- *Emotional liability*
- *Increased evening fluid intake*
- *Decreased libido*

GENERAL RECOMMENDATIONS TO PREVENT OVERTRAINING SYNDROME INCLUDE THE FOLLOWING:

1. *Educate athletes, parents and coaches regarding periodization and training techniques*
2. *Ensure adequate rest and recovery*
3. *Assess stress and coping mechanisms/support network*
4. *Avoid workouts and training*
5. *Increase resistance training by < 5% per week*
6. *Monitor training and include objective measurements of heart rate, weight, performance, sleep and mood*



SUMMARY

The greater the distance between the demands of training and the resources for recovery, the greater the risk of overtraining.

Prevention and preparatory strategies are vital to aiding the recovery process.

- *Optimize conditioning, nutrition, hydration and acclimatization to competitive demands will help prevent fatigue.*
- *Expose players to forceful eccentric, stretch-shortening cycle and power-focused resistance exercise to build resistance against DOMS and enable sustained play with smaller decrements in physical performance.*
- *Consume amino acids, protein, carbohydrates, appropriate fats, water and electrolytes regularly, but especially before, during and after training and/or competition*
- *Listen to the body if players feel weak, slow, poorly coordinated – they are fatigued. Therefore, an increased priority needs to be placed on recovery.*

- *Give time to regain normal performance measures. Use objectively-measured performance to objectively prescribe rest and recovery.*

- *The use of a carbohydrate-protein beverage immediately post-tennis practice or competition allows for replenishment of needed nutrients, and improves hormonal conditions in the body to allow for faster recovery, which translates into more positive adaptations.*

While much more information needs to be uncovered, it does appear that strategies that try to maximize recovery only after a match or between closely scheduled matches are less effective than strategies that seek to maximize recovery before the match or tournament.

Selection of the appropriate recovery strategies to address specific types of fatigue will depend on the recovery knowledge of the player and coach, and the availability and cost of strategies available.



RECOVERY STRATEGIES FOR DIFFERENT TYPES OF FATIGUE

TYPE OF FATIGUE	RECOVERY STRATEGIES
<p>METABOLIC FATIGUE (Energy Stores)</p>	<ul style="list-style-type: none"> ▶ Rehydrate & refuel (including small amounts of protein as well as carbohydrates) before, during & after training ▶ Use contrast temperature showers, pool, or spa, and active recovery activities to increase metabolism ▶ Recovery Snack and appropriate hydration within 45 minutes of training
<p>PERIPHERAL NERVOUS SYSTEM FATIGUE (muscles)</p>	<ul style="list-style-type: none"> ▶ Rehydrate & refuel before, during & after training ▶ Within 5 – 15 minutes after training use a spa or shower with jets focused on the large & fatigued muscles such as legs, shoulders and arms ▶ After training or later in the day – massage large muscle groups & include some jostling / light shaking techniques
<p>CENTRAL NERVOUS SYSTEM FATIGUE (brain)</p>	<ul style="list-style-type: none"> ▶ Steady & regular intake of carbohydrates during training & after training to maintain normal blood glucose levels to aid decision making ▶ After training – unwind, listen to music, visualization ▶ Sauna – contrast hot and cold (for older players >15 years of age) ▶ Rest with reduced cognitive stimulation
<p>PSYCHOLOGICAL FATIGUE (emotional, social, cultural)</p>	<ul style="list-style-type: none"> ▶ Focus on process rather than outcome measures ▶ Debrief by identifying 1-3 things that worked well and 1-3 that need more work ▶ Take mind off training with escapist or funny movie, TV, book, or socialize with family & friends ▶ 10-15 minutes before bed “switch-off” from the day by using relaxation techniques
<p>ENVIRONMENTAL & TRAVEL FATIGUE</p>	<ul style="list-style-type: none"> ▶ Preparation planning will minimize fatigue ▶ Stay hydrated and refueled ▶ Stay cool in the heat - use a pool, shade, iced towels, etc. ▶ Keep moving as much as possible on long journeys ▶ Minimize visual fatigue by wearing sunglasses outside & limiting time on computers & play stations

RECOVERY STRATEGIES CORRESPONDING WITH PLAYER DEVELOPMENT AND INCREASED WORKLOADS AND STRESS

(adapted from numerous sources including Calder, 2004, 2007)

Training Age: 0-1+ years	Training Age: 1-2 +/- years	Training Age: 3-7 +/- years	Training Age: 8-10 +/- years	Training Age: 10-12 +/- yrs.	Training Age: 1-100 +/- yrs.
During Training	During Training	During Training	Periodized recovery	Periodized recovery	During Training
Rehydrate every 15-30 minutes	Rehydrate every 15-30 minutes	Rehydrate every 15-30 minutes	(as previous stage) Plus:	(as previous stage) Plus:	Rehydrate and refuel regularly
After Training	After Training	After Training	<ul style="list-style-type: none"> ▶ Compressive <i>skins</i> post training ▶ 1-2 massages a week ▶ Strategies selected to suit specific fatigue ▶ Recovery program individualized ▶ Competition scenarios trialed ▶ Especially recovery from travel fatigue and adjusting to different facilities ▶ Increased range & use of psychological recovery ▶ Variety of active recovery and rest day activities 	<ul style="list-style-type: none"> ▶ Detailed competition planning of recovery programs including nutritional needs & timing ▶ Fine-tuning recovery strategies for different competition environments ▶ Player has major input into the recovery program ▶ Variation in recovery strategies to prevent monotony 	After Training
<ul style="list-style-type: none"> ▶ Drink (water, fruit juice/sport drink) & light snack (e.g. fruit, muffin, or yogurt, etc) ▶ Light stretch ▶ Shower at home 	<ul style="list-style-type: none"> ▶ Post game drink & snack ▶ Active recovery ▶ Light stretch ▶ Shower ▶ Meal within 2 hours 	<ul style="list-style-type: none"> ▶ Post game drink & snack ▶ Active recovery ▶ Light stretch ▶ Contrast shower ▶ Meal ASAP 			<ul style="list-style-type: none"> ▶ Post game sports drink & snack ▶ Active recovery ▶ Light stretch ▶ Contrast shower ▶ Meal ASAP
	Before bed	Before bed			Before bed
	<ul style="list-style-type: none"> ▶ Self Massage ▶ Stretching ▶ Relaxation (TV, book, music) 	<ul style="list-style-type: none"> ▶ Self Massage ▶ Stretching ▶ Relaxation (as for previous stage) Plus: Progressive muscle relaxation, visualization, etc. 			<ul style="list-style-type: none"> ▶ Self Massage ▶ Stretching ▶ Relaxation movie, TV, book, music, visualization, meditation, etc.
		Weekly			Weekly
		<ul style="list-style-type: none"> ▶ Active recovery (e.g. pool, golf, walk dog) ▶ Spa & plunge pool ▶ Stretching session (e.g. Yoga) 			<ul style="list-style-type: none"> ▶ Sports massage ▶ Active recovery (e.g. pool, golf, walk dog) ▶ Spa & plunge pool ▶ Stretching session (eg. Yoga)

*Training Age: Is defined as the age since an athlete has been training for tennis on a regular basis. An example is a 12 year old junior tennis player who has been taking lessons and practicing for 2 years. This athlete has a training age of 2.

RECOVERY IN TENNIS

A GUIDE TO IMPROVING PERFORMANCE AND LIMITING INJURY THROUGH IMPROVED RECOVERY

To access more information on tennis recovery, please visit the Sport Science page of playerdevelopment.usta.com

Each chapter was thoroughly peer-reviewed by other experts and their names are listed below:

Mitchel Alpert, MD

Jessica Battaglia, MS

George C. Branche III, MD

T. Jeff Chandler, EdD

Miguel Crespo, PhD

David Dines, MD

Todd Ellenbecker, DPT

Dan Gould, PhD

Brian Hainline, MD

W. Ben Kibler, MD

Mark Kovacs, PhD

Melisa Lemus, PT

Paul Lubbers, PhD

Rodney Marshall, BS

Satoshi Ochi, MA

Brian O'Malley, MS

Anne Pankhurst, BSc

Sally Parsonage, PhD

David Ramos, MA

Scott Reiwald, PhD

E. Paul Roetert, PhD

Robert Russo, MS

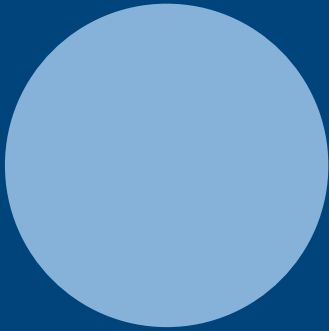
William A. Sands, PhD

Dawn Weatherwax-Fall, RD

Gary Windler, MD

Michael Yorio, MD

*USTA Sport Science Committee
(2009-2010)*



PLAYER DEVELOPMENT

United States Tennis Association
70 West Red Oak Lane, White Plains, NY 10604-3602
USOpen.org • PlayerDevelopment.usta.com

© 2010 USTA. All rights reserved.