Steadman◆Hawkins
SPORTS MEDICINE FOUNDATION VOLUME 8 SPRING/SUMMER 2002
An International Center for Research and Education — Keeping People Active

Patients in the News:
Bode Miller: "Healing Response" and the Comeback Kid

Editor's Note: The following profile is based on an interview by Dick Needham. Mr. Needham is a senior contributing editor of *Ski Magazine* .

Call it coincidence, but it seems every time world-class athletes in need of a body repair visit Steadman-Hawkins—Bruce Smith, Dan Marino, Joe Montana, Phil Mahre, Steve Mahre, John Elway, Picabo Street, Greg Norman—they return to the playing field in better shape than when they were competing at even their highest level.

Witness Bode Miller. In 2000-2001, the soon-to-be ski racing phenom had already had one World Cup podium finish (giant slalom) and was primed for a big result at the combined downhill/slalom event in St. Anton, Austria. He was fourth in the slalom going into the downhill, but 30 seconds into the downhill course Bode hooked an edge at 80 miles an hour, careened off the course, and crashed into a fence. Result: a complete ACL tear of the left knee coupled with damage to the meniscus. Diagnosis: total ACL reconstruction, with an extended rehab period that such a surgery would require.

But something happened along the way. Dr. Steadman opted to use a revolutionary new procedure that he had developed. During Bode's meniscus repair, he performed the "healing response." This arthroscopic procedure involves making three to 10 small "microfracture" holes in the bone at the femoral origin of the injured ACL. The blood clot from the bleeding bone captures the injured end of the ACL and eventually reattaches the ligament back to the bone. The "healing response" has many advantages, including a much shorter recovery period and less cost, and because it is less invasive, the chances for osteoarthritis to set in later are greatly reduced.

Three weeks following his surgery, Bode was fully mobile and without need of a brace. Encouraged, Dr. Steadman suggested waiting another three weeks to determine whether the "healing response" would take. When the three weeks were up, the news was even more encouraging. "My ACL," says Bode, "was

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PHOTO COURTESY OF JOHN KELLY.

IN THIS ISSUE

Sports and Wellness:
Stay Healthy on the Green with Simple Exercises

By Jeff Carlson

Editor's Note: Mr. Carlson is a physical therapist for the Howard Head Sports Medicine Center in Vail, Colo.

The time has come to dust off those clubs and get yourself in shape for another summer of golf. Diehards, like myself, have probably been taking advantage of the mild winter. I've played six times since mid-January and have a net and a mat set up in my living room to hit balls every night. I know my priorities.

If you're like most others, the dozens of days skiing and working out have you in great shape, but not exactly golf shape. Golf is a very unnatural motion that requires an enormous amount of rotation and torque of the lumbar spine (lower

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Steadman◆Hawkins Research Update:
Cell-Based Therapy for Cartilage Repair

Juan J. Rodrigo, M.D.

Editor's Note: Dr. Rodrigo is Professor of Orthopaedic Surgery at the School of Medicine, University of California (Davis), and a member of the Steadman◆Hawkins Sports Medicine Foundation's Scientific Advisory Committee.

Cartilage tissue regimentation requires the interaction of three basic biological elements: cells, growth and differentiation factors, and extracellular matrix scaffolds. Therapeutic approaches for tissue-engineered repair of cartilage defects have attempted to mimic the natural process of bone repair by delivering a source of cells capable of differentiating into chondroblasts (young cartilage cells), inductive growth and differentiation factors, or

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Bequests and Buzz Words

Planning the distribution of your assets to protect and provide for your family is prudent and thoughtful. If you're about to undertake those plans, we offer our "Bequests and Buzz Words" quiz to determine just how informed you are.

Match the definitions on the left with the phrases on the right, then check your answers at the end of the article.

We especially like No. 3 and hope you'll want to make a difference in our future with a bequest to Steadman◆Hawkins Sports Medicine Foundation. While charitable bequests certainly can add meaning to your will and our future, it's important to think about what type of bequest to leave since a well-planned bequest can create favorable tax consequences.

For instance, naming the Foundation as beneficiary of your retirement plan allows you to make a difference, but in a tax-wise way. Retirement plan assets can be exposed to multiple layers of taxation, potentially depleting resources you hoped your family would have. If you leave tax-burdened assets to the Foundation instead, these assets are taxed at lower rates. Therefore, potentially more wealth can go to your family.

1. The review of a will before a court of law to ensure it is authentic.	**A) Will**
2. A legally enforceable declaration directing the disposal of a decedent's property.	**B) Probate**
3. A lifetime opportunity to make a difference beyond your lifetime.	**C) Charitable bequest**

However you choose to include the Foundation in your plans, we would be grateful to hear from you. Having an idea of the testamentary support we may expect from our friends in future years is of great importance to us and those we serve. We will also be able to welcome you into the Founder's Legacy Society—our way of recognizing your gift and vision for our future.

For more information on bequests, gifts of retirement plan assets, or gifts that provide lifetime income, such as charitable remainder trusts, please call John McMurtry at (970) 479-5781. Please know that all information is confidential and requests for information never represent an obligation. ■

Answers: 1=B, 2=A, 3=C

Ormed Joins Foundation as New Corporate Sponsor

Ormed, GmbH & Co. KG, a manufacturer and distributor of orthopaedic and sports medicine products based in Fribourg, Germany, has joined the Steadman◆Hawkins Sports Medicine Foundation as a corporate sponsor. Ormed, which will be represented at the second Vail Cartilage Symposium, will bring 15 physicians from Germany to attend the three-day meeting.

Founded in 1992, Ormed has a staff of 130 and operates three subsidiaries and 65 distribution centers throughout Germany. The company specializes in manufacturing and distributing passive motion devices and other therapeutic systems, braces and splints. It has also developed breakthrough surgical technology in cartilage repair. The rental service team organizes outpatient treatment, including instructions on care and therapeutic treatment following surgery. Ormed's philosophy encompasses the development of innovative products, a carefully trained staff and sales force, and a well-established rental service throughout Germany. The company is a market leader in Germany in the field of continuous passive motion devices.

Frank Bömers, director of marketing, is pleased with the new sponsorship. "Our cooperation with the Steadman◆Hawkins Sports Medicine Foundation marks a new era in our commitment to excellent medical products and services." ■

Foundation to Host Second International Cartilage Symposium

The second International Cartilage Symposium, to be held Aug. 16-17 in Vail, Colo., will feature a world-renowned, international faculty of orthopaedic surgeons, each of whom has pioneered innovative procedures for treating articular cartilage injuries. The symposium, hosted by the Steadman◆Hawkins Sports Medicine Foundation and funded by Pfizer, Inc., will be co-chaired by Dr. J. Richard Steadman, founder of the Foundation and principal of the Vail-based Steadman-Hawkins Clinic, and Dr. Martin Boublik, principal of the Steadman-Hawkins Clinic's Denver office.

Dr. Lars Peterson of Sweden

The two-day meeting for practicing orthopaedic surgeons will include academic sessions and cadaver laboratory demonstrations. The symposium is being funded in part by an unresricted educational grant from Pharmacia Corporation and Pfizer, Inc.

Confirmed symposium faculty includes:

- Dr. J. Richard Steadman, who will present a lecture/demonstration on microfracture, a surgical procedure he has developed that recruits stem cells from bone marrow to form new cartilage over areas in the joint where bare bone is exposed.

- Dr. Lars Peterson of Sweden, who will demonstrate autologous chondrocyte transplantation, a two-stage procedure in which cartilage cells are collected from a patient's knee, grown outside of the body in a laboratory, and re-implanted into the knee joint surface defect.
- Dr. Laszlo Hangody of Hungary, who will discuss his experience with mosaicplasty. In this procedure, pieces of cartilage and bone are removed from a non-weight-bearing area of the knee and transplanted to a weight-bearing surface, to fill in where the cartilage has worn away.
- Dr. Allan Gross of Toronto, who will present his experience with allografting of chondral defects. In this procedure, large segments of bone and cartilage are removed from a donor cadaver's knee and implanted into a large defect.
- Dr. Richard J. Hawkins of Vail, who will discuss joint surface injuries in the shoulder.

With growing worldwide interest and concern over the increase in degenerative arthritis, this seminar will be timely and relevant to both the orthopaedic world and lay community. The meeting will be limited to 150 participants. Registration will be on a first come, first served basis.

For further information, contact Greta Campanale, education coordinator at the Steadman◆Hawkins Sports Medicine Foundation: (970) 479-5782. ■

Foundation Productivity Reaches New Levels in 2002

The contributions a scientific research organization makes to peer review organizations are true indicators of the effectiveness, value and sustainability of the organization. If the quantity of publications, videos and presentations and the quality of the peer review medical and scientific research, education and communications organizations accepting the Foundation's work is any indication, then the Steadman◆ Hawkins Sports Medicine Foundation is soaring to new heights.

Consider this:

Already in 2002, the Foundation has produced a record 44 papers, presentations, teaching videos and symposia which have been accepted by the following peer review organizations:

- *The American Academy of Orthopaedic Surgeons*
- *American Orthopaedic Society for Sports Medicine*
- *American Shoulder and Elbow Surgeons Society*
- *The Arthroscopic Association of North America*
- *The International Cartilage Repair Society*
- *Clinical Orthopaedics and Related Research*
- *World Congress of Biomechanics*
- *American Society of Biomechanics*

Donate On-Line

The Steadman◆Hawkins Sports Medicine Foundation has announced a web site enhancement that enables the Foundation to accept donations on-line. The Foundation's mission of "Keeping People Active Through Research and Education" assures the advancement of techniques, technologies and treatments for individuals suffering from arthritis, degenerative joint disease and injury. The Foundation relies on the generous support of its many donors to fulfill this mission.

To make it as easy as possible for donors, the Foundation recently added this service to its web site, www.shsmf.org. Merely click on the "Donate" button and the donation form will appear. All transactions are secure and the Foundation's privacy policy adheres to the strict standards established by the Foundation. Please feel free to contact John McMurtry at the Steadman◆Hawkins Sports Medicine Foundation with any questions. E-mail John at john.mcmurtry@shsmf.org or phone (970) 479-5781. ■

NFL Charities Makes $96,000 Grant to Foundation for Orthopaedic Research

Study Will Use Sophisticated Computer Model Developed by the Foundation

John Elway

For the 10th successive year, NFL Charities, the charitable foundation of the National Football League, has awarded a substantial research grant to the Steadman◆ Hawkins Sports Medicine Foundation for new and continuing work on the causes, treatment and prevention of sports-related injuries. The research project, "Force in the Upper Extremity Muscles with Intact and Ruptured Biceps Tendons: Implications for Treatment of Proximal Biceps Ruptures," will broaden our knowledge of how to treat bicep tendon pathology. The two current approaches to treatment are surgical or non-surgical, in which the bicep tendon is allowed to remain detached. Retired quarterback John Elway, who led the Denver Broncos to the Super Bowl after he ruptured his bicep tendon in pre-season play, was treated non-surgically. This year's $96,000 commitment is part of the NFL's continuing commitment to its athletes and to the public at large.

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(NFL CHARITIES cont. from pg. 3)

The study will utilize a sophisticated model of the upper extremity to quantify and explain the roles of the individual muscles of the shoulder and elbow in standard motions, with and without a ruptured biceps tendon. This complex computer model, developed by Dr. Marcus Pandy and Dr. Brian Garner at the University of Texas at Austin, will give researchers the ability to estimate individual muscle forces and joint reaction forces at the shoulder, elbow and wrist. Currently with this model, researchers can quantify the force required by each of the muscle bundles when performing exercise. This data will be invaluable in helping us understand the dynamics of muscle strength in the performance of upper-limb motions and will help clinicians make appropriate decisions regarding the treatment of biceps injuries.

Already considered one of the most sophisticated shoulder models in the world, the Biomechanics group within Steadman-Hawkins are working closely with Dr. Pandy to further develop and refine this model so that it can be utilized to study and understand other shoulder injuries such as rotator cuff tears. ■

Meet Our Staff:
Michelle Sabick, Ph.D., Senior Staff Scientist, Biomechanics Research Laboratory.

Dr. Sabick

Dr. Sabick joined the Foundation in the spring of 2000, bringing a wealth of knowledge and experience, along with an outstanding academic background. During her first two years, her main focus has been on upper-extremity research, investigating mechanics, rehabilitation and computer modeling of the shoulder. Dr. Sabick has directed a major portion of her research toward a study of the throwing motion. Information gained from this research will contribute to our knowledge of the upper extremity and help us determine the causes of shoulder injuries and how to prevent them. Her research will benefit Little League baseball players, their parents, coaches and physicians.

Dr. Sabick graduated summa cum laude from Case Western Reserve University in 1992. She earned a B.S. degree in biomedical engineering, with a specialty in biomechanics. Following her graduation, she enrolled in graduate studies in biomechanics at the University of Iowa. In 1994, Dr. Sabick received her M.S. degree in biomedical engineering, with specialties in sports biomechanics and geriatric engineering. In 1996, she led a student design team that was awarded first place in the U.S. Olympic Committee's Sport Science and Technology Design Contest. She completed her Ph.D. in biomedical engineering with a specialty in biomechanics at the University of Iowa in 1997. Her thesis was entitled "The Effects of Fall Direction and Protective Responses on the Likelihood of Hip Fracture in Falls."

Dr. Sabick was awarded a National Research Service Award Post-Doctoral Fellowship to conduct research at the Orthopedic Biomechanics Laboratory at the Mayo Clinic in Rochester, Minn. Her research at the clinic included studies of upper-extremity biomechanics in wheelchair propulsion, muscle activation in golfers, and functions of wrist ligaments.

As a complement to her work at the Foundation, Dr. Sabick has taught courses in biomechanics at the Colorado School of Mines and serves as an affiliate faculty member in the Department of Clinical Sciences at Colorado State University. She has also conducted research projects in collaboration with the Mayo Clinic, the University of Texas at Austin, and Regis University in Denver.

On her experience at the Foundation, Dr. Sabick said "Interacting with the physicians and working with the great team of researchers in the Biomechanics Research Laboratory has been a terrific experience for me. I have gained a new understanding of how clinicians interpret research and use it in their practices. Every day presents a new and interesting challenge."

Dr. Sabick and her husband Karl enjoy backpacking, snowboarding and running on the trails near their mountain home. ■

Research Audit Gives Foundation High Grades
Report Documents Major Contributions to Orthopaedics

By James H. Kimura, Ph.D.

Editor's note: Dr. Kimura is head of the Division of Research, Bone and Joint Department of Orthopaedic Surgery at Henry Ford Hospital in Detroit, Mich. This report is a condensed version of the final audit report and was based on material from the 1999 and 2000 Annual Research Reports of the Foundation and on material provided to Dr. Kimura in conjunction with his visit to the Foundation in December 2001.

The Steadman◆Hawkins Sports Medicine Foundation was established in 1988 by Dr. Richard Steadman as a nonprofit, charitable organization dedicated to addressing orthopaedic problems that restrict the physical activity of individuals through research and education.

The Foundation is governed by a Board of Directors made up of 29 distinguished citizens from 12 states and the District of Columbia. There is an outstanding Scientific Advisory Board composed of basic scientists and clinical researchers that meets annually to provide guidance on the Foundation's research and educational activities. Associates of the Foundation conduct their research and educational activities as a part of three major research areas—Basic Science, Clinical and Biomechanics—as well as units on Education, Information Systems and Visual Services.

Funding of the Foundation is largely divided between charitable contributions and corporate partnerships, with annual expenditures of approximately $3 million. The financial activities are reviewed each year by an independent accounting agency that certifies the Foundation's nonprofit status. It should also be noted that no arrange-

ments have been made with any corporate partner that prevents publication or presentation of research findings resulting from Foundation activities.

William G. Rodkey, D.V.M., director of Basic Science Research

RESEARCH

Research in Basic Science is under the direction of William G. Rodkey, D.V.M. There are two major projects underway. The first is an evaluation of a technique developed by Dr. Steadman that is used to elicit repair responses in focal defects in articular cartilage. The method utilizes a surgical awl to produce defects in the exposed bone that are about three millimeters deep and about three millimeters apart, leaving a bony lattice between each hole. This protocol is based on the observation that full-thickness cartilage defects that extend into the subchondral bone to produce bleeding and subsequent hematoma formation lead to the formation of new cartilage, while partial defects in cartilage never heal.

The refinement by Dr. Steadman of the full-thickness defect consists of producing a uniform pattern of microfracture holes in the bone that creates sufficient trauma for the influx of cells and growth factors sufficient to initiate the healing response while maintaining a large surface area of healthy bone in order to provide a sound foundation for the attachment of repair tissue. The surgery can be performed through arthroscopic procedures that minimize trauma to the joint. An important research finding is that calcified cartilage, if present, interferes with the integration of the repair tissue with the underlying bone, weakening the repair tissue. This observation led to a revision of the procedure used in humans to ensure that all calcified cartilage within the defect is removed prior to introducing microfractures.

A second major project deals with the use of microfracture to enhance healing in partial ligament tears, commonly referred to as "Healing Response." The hypothesis being tested is that microfractures will provide cells, growth factors and scaffolding to enhance the repair of torn ligaments. The results of the research are exciting, in that they suggest that the microfracture method may be useful in enhancing healing in other ligaments, such as the anterior cruciate ligament and other ligaments that typically do not heal after tearing.

Clinical Research is headed by Karen Briggs, M.B.A. The strength of this research lies in the extensive patient database that has been accumulated over the years. There is a dedicated effort to collect extensive information on all knee and shoulder patients seen in the clinic. Standard clinical assessment instruments are used as part of the evaluation and the data is stored and maintained by a dedicated information systems unit. By the end of last year, there were about 9,500 knee and 2,400 shoulder surgery patients in the database. All human studies have Internal Review Board approval. The unit functions as a resource that can be utilized by clinicians with a variety of clinical questions. The projects under investigation are varied, although major themes are emphasized. Clinical Research was an active research area with eight published papers, six papers accepted for publication, and five manuscripts in review for 2001.

Studies on microfracture for the treatment of chondral defects and for anterior cruciate ligament repair of tears near the insertion site are continuing long-term investigations that track patients who have undergone these procedures. One report presents results with an average follow-up period after surgery of 11 years. The importance of such a long-term follow-up for a clinical procedure cannot be overemphasized, since orthopaedic procedures are targeted to produce results with long lifetimes. The extensive data accumulated to date and the resources in place that support continued accumulation of data are a major asset of this research unit. These clinical studies of the "healing response" associated with microfracture treatment are likely to provide definitive data on establishing the efficacy of the technique.

Another notable area of research is the examination of assessment tools used to measure the success of surgical outcomes. This work is done in collaboration with Dr. Mininder Kocher, Children's Hospital and Harvard Medical School. In one study, "Determinants of Patient Satisfaction with Outcome after Anterior Cruciate Ligament Reconstruction," investigators found that while objective measures such as degree of flexure contraction, effusion, meniscal pathology at surgery and patellofemoral tenderness showed some correlation with patient satisfaction, subjective variables associated with symptoms and function were the strongest. This type of investigation provides important contributions to orthopaedics in providing direction in the development of more reliable and appropriate measures of surgical procedure success.

Another strength of the clinical research program is the opportunity to assess clinical problems in high-level athletes. Recent studies illustrate the potential of the unit. The effect of functional braces on protecting an anterior cruciate ligament-deficient knee was studied in a group of 159 professional skiers. It was found that skiers without functional bracing were six times more likely to sustain a subsequent knee injury. Furthermore, the injuries in individuals without bracing were about eight times more likely to require surgery. This work is currently in review for publication in the *American Journal of Sports Medicine*. Another study examined the effect of "Posterior Instability of the Shoulder with Secondary Impingement in Elite Golfers." This study has been accepted for publication in the *American Journal of Sports Medicine*.

Research into shoulder problems is also a major area of continuing clinical research. Shoulder instability, osteoarthritis and rotator cuff are three areas now under study. Work in each of these areas has resulted in publications appearing this year.

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(RESEARCH AUDIT cont. from pg. 5)

Biomechanics is headed by Michael R. Torry, Ph.D. Biomechanical laboratory research focuses on kinesiology and computer modeling as it relates to activities associated with the knee and shoulder. Areas of research reported on in the 2000 Annual Report have been very productive, leading to three publications, four manuscripts accepted for publication, and three manuscript in review for 2001.

Of note was a series of three papers that analyzed the relationship between throwing mechanics of professional baseball pitchers and shoulder distraction, extended play and elbow stress. These studies are another example of the ability of this research group to collect extensive data on high-level athletes.

A study in press examined knee stability in ACL-deficient knees with and without a functional knee brace. In static tests, anterior translation was decreased by bracing. However, even greater stability was achieved by a 50 percent contraction of the hamstrings. Dynamic tests suggested that bracing decreased anterior translation, but the differences were not statistically significant. The study concluded that bracing may help in cases of hamstring weakness. This study has direct relevance in assessing the utility of using functional braces for various activities.

Another paper, also accepted for publication, examined the kinematics of landing from a 60 cm fall in normal and ACL-reconstructed individuals. It found that ACL-reconstructed individuals landed differently from normal individuals and that the landing strategy reduced load to the knee. This suggested that, for better performance, rehabilitation strategy may need to focus on strengthening the entire leg and not just specific muscles.

Rehabilitation protocols were compared in ACL-reconstructed patients by kinematic analysis. Patients were rehabilitated either with a metronome set at the patient's preferred stride frequency or at a calculated resonant frequency or without the metronome (resonant stride frequency theoretically provides locomotion at minimal metabolic cost). While both regimens provided similar recovery, only the resonant frequency group significantly improved gait and quadriceps function during the treatment period.

A major effort of the laboratory is the development of mathematical models to simulate and predict the effects of alterations in particular muscular inputs on motion. A dynamic model for the knee and lower limb was developed in collaboration with Dr. Marcus Pandy of the University of Texas (Austin). This work has been accepted for publication. In it, the authors describe a mathematical model that incorporates the bones of the lower limb, elastic elements that represent the geometric and mechanical properties of ligaments and joint capsule, and muscle groups. It was found that stress on the ligament was three times lower in squat to stand than in unweighted knee extension. Maximum forces indicated that the squat to stand is a safe exercise for rehabilitation of patients having undergone surgical repair.

"(The Foundation) is a nonprofit organization whose members conduct original research, both basic and clinical, that is of high quality and is published in a timely manner… All research is conducted in a professional fashion. It is clear that the Foundation's work is entirely in the public interest. "

In a manuscript currently in review, the effect of hamstring action on the stability of the ACL-deficient knee in knee extension was examined. It is known that some co-contraction of the hamstrings is necessary to stabilize the knee during extension. The authors concluded that hamstrings co-contraction is more effective at stabilizing the knee than low-resistance extension exercise.

The knee model is now sufficiently developed to address numerous questions related to dynamic muscle activity and lower-limb motion. Emphasis has now turned to developing a mathematical model to describe shoulder motion and muscle forces. Developed as a three-dimensional model, it makes mathematical analysis extremely complex. It is difficult to determine with any accuracy bone position from surface markers that are conventionally attached to the skin. To circumvent this problem, externally visible markers were implanted into the bone of the shoulder. The subject's motion during various activities was captured by multiple high-speed video cameras. This data constitutes the most accurate 3D kinematic information data set available anywhere in the world. It will be used to construct the mathematical model and compare differences in motion of external surface markers and actual bone motion.

The medical field currently does not have any valid understanding of shoulder motion. The shoulder, which is entirely supported by soft tissue and muscular action, is such a complex structure that its motions tend to be very complex. The dynamics of muscular activity associated with motion are, as a result, only superficially understood. A 3D dynamic model of the shoulder will be very important in providing a detailed understanding of the dynamic forces acting on the bones, fibrous soft tissue and muscles during complex activities.

EDUCATION

The Foundation's educational component comprises several areas. First, there are six Fellows who train in sports medicine. They conduct a variety of clinical and basic science projects as well as being trained in the surgical specialty. In addition, the staff organizes conferences and offers support for its educational programs.

A Fellows conference is held each year, which brings together past and current Fellows to present and discuss current research. In addition, the Foundation's audiovisual facility produces video and educational programs that are used by Foundation members in their academic presentations as well as for placement on an extensive Foundation web site for the education of the general public.

In summary, the Steadman◆Hawkins Sports Medicine Foundation conducts research and education in the area of sports medicine with the goal of keeping people of all ages physically active. It is a nonprofit organization whose members conduct original research, both basic and clinical, that is of high quality and is published in a timely manner. All research is conducted in a professional fashion with approval by the Internal Review Board and animal welfare committees where required. It is clear that the Foundation's work is entirely in the public interest, and there are no restrictive arrangements with commercial concerns associated with any of the Foundation's research. ■

Steadman◆Hawkins Update:
Publications, Presentations and Research

Annual Meeting of the American Academy of Orthopaedic Surgeons
The Foundation is once again on track to set a record for the number of presentations and publications accepted by prestigious medical and scientific research, education and communications organizations.

In February, Dallas was the location of the 69th Annual Meeting of the American Academy of Orthopaedic Surgeons (AAOS), an organization representing 17,000 members. The Foundation was well represented by the Clinical Research Department, which prepared seven presentations and poster exhibits that were made by Foundation principals for this annual meeting.

Academy Highlights:

Richard J. Hawkins, M.D., authored the paper *Prevalance of Glenohumaeral Osteoarthrosis With Shoulder Instability* (co-authors included Michelle L. Cameron, M.D.; Karen K. Briggs, M.B.A .; Mininder S. Kocher, M.D.; and Marilee P. Horan). Patients with shoulder instability, time from injury to surgery, and older age showed significant associations with arthritis, whereas direction of instability did not.

The poster presentation *A Minimally Invasive Technique (Healing Response) to Treat Acute ACL Injuries in Patients 40 Years and Older*, which was also presented during the American Orthopaedic Society for Sports Medicine Specialty Day, has generated a great deal of interest in the orthopaedic world, in the media and with the general public after release of information on the "healing response" (see "Patients in the News"). **J. Richard Steadman, M.D.**, who pioneered this procedure, was the lead author of the presentation. Co-authors included Michelle L. Cameron, M.D.; Karen K. Briggs, M.B.A.; and William G. Rodkey, D.V.M.

Related to this poster was the presentation *Determinants of Patient Satisfaction After Anterior Cruciate Ligament Reconstruction.* Authors included Mininder S. Kocher, M.D.; J. Richard Steadman, M.D.; Karen K. Briggs, M.B.A .; David Zurakowski, Ph.D.; William I. Sterett, M.D.; and Richard J. Hawkins, M.D. This poster identified the determinants of patient satisfaction after ACL reconstruction.

A third poster exhibit entitled *Lysis of Pretibial Patellar Tendon Adhesions (Anterior Interval Release) to Treat Anterior Knee Pain After ACL Reconstruction* was authored by Sumant G. Krishnan, M.D.; J. Richard Steadman, M.D.; Kimberly Hydeman; and Matthew Close. This paper reported the results of anterior interval release to treat recalcitrant anterior knee pain after ACL reconstruction.

Another presentation was *Relationship of Instrumented Knee Laxity, Lachman Examination, and Pivot-Shift Examination to Subjective Symptoms and Function After ACL Reconstruction,* by Mininder S. Kocher, M.D.; J. Richard Steadman, M.D.; Karen K. Briggs, M.B.A.; William I. Sterett, M.D.; and Richard J.Hawkins, M.D. This paper examined the relationship between objective measures of ligament stability and subjective measures of symptoms and function after ACL reconstruction.

Mininder S. Kocher, M.D., was the lead author of the presentation *Management and Complications of ACL Injuries in Skeletally Immature Patients*. The authors included Richard J. Hawkins, M.D.; Hillary S. Saxon; and W. David Hovis, M.D. Formatted as a questionnaire, the presentation summarized experience with management and complications of pediatric anterior cruciate ligament injuries.

American Academy of Orthopaedic Surgeons Multimedia Education Center

The Academy accepted 25 teaching video presentations. Eight of these videos were produced by the Foundation, and the video *Diagnostic Wrist Arthroscopy: Equipment, Anatomy and Surgical Technique,* by Sumant G. Krishnan, M.D.; and Randy W. Viola, M.D., was one three 2002 distinguished award winners. Congratulations to video services producers John Lenk and Karen Mehlhart.

Seven other videos were accepted. They included:

- *An Update on Acromioclavicular Injuries.* Theodore F. Schlegel, M.D.; Martin Boublik, M.D.; and Richard J. Hawkins, M.D.
- *Surgical Technical for Subscapularis Repair, Biceps Tenodesis and Margin Convergence Rotator Cuff Repair.* Sumant G. Krishnan, M.D.; and Richard J. Hawkins, M.D.
- *Arthroscopic Assessment and Treatment of Partial-Thickness Tears of the Rotator Cuff.* Sumant G. Krishnan, M.D.; and Richard J. Hawkins, M.D.
- *Two-Incision ACL Reconstruction.* David S. Gazzaniga, M.D.; and J. Richard Steadman, M.D.
- *Surgical Treatment of the Arthrofibrotic Knee.* Peter J. Millett, M.D.; and J. Richard Steadman, M.D.
- *Advanced Stretching and Strengthening of the Colorado Rockies.* Richard J. Hawkins, M.D.; and John M. Tokish, M.D.
- *The Athlete's Shoulder Tour.* Edited by Richard J. Hawkins, M.D.; and Michael L. Pearl.

American Shoulder and Elbow Surgeons Society

The research paper *Subscapularis Muscle Activity During the Lift-Off and Belly Press Tests* was accepted for publication by the American Shoulder and Elbow Surgeons Society and was named a finalist for the Neer Award. Authors included John M. Tokish, M.D.; Michael J. Decker, M.S.; Michael R Torry, Ph.D.; Henry Ellis; and Richard J. Hawkins, M.D.

The Arthroscopic Association of North America Annual Meeting

At the Arthroscopic Association of North America (AANA) annual meeting in Washington, D.C., in April, two posters and one podium presentation were accepted: *A Minimally Invasive Technique (Healing Response) to Treat Acute ACL Injuries in Patients 40 Years and Older,* by J. Richard Steadman, M.D.; Michelle Cameron, M.D.; Karen K. Briggs, M.B.A.; and William G. Rodkey, D.V.M.; *Lysis of Pretibial Patellar Tendon Adhesions (Interval Release) Determinants of Patient Satisfaction After ACL Reconstruction,* by Sumant G. Krishnan, M.D.; J. Richard Steadman, M.D.; Peter J. Millett, M.D.; Kimberly Hydeman; and Matthew Close; and *Outcomes of Patients Treated*

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Arthroscopically by Microfracture for Traumatic Chondral Defects of the Knee: Average 11-Year Follow-Up, a benchmark presentation that included J. Richard Steadman, M.D.; Karen K. Briggs, M.B.A.; Juan J. Rodrigo, M.D.; Mininder S. Kocher, M.D.; Thomas J. Gill, M.D.; and William G. Rodkey, D.V.M.

Fourth Symposium of the International Cartilage Repair Society (ICRS)

During its fourth symposium in Toronto in June, the ICRS accepted one presentation and one poster. The presentation *Patient Satisfaction and Functional Outcome After Microfracture of the Degenerative Knee* was authored by J. Richard Steadman, M.D.; Bruce S. Miller, M.D.; Karen K. Briggs, M.B.A.; Jason Folk, M.D.; and Juan J. Rodrigo, M.D. The poster *Collagen Meniscus Implants: Long-Term (5 to 6 Years) Feasibility Results and Multicenter Clinical Trials Update* was authored by William G. Rodkey, D.V.M.; and J. Richard Steadman, M.D.

Clinical Orthopaedics and Related Research
Microfracture Procedure gains acceptance

An important research project has been accepted by the journal *Clinical Orthopaedics and Related Research*. Titled "Early Events in Cartilage Repair Augmented by Subchondral Bone Microfracture in an Equine Model," publication of this project in this prestigious journal is a significant milestone for the Foundation as the microfracture procedure gains acceptance in orthopaedics as the initial procedure of choice. Authors included Dave D. Frisbie; J.T. Oxford, L. Southwood; G.W. Trotter; William G. Rodkey D.V.M.; J. Richard Steadman, M.D.; J. L. Goodnight; and C. Wayne McIlwraith, D.V.M., Ph.D.

Annual Meeting of the American Orthopaedic Society for Sports Medicine (AOSSM)

The annual meeting of AOSSM, to be held in Orlando June 30-July 3, will again be well represented by Foundation members. Of the thirty-six posters accepted in advance of the meeting, four were originated by the Foundation. They include: *Determinants of Patient Satisfaction with Outcome after Rotator Cuff Surgery,* James O'Holleran, M.D.; Mininder S. Kocher, M.D.; Marilee Horan; Karen Briggs, M.B.A.; and Richard J. Hawkins, M.D.; *An Analysis of Shoulder Distraction Forces in Little League Pitchers,* Thomas A. Joseph, M.D.; Michelle B. Sabick, Ph.D.; Michael R. Torry, Ph.D.; Michael J. Decker, M.S.; Richard J. Hawkins, M.D.; and Theodore Schlegel, M.D.; *Muscular Weakness Causes Increased Peak Adductor Moment During Gate,* Peter J. Millett, M.D.; Michael R. Torry, Ph.D.; Mary Pflum; Michael Decker, M.S.; and J. Richard Steadman, M.D.; and *Effects of Braiding on Tensile Properties of Four-Strand Human Hamstring Graphs,* Peter J. Millett, M.D.; Bruce S. Miller, M.D.; William I. Sterett, M.D.; William Walsh, Ph.D.; and Richard J. Hawkins, M.D.

Foundation principals will also present four papers, two symposia and one course lectureship. Presentations will include: *Gender Differences in Lower Extremity Positions and Muscular Shock Absorption During Landing,* by Douglas J. Wyland, M.D.; Michael J. Decker, M.S.; Michael R. Torry, Ph.D.; William I. Sterett, M.D.; and J. Richard Steadman, M.D.; *Electrothermal Arthoscopic Shoulder Capsulorrhaphy: A Minimum Two Year Follow-Up,* by Sumant G. Krishnan, M.D.; Richard J. Hawkins, M.D.; Spero G. Karas, M.D.; Marilee Horan; and Thomas, J. Noonan, M.D.; *Rupture of the Subscapularis Tendon After Open Anterior Instability Surgery: Diagnosis, Treatment, and Outcome* by, Bruce S. Miller, M.D.; Thomas J. Noonan, M.D.; Marilee Horan; and Richard J. Hawkins, M.D.; and *Relationship Between Objective Assessment of Ligament Stability and Subjective Assessment of Symptoms and Function After ACL Reconstruction,* by Mininder S. Kocher, M.D.; J. Richard Steadman, M.D.; Karen K. Briggs, M.B.A.; and William I. Sterett, M.D.

Dr. Hawkins will moderate the symposium *Treatment of Chronic Proximal Biceps Tendinitis.* Dr. Steadman will participate in the panel *Current Concepts: Salvage Procedures for the Post-Meniscectomy Athlete*. He will also present *Meniscal Scaffold.* Dr. Rodkey, director of Basic Science Research for the Foundation, has been chosen as an instructor for the course *Tendinosis and Tendinitis: Pathophysiology, Non-operative, and Operative Management.*

Fourth World Congress of Biomechanics

The Fourth World Congress of Biomechanics, to be held in Calgary in August, is the premier event in biomechanics and the official congress of the World Council for Biomechanics. Congratulations to the Biomechanics Research Laboratory, which has developed a record nine abstracts that have been accepted by the Congress. They include:

- *Tibio-Femoral Kinematics and Contact Patterns Are Altered Due to Weakness of the Semitendinosus and Gracilis,* by Michael.R. Torry, Ph.D.; T. Yanagawa; Kevin B. Shelburne, Ph.D.; J. Richard Steadman, M.D.; and William I. Sterett, M.D.
- *Quadriceps Weakness Causes an Increase in the Peak Adductor Moment During Gait* by, M. Plum, Michael R. Torry, Ph.D.; Peter Millett, M.D.; Michael J. Decker, M.S.; and J. Richard Steadman, M.D.
- *Evaluation of Tibiofemoral Compressive and Shear Loads in the Medial and Lateral Knee Compartments During Isometric Exercises* by T. Yanagawa; Michael R. Torry, Ph.D.; Kevin Shelburne, Ph.D.; J. Richard Steadman, M.D.; and William I. Sterret, M.D.
- *Gender Differences in Lower Extremity Shock Absorption During Vertical Drop Landings* by, Michael J. Decker, M.S.; Michael R. Torry, Ph.D.; Doug Wyland, M.D.; William I. Sterett, M.D.; and J. Richard Steadman, M.D.
- *Muscle Activation Differences Between the Upper and Lower Subscapularis Muscles During Abduction and Rotation* by, Michael Decker, M.S.; Michael Torry, Ph.D.; Henry B. Ellis; John M. Tokish, M.D.; and Richard J. Hawkins, M.D.
- *Effect of Hamstrings Muscle Action on Stability of the ACL-Deficient Knee* by, T. Yanagawa; Kevin B. Shelburne, Ph.D.; F. Serpas; and Marcus G. Pandy, Ph.D.

- *Evaluation of Tibiofemoral Compressive and Shear Loads in the Medial and Lateral Knee Compartments During Isometric Knee Exercises* by, T. Yanagawa; Michael R. Torry, Ph.D.; Kevin B. Shelburne, Ph.D.; J. Richard Steadman, M.D.; and William I. Sterett, M.D.,
- *Anterior-Cruciate Ligament Forces in the Intact Knee During Normal Gait,* by Kevin B. Shelburne, Ph.D.; Marcus G. Pandy, Ph.D.; F.C. Anderson; and Michael R. Torry, Ph.D.
- *Ligament Forces in the Anterior Cruciate Deficient Knee During Gait,* by Kevin B. Shelburne, Ph.D.; Marcus G. Pandy, Ph.D.; F.C. Anderson; and Michael R. Torry, Ph.D.

Education

The Twelfth Annual Fellows Meeting, held in December in Vail, brought together orthopaedic surgeons who have participated in the Steadman-Hawkins Fellowship Program to discuss current orthopaedic treatment options, surgical techniques and research.

A highlight of this year's meeting was the participation of the Cleveland Clinic Fellowship Society and its program director, John A. Bergfeld, M.D. Special guest lecturer was David W. Altchek, M.D., from the Hospital for Special Surgery in New York City, who gave two presentations: "Biomechanical and Anatomical Consideration for Internal Impingement" and "Management of MCL Injuries of the Elbow in Throwers."

Also presenting was Marcus Pandy, Ph.D, Professor in the Department of Biomedical Engineering at the University of Texas at Austin, who lectured on "Biomechanical Modeling of Movement." Charles P. Ho, M.D., Ph.D., of National Orthopedic Imaging Associates, presented "MRI of Elbow Injuries in the Throwing Athlete." Mininder S. Kocher, M.D., M.P.H., of the Department of Orthopaedic Surgery at Children's Hospital in Boston, gave an "Update on Outcomes Research from the Steadman◆Hawkins Sports Medicine Foundation." Drs. Pandy, Ho and Kocher are active members of Steadman◆Hawkins Sports Medicine Foundation's Scientific Advisory Committee.

Awards

The American Society of Biomechanics has selected the abstract "Anterior-Cruciate Ligament Forces in the Intact Knee During Normal Gate" as one of two finalists in the 2002 *Journal of Biomechanics* award competition. The abstract was co-authored by Kevin Shelburne, Ph.D.; Marcus Pandy, Ph.D.; F. Anderson; and Michael Torry, Ph.D. The award, one of the most prestigious in biomechanics, will be announced at the Fourth World Congress on Biomechanics in August.

In addition, the Clinical Research department, under the directorship of Karen Briggs, M.B.A., was awarded a $6,500 grant from the American Shoulder and Elbow Society for validation of the ASES score, a subjective scoring system used to measure patient satisfaction.

Audit

For the past eight years, the Foundation has had an external financial audit conducted to review its financial reporting and nonprofit compliance issues. For the first time in the Foundation's history, two research audits were conducted. The first audit was conducted by **James H. Kimura, Ph.D.**, who is head of the Division of Research, Bone and Joint Department of Orthopaedic Surgery at Henry Ford Hospital in Detroit, Michigan (see page 3). **Dr. Mininder S. Kocher** of Children's Hospital in Boston and Harvard Medical School also conducted an audit of the data being collected on microfracture, "healing response" and shoulder thermal patients. The audit revealed no errors in translation from the paper data forms to the computerized entries.

Board of Directors in the News

John C. Tolleson Joins Foundation's Board of Directors

John C. Tolleson has joined the Board of Directors of the Steadman◆Hawkins Sports Medicine Foundation. He is chairman of The Tolleson Group and managing director of Arena Capital Partners, both private investment firms, and is the former chairman and chief executive officer of First USA, Inc. (acquired by Bank One Corp. in 1997), which he founded in 1985.

Tolleson serves as a director or trustee on several boards, including Haggar Corp., Southern Methodist University, Southwestern Medical Foundation and Dallas County Advisory Board of the Salvation Army. In addition, he is a member of the Board of Directors of the Willis M. Tate Distinguished Lecture Series and the John Goodwin Tower Center for Political Studies at Southern Methodist University in Dallas, where he also serves on the Executive Board of the Edwin L. Cox School of Business. Tolleson is the recipient of the Edwin L. Cox School of Business Distinguished Alumnus Award.

Media

In February, the world not only focused its attention on Salt Lake City and the Winter Olympics, but on the sensational American skier **Bode Miller** and the "healing response" procedure pioneered and performed by Dr. Steadman to repair Miller's ACL. Miller, who had injured his ACL the year before, went on to win two silver medals and finished second in the overall World Cup slalom standings. Major stories on Miller and the healing response appeared in the Nov. 4 and 11 ***Denver Post*** ("Miller's Miracle: Healed Knee," by John Meyer) and the Feb. 8 ***Boston Globe*** ("Easy Rider," by Tony Chamberlain). **NBC Sports** Olympic coverage also covered the story in a feature on Miller and Dr. Steadman. NBC Sports journalists Todd Brooker and Christin Cooper-Tache—both former Steadman-Hawkins patients—prepared the piece as part of NBC's Olympic coverage. Miller's performance was the best in 18 years by an American male since Phil Mahre's Olympic slalom win in 1984 (Mahre was also a Steadman patient). **Ivica Kostelic**, another former patient of Dr. Steadman's, topped Miller in the Olympic slalom standings and went on to win the overall World Cup Slalom Title. ■

Can Gender Differences in the Prevalence of Osteoarthritis Be Due to Differences in Mechanical Loading During Walking?

By Michael Decker, M.S., Staff Scientist
Biomechanics Research Laboratory

Due to the increase in injuries associated with high dynamic loading to the musculoskeletal system during running, walking has become one of the preferred modes of exercise for millions of people. Many, however, are unaware that walking can also place a considerable load on the musculoskeletal system, particularly the knee. For example, when the foot contacts the ground, an upward force, or shock wave, is applied to the foot and transmitted through the ankle joint to the knee joint, then throughout the rest of the skeletal system. Current research has determined that the loading rate of this shock wave is a primary cause of many orthopaedic conditions, including knee pain and osteoarthritis (OA).

Knee joint degeneration initiated by a mechanical means has recently received great attention. It has been found that an excessively high rate of loading is largely due to poor shock absorption from the quadriceps muscles. Poor muscular shock absorption allows hard and fast loading and increases the shock absorption demands from the bones. Bones are able to absorb energy through bending and tiny fracturing in the ends of long bones—the trabeculae lattice—just underneath the cartilage. Repetitive microtrauma to the bones from poor muscular shock absorption prevents adequate healing of the tiny bone fractures. Eventually, the ends of the long bones become thick and hardened and no longer provide the same level of shock absorption. Reduced shock absorption from the muscles and bones increases the loading to the cartilage on the ends of the bones and meniscus. The result is a painful, arthritic knee.

Interestingly, recent evidence suggests that women are at nearly twice the risk of developing knee OA than men, indicating that female gender is a significant risk factor for OA. Knee OA is more prevalent among women than among men at all ages, suggesting factors other than hormonal differences are contributing to this gender disparity. In addition, the prevalence of symptomatic OA at all levels of radiographic severity, and reports of knee pain, are nearly twice the rate in women as it is in men. The exact cause for this gender difference in knee OA prevalence is currently unknown, but we propose that it is due primarily to a difference in mechanical loading which occurs during activities of daily living such as walking. From this perspective, joint degeneration would require many gait cycles over many years. Thus, we hypothesized that the mechanical loading during gait is greater in relatively young and active females compared to that of a group of males.

Figure 2*. The initial collision of the foot with the ground (right leg pictured above) creates a shock wave throughout the skeletal system. The loading rate of this shock wave has been found to be a cause of degenerative changes in the knee.*

We investigated the maximum rate of loading at self-selected walking speeds with a treadmill that housed two force plates. We also manipulated the stride rate to be 15 percent faster and slower, while keeping speed constant, to determine whether the female group had different magnitudes of loading with different stride rate/stride length combinations when compared to males.

Both genders demonstrated similar changes in stride lengths and loading to the three stride rate conditions. When the stride rates were faster and slower, both genders demonstrated shorter and longer stride lengths, respectively, compared to the preferred stride rate condition. Figure 1 demonstrates that the preferred stride rate yields the smallest loading rates and deviations from the preferred stride rate yields, on average, 27 percent higher loading rates. Although both genders had similar changes in stride length and loading between stride rate conditions, the loading rate was, on average, 41 percent higher across the three stride rate conditions for the female group compared to the male group.

The results demonstrated that both males and females choose a stride rate/stride length combination during walking that minimizes the potentially dangerous loading rates associated with joint degeneration. Interestingly, an average change in step length as small as four inches either longer or shorter from that of preferred was found to increase the loading rates. However, females were shown to have greater loading rates at each stride rate/stride length combination compared to that of males. This supports the notion that females may have a greater

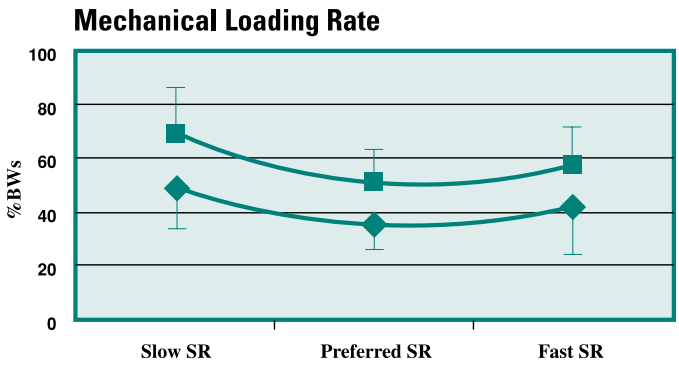


Figure 1*. Maximum loading rates and standard deviations for males (diamonds) and females (squares) during three stride rate (SR) conditions.*

Non-weight-bearing aerobic activities such as swimming and biking are beneficial to your joints because you can burn calories for weight loss without the large ground impacts.

prevalence of knee OA due to a mechanical performance difference during walking.

Injury prevention, including OA, is the primary mission of the Biomechanics Research Laboratory, and its current work highlights the need for people, particularly females, to be more aware of what is going on beneath their feet. We must emphasize that although excessive loading may be injurious to your joints, the skeletal system needs to be loaded to maintain strong and healthy bones. But once again, there is a happy medium between too much and too little, and following are some recommendations for helping you attain this balance.

One of the most overlooked areas in protecting your knees is the period when you are busy at work. The type of shoe you wear is critical to the protection of your joints. Dress shoes, particularly women's dress shoes, have minimal cushioning. It is well established that cushioned shoes, or cushioned insoles, can reduce the rate of loading compared to other types of dress shoes.

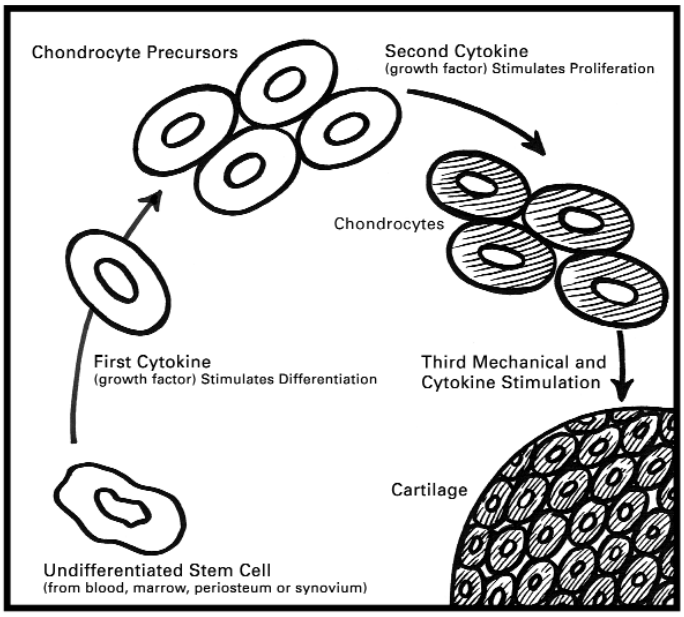
Now that summer is here, walking or running may again become a popular event. Aerobic activity cannot be stressed enough for individuals who are overweight, since being overweight increases the loading and risk of OA. Non-weight-bearing aerobic activities such as swimming and biking are beneficial to your joints because you can burn calories for weight loss without the large ground impacts. However, weight-bearing activities, such as walking or jogging, burn more calories but produce greater loading to your joints. To protect yourself from excessive loading during weight-bearing activities, appropriately cushioned shoes are helpful. Perhaps even more important is the surface that you walk or run on. Performing these activities on soft surfaces, such as dirt trails or on the shoulder of the road, is better for your joints than walking or jogging on hard surfaces, such as asphalt roads. The addition of walking poles can help further reduce loading as well.

Going to the gym is another way to protect your knees from potentially harmful forces. Strength training the quadriceps muscles is an important facet of any workout, since research has shown that subjects with strong quadriceps have lower loading rates when compared to others with weak quadriceps. Inclined treadmill walking or running is also beneficial as it requires greater knee flexion at contact and, as a consequence, allows the lower extremity to be in a compliant shock absorption mode, which can reduce loading and promote quadriceps strength.

A great deal more work is needed to determine whether gender differences in mechanical loading rates exist across all age groups, and whether the longitudinal utilization of larger loading rates leads to earlier and greater prevalence of knee OA. Although past research indicates that the female gender is a risk factor to knee OA, we feel that excessive mechanical loading contributes significantly to this statistic and is modifiable by several preventative measures. ■

(RESEARCH UPDATE cont. from pg. 1)

CARTILAGE FORMATION MODEL (Figure 1)



ART BY: TIM CAMBELL, HILL & COMPANY

bioresorbable scaffolding matrices to support cellular attachment, migration and proliferation. In our last two newsletters, we discussed growth and differentiation factors (cytokines) and gene therapy as ways to improve cartilage repair. In this issue we'll focus on ways to improve cartilage repair by adding cells to the repair site.

Many of the standard approaches to the treatment of full-thickness cartilage loss in the knee and other joints have utilized the concept of cell-based therapy. Microfracture, for example, brings new stem cells from the bone marrow into the defect so they can become attached to the rough surfaces and change into cartilage cells. Another technique, abrasion chondroplasty, involves abrading the bare bone to bleeding vessels that will provide some stem cells from the blood to the blood clot formed in the defect. A third technique, autologous chondrocyte implantation (ACI), involves injecting chondrocytes under a periosteal (bone) sheet that has been sewn over the defect. The latter technique introduces mature cartilage cells, as opposed to stem cells, and are used in the first two techniques mentioned above. Stem cells are undifferentiated cells found in marrow and blood that have the capability of developing into cartilage cells, whereas the ACI technique employs expansion of previously harvested cartilage cells that are grown in tissue culture and allowed to multiply.

The development of cell-based approaches has advanced dramatically in recent years as an understanding of cartilage cell biology has improved. The concept of cell-based therapy is that the repair process does not rely on stem cells for the syn-

(Continued on page 12)

(RESEARCH UPDATE cont. from pg. 11)

thesis of new cartilage. As a result, this therapy is particularly attractive for patients who have a diminished pool of stem cells. Older patients (over 45) typically have fewer stem cells in the marrow and blood, and their healing capacity after abrasion or microfracture is not typically as good as that of a younger patient. Similarly, the supply of stem cells might be compromised when the tissue bed is compromised. For example, often in chronic arthritis of the knee, the exposed bare bone is sclerotic (hard) and does not provide the number of stem cells that would be provided by a healthy bone.

New techniques are evolving rapidly to provide increased numbers of stem cells to healing cartilage. One example is a machine that can prepare a platelet and stem-cell-rich concentrate of plasma from 50 cc (2 tablespoons) of blood. The platelets provide important cytokines (growth chemicals), such as TGF-B, PDGF, EGF, and VEGF, and the stem cells can turn into cartilage cells. Preliminary experiments in animals with cartilage defects have shown that this preparation can stimulate new cartilage formation when injected into the knee. Future experiments will be designed to introduce the platelet and stem-cell-rich plasma as a gel into every other hole of the bed prepared with the microfracture technique. Significant improvement in the amount and quality of healing cartilage is expected. Another attractive aspect of the technique is that the cells can be introduced with the arthroscope through small (quarter-inch) incisions, as opposed to opening the knee.

Matrices (sponges) have been studied for the introduction of cell-based therapies. Cells can be derived from a harvest of marrow or blood, and then concentrated into a stem-cell-rich solution. Microsponges made of collagen can be impregnated with these cells, and then introduced into a cartilage defect. Problems have occurred in animal experiments, however, which indicates that the collagen matrix shrinks and adequate coverage of the defect is not achieved. Further experiments with another matrix made of a hyaluronate gel appear much more promising. Bioresorbable polymers are also being studied as delivery vehicles. More work needs to be done to develop the best delivery matrix, since it's important to keep the new cells at the repair site and not let them float away.

Surgical techniques involving sheets of periosteum (bone covering) and perichondrium (cartilage covering) sewn over cartilage defects have been studied as a source of new repair cells. These techniques use the stem cells on the undersurface of the sheet to provide prechondrocytes for cartilage repair. One of the main difficulties with these techniques is that they require a major open surgical procedure to complete the repair. First, a separate incision is required away from the knee (over the leg bone or a rib) to harvest the sheet of periosteum (about the size of a quarter). A second two- to three-inch incision is then required to open the knee for suturing of the periosteal or perichondral sheet over the cartilage defect. A second-generation technique, called autologous chondrocyte implantation (ACI), also includes injection of chondrocytes previously harvested from an earlier arthroscopy. The chondrocytes are injected under the sutured periosteal sheet. The addition of the more invasive surgical procedures is a disadvantage compared to the cell-based therapies using arthroscopic techniques.

In summary, exciting new techniques are being developed to add cartilage precursor cells or mature cartilage cells to healing cartilage defects. The normal cascade of development of mature cartilage cells from stem cells is shown in Figure 1. It appears that successful harvesting of stem cells, chondrocyte precursors or chondrocytes can be achieved and delivered to the repair site. Subsequent stimulation by the appropriate cytokines and mechanical environment can achieve healthy cartilage repair tissue. It is expected that the repair tissue will be even stronger and more durable than that achieved by the standard techniques used today. Sophisticated designs have even tried to combine cell therapy, cytokine therapy and gene therapy to improve the repair. The latter designs will be the subject of an article in our next newsletter. ■

(SPORTS AND WELLNESS cont. from pg. 1)

Lower Back Rotational Stretch

ALL PHOTOS: JOHN LENK

Double Knees to Chest

Hamstring Stretch

back). Not having a flexible, stable lower back can lead to injuries. Fortunately, these injuries can easily be avoided.

Stretching exercises are extremely important to increase the amount and quality of motion a joint allows. And the greater your shoulder turn and/or hip rotation, the more power you can generate to hit those 300-yard drives. Stretching is important before and after playing. So is a pre-season routine that can enable you to jump right into mid-season form. So let's talk about lower back rotation, lower back extensors, hamstrings, and, for "righties," left shoulder flexibility.

Lower Back Rotational Stretch: Lie on your back and extend one leg fully. Flex the hip and knee of your other leg and place that ankle on the outside of the extended leg's thigh. Pull the knee to the opposite shoulder. Be sure to keep both shoulders on the ground, concentrating on rotation of your lower back. Hold for a count of 15 and repeat two times on each side.

Double Knees to Chest: Tighten your abdominal muscles and hold your back flat. Then bring both knees up to your chest, grasp your knees with your hands, and hold your knees against your chest for

Cross Arm Stretch

Transverse Abdominus Isometrics

15-20 seconds. Return to the starting position, rest, then repeat two more times.

Hamstring Stretch: Sit with your leg out straight and lean forward reaching for your toes. Be sure to keep your back straight; the stretch will be felt on the back of your thigh, and sometimes down as low as your calf muscle. Hold for a count of 15 and repeat two times on each side.

Cross Arm Stretch: To stretch your left arm, pull your left arm across your body, pulling your elbow towards your right shoulder. The stretch will be felt in the back of the left shoulder. Hold for a count of 15 and repeat two-three times. (Left-handed golfers should stretch their right arm.). Keep the elbow straight as you stretch to get in the habit of keeping that arm straight through the entire backswing.

Strengthening exercises are important, but we're not looking for size and power. Overall cardiovascular and muscular fitness is significant, but the small muscles around the torso that provide balance and stability are key. Balance is crucial to the golf swing; without it, making consistent shots is easier said than done. Surrounding your spine are several muscles that give you stability and mobility in all directions. Providing balance and helping to avoid injury are the transverse abdominus and multifidus muscles. These two muscles surround the spine and provide strength and stability during movement. With injury, these small muscles tend to "shut off," not providing enough support. Predominantly for players with lower back problems, an easy fix is to retrain your transverse abdominus. It is an easy exercise that can be performed during all activities. The first step is learning to contract the muscle on command, then being able to tighten the muscle while doing just about any movement or exercise.

Transverse Abdominus Isometrics: Lie on your back with your knees bent 90 degrees. Place your fingertips just inside the front of your hip bones. Take a deep breath in and out and gently draw in your abdominal wall. Feel like you're trying to pull your bellybutton down towards the floor. The contraction will be felt under your fingertips. It's important that you keep your spine in a neutral position; you do not want your back arching or flattening while working on this contraction. You may find this difficult to do, especially if you have an injury. Work on repetitions, holding roughly 10 seconds each time.

As the contractions become easier for you, try raising one foot off the floor while maintaining your tight abdominal wall. This is more difficult yet, so be even more conscious of your lower back flattening into the table, which you don't want it to do. Begin alternating feet, and hold the contraction the entire time.

Next, progress to seated or standing exercise while holding the transverse abdominus tight at all times. One exercise is to hold the muscle strong while riding a stationary recumbent bike. Even more practical is to hold strong while driving your car to work.

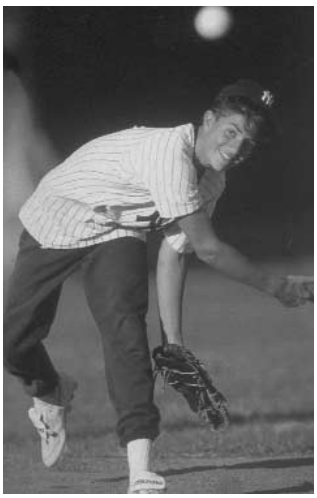
As you get more and more proficient with this exercise, incorporate it into everything you do, particularly before lifting a heavy object or bending over. Also try tightening the muscle even when you're in pain—the increase in strength and stability can only help.

At Howard Head Sports Medicine Center in Vail, Mike Garofalo, P.T., and I have developed a golf program to help any player of any level get to the point of playing better and feeling better. We offer videotaped biomechanical swing evaluations, and from that information we can determine your strengths, weaknesses, restrictions and/or limitations. We also provide an exercise routine tailored to an individual's problems. Stop in or call anytime. ■

Differences in Pitching Motion Between Professional and Little League Baseball Pitchers

Improper Trunk Control May Cause Shoulder Injuries in Youth Pitchers

Michelle B. Sabick, Ph.D.
Senior Staff Scientist, Biomechanics Research Laboratory



Most of the existing research on pitching biomechanics is focused on elite adult pitchers, with very little data available describing the biomechanics of youth pitchers. Understanding the biomechanics of youth baseball pitchers is important for several reasons: (1) the number of active youth pitchers is much greater than the number of elite athletes, (2) injuries due to overuse and poor throwing mechanics are common in youth pitchers, and (3) the pitching mechanics of less-skilled pitchers may lead to different stresses on the arm than occur in more-skilled professional pitchers. Unique aspects of the developing skeleton make it susceptible to a spectrum of injuries not commonly seen in adult athletes.

Although these injuries are most likely due to the musculoskeletal changes occurring during growth, they may also be, at least in part, due to pitching technique. Scientists in the Biomechanics Research Laboratory at the Steadman◆Hawkins Sports Medicine Foundation have compared the biomechanics of Little League pitchers with that of elite adult pitchers to identify important differences that might explain common injuries seen in the youth pitcher population. Overuse injuries in youth pitchers are becoming increasingly common as pitchers train more often and more specifically at younger and younger ages.

(Continued on page 14)

(PITCHING MOTION cont. from pg. 13)

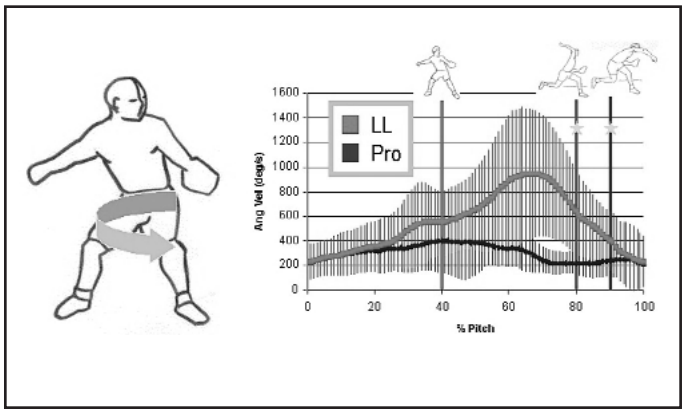


Figure 1. *Comparison of the twisting speed of the hips in Little League (LL) and professional (Pro) pitchers during the pitching motion. Little League pitchers twisted their hips more rapidly than did the professional pitchers, and the timing of the rotations was different.*

Both shoulder and elbow injuries are common in youth pitchers. The forces applied to the shoulder during the pitching motion have been blamed for a syndrome called "Little League shoulder," in which the patient experiences pain in the shoulder while pitching, a pain that usually gets worse over a period of time. X-rays of pitchers with this type of injury often show that the growth plate in the shoulder is injured. Normal growth and development of the arm, as well as a return to throwing, can usually be achieved after the patient stops throwing for a couple of months.

The elbow is an even more common site of injury in young pitchers. The pitching motion causes tension on the inside of the elbow and compression on the outside of the elbow. This can cause the muscles that attach to the inside of the elbow to pull away from the bone, a so-called avulsion injury, and the squeezing on the outside of the elbow can cause cartilage degradation or premature closing of the growth plate in that area.

To study the biomechanics of pitching, 25 professional and 14 youth baseball pitchers were filmed while pitching, using special high-speed video cameras. From these video recordings, the movements of the pitching arm, the trunk, and the legs were measured. Data from the Little League pitchers was compared to that from the professional pitchers to help us understand how the groups differ in terms of technique. It also gave us insight into how youth pitchers may be causing some of the common elbow and shoulder injuries.

We found three important differences between the motions of Little League and professional pitchers. First, the upper arm rotated faster and the elbow straightened faster in the youth pitchers than in the professional group, even though the youth pitchers' average throwing speed was 48 mph compared to 87 mph for the professional pitchers.

Second, the youth pitchers did not cock their arms as far backward as the professional pitchers prior to accelerating the ball forward toward release. Even with these differences, the arm motions of the youth pitchers were similar to those of the professional pitchers in our study.

The third, and probably most striking, difference between the Little League and professional pitcher groups was in the way they moved their trunks. The youth pitchers tended to twist their upper bodies and hips much more rapidly than did the professional pitchers. For example, the peak rotational speed of the upper trunk and shoulders averaged 2100 degrees per second in the youth pitchers we studied, compared to 1200 degrees per second in the professional pitcher group (Figure 1).

In summary, even though the pitching motion of Little League pitchers is similar to that of professional baseball pitchers, there are some significant differences between the motions of the arms and trunks of the two groups. Our data supports the observation made by other researchers that youth baseball pitchers control their trunk motion in a less efficient way than elite pitchers. Fast rotation of the trunk occurred very early in the pitching motions of the professionals, while it occurred much later in the youth pitchers. Proper timing of pelvis and upper-trunk rotation are necessary to effectively transfer energy from the trunk to the throwing arm. Therefore, increased twisting speed in the trunk may be a compensation for improper timing of arm motion or insufficient muscle strength in youth pitchers.

Improper energy transfer from the trunk to the upper extremity may lead to increased internal rotation of the shoulder and elbow extension velocity in youth pitchers compared to the professionals. Our data also suggests that trunk rotation is related to the amount of stress at the shoulder during the pitch. Therefore, improper trunk control may have implications for shoulder injuries in youth pitchers, such as the development of "Little League shoulder." ■

(PATIENTS IN THE NEWS cont. from pg. 1)

Bode Miller
PHOTO: AP/WORLD PHOTOS

re-growing entirely on its own." By July, Bode was back on skis once again, training at Mt. Hood, Ore., and "feeling 100 percent, going right after it right away." In the season's first World Cup giant slalom in Sölden, Austria, Bode finished a remarkable fifth—eight months after his surgery.

Bode's new knee—and his determination to "go right after it" paid off big last season, with four World Cup victories, a second in the World Cup slalom standings, a fourth in the overall World Cup standings and two silver medals at the Salt Lake City Winter Olympics.

For most, those kinds of results would rank high in the memory bank. For the 25-year-old from Franconia, N.H., however, his most memorable moment was the day he made the U.S. Ski Team. Competing in the U.S. National Championships at

Sugarloaf, Me., Bode came from 30th position in the slalom to capture third. "My family was there, all my classmates were there," says Bode. "It was the greatest!"

When Bode isn't on the course, he's on the court. An all-state tennis player, he has been a coach and counselor at the family's Tamarack Tennis Camp for years and, as this is written, is "just trying to relax and get the energy systems back up."

"Tennis," says Bode, "is a great mental exercise. It's a longer event than ski racing and it helps you stay focused for a longer period of time." But wait, there's more. Golf, for example. A low- to mid-70's shooter, Bode took up the game at 15 but didn't "get serious" about golf until five years ago. "I really enjoy the game," he says. "When I retire from ski racing, I'd like to play tournament golf—if I still have the competitive energy."

Competitive energy isn't something that Bode is likely to run out of anytime soon. The 2006 Winter Olympics are still ahead ("It's a long way away, but I plan to be there") and he's already looking to compete in tournament tennis if he can bring in some major events locally ("It's important for the kids to see their coaches compete").

Besides, he always has the comfort of knowing that the staff at Steadman-Hawkins will be there to make sure the physical part is up to the energy part. "Dr. Steadman and his staff," says Bode, "are the greatest—supportive and super friendly. It makes a nice environment to be in when you're injured, bummed out and trying to keep your spirits up."

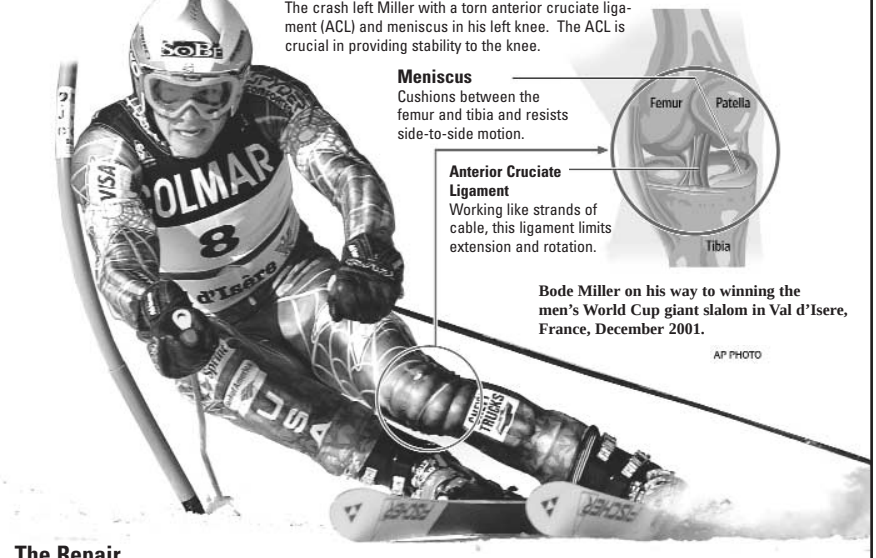
The Steadman◆Hawkins Sports Medicine Foundation is key to the medical breakthroughs that have brought athletes, like Bode Miller, back to their best. It provides the research environment in which important new procedures, like the "healing response", are developed, nurtured, tracked and refined to promote top-of-the-game performance—for world-class competitors and weekend warriors alike. ■

Rehabilitation The Best Medicine

Bode Miller suffered a torn anterior cruciate ligament in a downhill crash in February 2001 at the World Alpine Championships in Austria and was able to come back for the Olympic year in 2002 thanks to the "healing response" procedure and a heavy exercise program. And to put an exclamation mark on his miraculous recovery, Miller responded with four World Cup victories, a second in the World Cup slalom standings, a fourth in the overall World Cup standings, and two silver medals at the Salt Lake City Winter Olympics.

The Injury

The crash left Miller with a torn anterior cruciate ligament (ACL) and meniscus in his left knee. The ACL is crucial in providing stability to the knee.



Bode Miller on his way to winning the men's World Cup giant slalom in Val d'Isere, France, December 2001.

AP PHOTO

The Repair

The meniscus cartilage had dislocated to the front of the knee, causing the knee to lock. ACL reconstruction requires some movement in the knee. Because of this, the meniscus had to be repaired first.

1. Meniscus Surgery
While working on the meniscus, Dr. Steadman discovered the ACL tear was at the femur. He decided to perform the "Healing Response."

2. ACL Repairs Itself
Areas on the femur are selected where the ACL will reattach. This bone site is perforated arthroscopically with a microfracture awl to produce a "super clot" from the microfracture holes located at the femoral origin of the ACL.

3. The Outcome
There is no fixation or immobilization, and the repair relies completely on the surgically induced "super clot," which emerges from the bone marrow, to capture and reattach the torn ACL.

GLOBE STAFF GRAPHIC/JOAN McLAUGHLIN

(REPRINTED COURTESY OF THE BOSTON GLOBE)

Healing Response: Minimally invasive procedure stimulates body's healing of ACL injuries.

By William G. Rodkey, D.V.M.

Editor's Note: Dr. Rodkey is director of Basic Science Research for the Steadman◆Hawkins Sports Medicine Foundation.

Defects in the anterior cruciate ligament (ACL) rarely heal spontaneously. The torn ACL sometimes scars to the posterior cruciate ligament (PCL), but this does not result in any significant biomechanical function. ACL injuries continue to present a difficult problem for orthopaedic surgeons because it is difficult to predict whether such injuries will cause severe disability or only minimal impairment.

Consequently, Dr. Steadman has developed a procedure called the "healing response" as an alternative to formal reconstruction, or to no intervention. This procedure is designed especially for proximal one-third (near the thigh bone) ACL injuries, the type frequently seen in skiers. It is minimally invasive and uses the microfracture awl arthroscopically to produce a "super clot" from microfracture holes located at the femoral origin of the ACL. There is no fixation or immobilization, and we rely completely on the surgically induced "super clot," which emerges from the bone marrow, to capture and heal the torn ACL.

We believe that the "healing response" procedure has significant advantages that outweigh the potential disadvantages. It is a technically easy procedure for the surgeon to perform with minimal downside risk.

The Steadman◆Hawkins Sports Medicine Foundation is dedicated to keeping people of all ages physically active through orthopaedic research and education in the areas of arthritis, healing, rehabilitation and injury prevention.

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Mark Your Calendar

July 27, 2002 Evening of Dreams. The Steadman◆Hawkins Sports Medicine Foundation and the Vail Valley Medical Center Foundation present an evening of Vail Valley Cuisine and the opportunity to bid on dreams for a lifetime. Ford Amphitheater, Vail, Colorado. For more information, call Rachele Palmer at (970) 479-5809 or via E-mail rachele.palmer@shsmf.org

August 15-17, 2002 Second Vail Cartilage Symposium. The Lodge at Vail, Vail, Colorado. For more information, call Greta Campanale, (970) 479-5782 or via E-Mail greta.campanale@shsmf.org

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181 West Meadow Drive
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