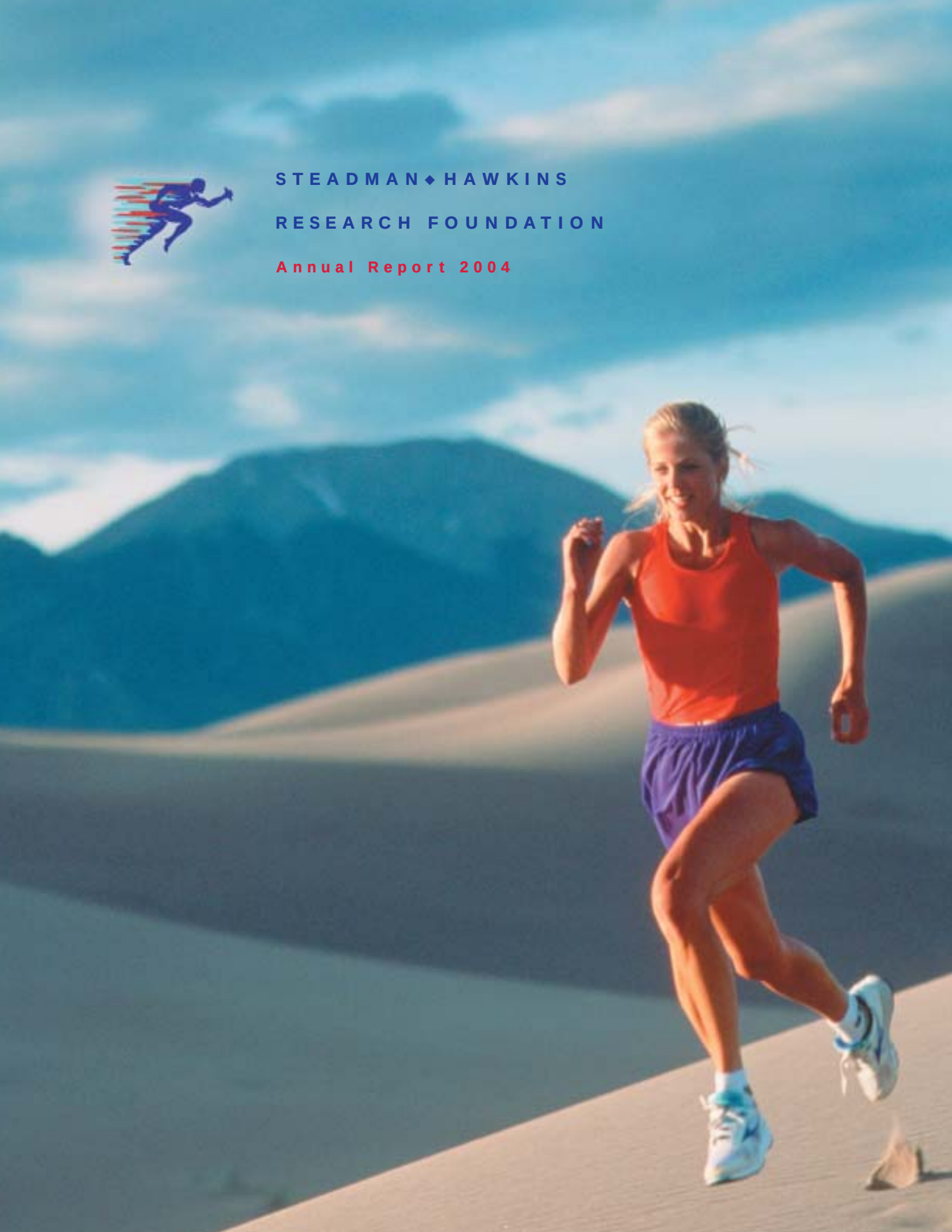


STEADMAN◆HAWKINS RESEARCH FOUNDATION

Annual Report 2004

Contents

The Steadman◆Hawkins Research Foundation wishes to express deep appreciation to John P. Kelly, who donated many of the stock photos in this year's Annual Report and contributed his time to photograph the many Foundation and operating room subjects.

Kelly is a renowned sports and stock photographer who approaches every photo shoot like a commando. His sense of motion combines with his obvious love of natural light to produce vibrant graphic images. He shoots extensively for a variety of prominent manufacturers in the sports and recreation industry; and his experience includes numerous assignments at the Olympics, Wimbledon, U.S. Open Golf, and World Cup Skiing. When Robert Redford needed a poster that reflected the spirit of his movie "A River Runs Through It," he called Kelly. More recently, Redford employed Kelly's photographic talents during the making of the "Horse Whisperer." Whether covering the Olympics or trekking in the Himalayas, Kelly is always ready for his next photographic adventure.

Mission

The Steadman◆Hawkins Research 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.

History

Founded in 1988 by orthopaedic surgeon Dr. J. Richard Steadman, the Foundation is an independent, tax-exempt (IRS code 501(c)(3)) charitable organization. Known throughout the world for its research into the causes, prevention, and treatment of orthopaedic disorders, the Steadman◆Hawkins Research Foundation is committed to solving orthopaedic problems that limit an individual's ability to maintain an active life. In 1990, Dr. Steadman was joined by renowned shoulder surgeon Dr. Richard J. Hawkins. Together, they brought the Foundation's research production in knee and shoulder studies to a new level.

The Foundation has influenced the practice of orthopaedics — from diagnosis to rehabilitation. Recognizing that the body's innate healing powers can be harnessed and manipulated to improve the healing process has led to exciting advances in surgical techniques that are used today by orthopaedists in many practices. The microfracture technique, for example, is now accepted as a treatment that may make it possible to postpone or even eliminate the need for knee replacement surgery.

One of the largest independent orthopaedic research institutes in the world, the Steadman◆Hawkins Research Foundation has become one of the most productive and innovative foundations in orthopaedic research and education. Philanthropic gifts are used to advance scientific research and to support scholarly academic programs that train physicians for the future. Through its Fellowship Program, the Foundation has now built a network of 130 Fellows and associates worldwide who share the advanced ideas and communicate the concepts they learned in Vail.

THE FOUNDATION'S PRIMARY AREAS OF RESEARCH AND EDUCATION ARE:

- **Basic Science Research** – Undertakes studies to investigate the mysteries of degenerative arthritis, cartilage regeneration, and arthritic changes in the knee and shoulder.
- **Clinical Research** – Conducts "process" and "outcomes" orthopaedic research that aids both physicians and patients in making better-informed treatment decisions.
- **Biomechanics Research Laboratory** – Performs knee and shoulder computer modeling and related studies in an effort to reduce the need for surgical repair.
- **Education and Fellowship Program** – Administers and coordinates the physicians-in-residence Fellowship Program, hosts conferences and international medical meetings, and produces and distributes publications and videotapes.

SINCE ITS INCEPTION, THE FOUNDATION HAS HELPED PEOPLE OF ALL AGES REMAIN PHYSICALLY ACTIVE THROUGH ORTHOPAEDIC RESEARCH AND EDUCATION. IT CONTINUES TO PURSUE ITS GOALS OF:

- Understanding and enlisting the body's innate ability to heal.
- Designing and validating surgical and rehabilitation techniques, as well as non-operative treatments for arthritis.
- Producing and publishing scientifically validated research in leading medical and scientific journals.

The Year in Review

Dear Friends:

In this 2004 Annual Report you will read about the work and achievements of our dedicated staff. You will learn of the discoveries of Dr. William G. Rodkey, Director of Basic Science Research and a leading contributor to the universal success of microfracture, a procedure to grow repair cartilage. In 2004, Dr. Rodkey's Basic Science Research team continued to work on improving microfracture and cartilage healing. For the first time, they were able to demonstrate that an experimental model of cartilage healing using gene therapy can be used to successfully enhance the growth and repair of cartilage.

In the Clinical Research Department, Karen Briggs, M.P.H., M.B.A., has maintained the largest database of surgical details and outcomes in the world, with comprehensive records of more than 12,000 knee and nearly 3,000 shoulder surgeries. The information stored in the database has been the source for numerous peer-reviewed publications written by the Foundation. More importantly, the work of Ms. Briggs has allowed researchers to identify risk factors for arthritis and has led to significant discoveries that will help prevent this leading cause of disability worldwide.

Dr. Michael R. Torry and his team in the Biomechanics Research Laboratory are successfully mapping joints and creating three-dimensional models that mimic natural movements and pressures. Using computer technology, they are determining how muscles, tendons, and ligaments are stressed during various activities. Knowing how and why injury and disease occur can be the first step in successful prevention and treatment. Though still in its infancy, three-dimensional modeling is giving physicians and researchers incredible views and increased understanding of why less-invasive surgical treatments are effective in restoring normal load bearing in joints. This understanding will allow physicians to select procedures that are most appropriate for the individual patient. The development of a virtual shoulder model has been a top priority for the laboratory and in 2004 the work continued to scientifically validate the model. Once in use, this technology will help us understand how the shoulder moves and which muscles and ligaments are involved.

Academic medicine continues to take notice of our research. The number of publications in medical journals is a primary consideration in assessing the strength of an academic department or organization. The three major medical journals in orthopaedic sports medicine are the *Journal of Bone and Joint Surgery*, the *American Journal of Sports Medicine*, and *Arthroscopy*. The Foundation tracked its number of publications in these journals from 2002 to 2004 and compared the results to four other top academic programs. The Steadman◆Hawkins Research Foundation ranked first in number of publications in these three journals. This is important to us because we want to be sure that our research findings are disseminated to the broader world of orthopaedics for the benefit of mankind. But publications would be just basic research reports without practical application. In this report you will meet Al Perkins and learn of his 25-year journey to remain active so he could continue to participate in his son's activities. His search allowed him to benefit from the Foundation's development of joint preservation techniques.

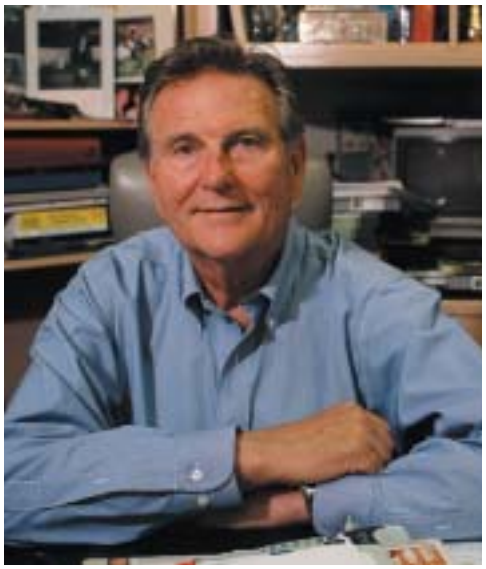
For 16 years, we've helped people such as Al perform at their highest level possible, but the name "Sports Medicine" implies that we only treat athletes. In reality, our research has benefited people from all walks of life. And thanks to our many donors and supporters, the Foundation is a world leader in orthopaedic research. Because of this, we changed our name to the Steadman◆Hawkins Research Foundation.

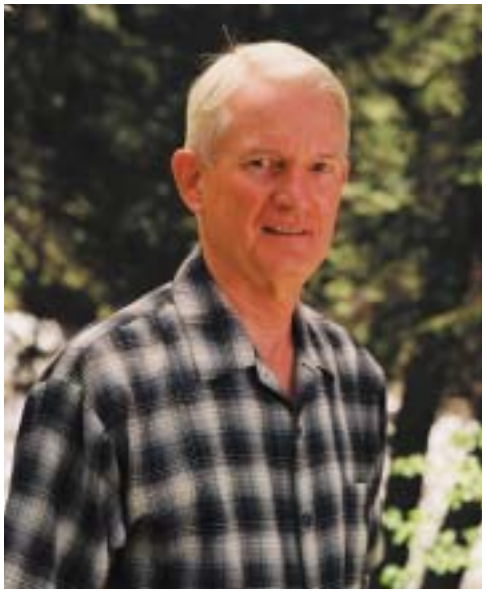
We're giving credit where credit is due. This Foundation was created for the purpose of keeping people active for life—elite athletes, weekend warriors, high school heroes, mid-lifers, and even those of us who hung up our skis, cleats, and baseball gloves many years ago. We all benefit from the work of the Steadman◆ Hawkins Research Foundation, and the Foundation benefits tremendously from you. Since 1990, the Foundation has spent $25 million on research, education, and support programs. We could not have done this without the commitment, dollars, and concerns of many individuals.

The desire of each of us to lead a full, active life has been the driving force for the groundbreaking treatment protocols pioneered by the Foundation and its unique philosophy of treating and helping prevent degenerative arthritis. Because we believe that the body's own tissue is the optimum restorative medium, we're focused on how the body heals itself and on developing leading-edge research and treatment techniques to harness and accelerate that ability.

But our commitment does not end here. We're also dedicated to sharing what we learn through our world-renowned Fellowship Program, thousands of scientific research papers and presentations, and a clinical database. Of course, there's a great deal more to be done and we need continued support to do it.

Our core values haven't changed, and our dedication will never waiver. It's an exciting time at the Steadman◆Hawkins Research Foundation—one we hope to share with you.





Sincerely yours,

J. Richard Steadman, M.D.
Chairman of the Board

Norm Waite, Jr.
President and Chief Executive Officer

An Active Legacy

Dr. Richard Steadman wants to be known for far more than surgically salvaging the careers of superstar athletes.

By David O. Williams

Editor's note: This article first appeared in the holiday 2004 edition of *Vail Beaver Creek* magazine.

Dr. Richard Steadman's skills with a scalpel have earned Olympic medals, NFL sack records, Super Bowl rings and countless world championships, but the "surgeon of the stars" would much rather be remembered for something other than salvaging or prolonging the careers of skiers such as Phil Mahre, Picabo Street, and Bode Miller and football greats such as Joe Montana, John Elway, and Bruce Smith. "Steady," as a bevy of hall-of-fame athletes call him, would rather be known as the doc who kept millions of weekend warriors out on the links or on the slopes late into life.

"I'd much prefer to be known for figuring out a procedure that helps people with arthritis, or gets people back in action that have had cartilage injuries, or an easier way to recover from an ACL surgery," says Steadman. "I'd rather be known for that than the fact that I've treated some famous athletes. I'm proud to have treated them, and I'm honored that they came to me, but if I wanted to be known for something, I'd rather be known for these things that affect everybody, me included."

One of the key factors that led Steadman to relocate his practice to Vail, Colorado, from the Lake Tahoe area in 1990 was the degree to which the community embraced his non-profit scientific research and education efforts. The Steadman◆Hawkins Research Foundation has tracked more than 12,000 knee surgeries — one of the largest orthopaedic databases in the world — and has meticulously conducted research validating a slew of successful breakthrough surgical techniques.

One of them, "healing response," got Miller back on skis and in double silver-medal-winning form at the 2002 Winter Olympics in Salt Lake City less than a year after completely tearing his ACL at the 2001 World Alpine Championships in Austria. Healing response, an arthroscopic technique that involves making holes in the bone so a blood clot forms and reattaches the anterior cruciate ligament, is an offshoot of microfracture surgery, which Steadman also pioneered.

Microfracture, which regenerates cartilage in joints by using small incisions, was used only by about one percent of orthopaedic surgeons worldwide in 1994. Ten years later, that statistic is up to 85 percent, and while his Clinic has blazed the trail in performing the revolutionary technique, it was the Foundation that painstakingly validated its effectiveness and shared it with the world.

"(Steadman) is willing to push the envelope," says three-time overall World Cup champion Phil Mahre, whose ankle was rebuilt by Steadman less than a year before he won a silver medal at the 1980 Winter Olympics in Lake Placid. "They're willing to try new things and do new things, and it just furthers everybody's careers and everybody's athletic experience, whether you're a competitive athlete or just an average Joe who wants to be competitive on weekends."

Mahre, who went on to win a gold medal at the 1984 Winter Olympics in Sarajevo, has benefited from Steadman's expertise both as an elite athlete and as a backyard ballplayer. Mahre's second Steadman surgery was a healing response 10 years after the man who is arguably America's greatest ski racer of all time had retired. He had torn his ACL playing flag football.

Degenerative arthritis, the debilitating deterioration of joint cartilage, impacts one in three adults and more than half of everyone over the age of 65. And his office may be plastered with tributes from his three decades of operating on world-class athletes, but the soft-spoken and unassuming Steadman seems sincere when he says it's the millions of lives touched by the acceptance and spread of microfracture surgery that bring him the most joy.

"It's always fun to treat an elite athlete, but there's only about a thousand of them in the world, so there's no way you can treat all of them anyway, and there are millions of people who want to be athletic, so that's really our Foundation's focus," Steadman says.

"That's where we're really going with this Foundation, to help that person, and I'm honored that high-profile people come see me, but if I'm going to be remembered for something, I'd rather it be more on the side of the things that the Foundation is doing than being somebody's doctor."

The concept of a charitable research and education foundation was born in 1988 while Steadman was still based in Tahoe. It started as a mechanism for taking the guesswork out of his practice by studying, tracking, and validating various surgical techniques. Very early on, Steadman decided none of the data the Foundation uncovered should be privileged.

"We've taken the path that if we come up with a good idea proven at the Foundation, then we provide that to physicians worldwide," Steadman says. "So frequently we adopt a

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technique and it helps people around the world instead of just helping us in our practice.

"So I think that's the thing that distinguishes us from business. If IBM comes up with an idea, they put a screen around it, whereas if we come up with an idea that's good, and we've actually come up with some ideas that are good, it becomes an honor for us to have other people accept our ideas in areas that we work on."

The Foundation is one of the most highly regarded in the orthopaedic community, frequently publishing influential papers and attracting top surgeons from around the world to its fellowship program. Ask people from far-flung places what they know about Vail, and the first thing they'll say is it's a great place to ski, but then, surprisingly, many will mention that famous clinic where all the athletes go to be repaired after career-threatening injuries.

Steadman and his shoulder-and-arm-specialist partner Dr. Richard "Hawk" Hawkins are perhaps victims of their own wild success when it comes to their public image. Surgical consultants for the Denver Broncos, Steadman and Hawkins have also operated on everyone including Monica Seles right after she was stabbed by a deranged fan.

So it should come as no surprise that the media tend to fixate on the famous and that reporters' eyes glaze over when the topic turns to cutting-edge biomechanics research or the latest peer-reviewed article in a leading medical journal. It's tough then for the general public to make the distinction between the famous for-profit Clinic and a charity-funded Foundation that relies primarily on the largess of donors.

"I think some people just misunderstand the Clinic and the Foundation," says Steadman. "Although they work hand-in-hand, the physicians don't have any income from the Foundation—none—and we actually provide a lot of the financing for the projects in the Foundation. So we're being philanthropic, but we're also the people who are coming up with a lot of the ideas that can improve people's athletic lifestyles."

In addition to long-standing contributions from corporate benefactors, organizations able to make the distinction between the Clinic and the Foundation, the nonprofit organization receives funds from past patients who are indoctrinated in the role the Foundation plays in substantiating and improving the surgical and rehabilitation techniques.

Then there are the special events such as the Colorado Classic, a weekend of dinners, wine tastings and golf at the Sonnenalp Golf Club in August that raises about five percent of the foundation's annual operating budget.

"At an event like this the money raised is going directly to the Foundation—not straight into the hands of Drs. Steadman and Hawkins at the Clinic," says Foundation board member and 11-time Steadman patient Cindy Nelson. She was the first American to win a World Cup downhill (1974) and a bronze medalist at the 1976 Winter Olympics in Innsbruck, Austria. "In fact, the doctors are some of the biggest contributors to the Foundation."

Nelson was Steadman's first elite athlete patient in 1972 and was later working as the director of skiing at Vail when Steadman was considering relocating from Tahoe. Nelson and the owner of Vail at the time, George Gillett, were instrumental in persuading the surgeon to head east. But as a Foundation board member and former superstar patient, Nelson perhaps better than anyone understands the challenges of differentiating the work of the Foundation from the high-profile successes of the Clinic.

"Because they've become so famous and so expert at what they do, they've created their own recognition. That's a good thing because it has a ring of quality to it, but it sometimes has a negative impact in that people think we're talking Clinic when we're really talking Foundation. We wrestle with it on the board all the time," Nelson says.

"We have a need for people to understand that the Foundation is not the Clinic, and that the Foundation actually supports the work of doctors in the Steadman-Hawkins Clinic as well as worldwide."

Despite her extensive surgical history, Nelson continues to live an incredibly active lifestyle, and she attributes it to the work of Steadman, through both the Clinic and the Foundation. "Here I am, 11 surgeries later, I'm very active. I had

some bad injuries and I'm really in the middle of my life and I want to continue to stay active. I don't want these injuries to become so arthritic that I become lame or I can't do things pain-free," Nelson says. "I believe that the work that has been done by this Foundation will have a great enough impact on the medical profession that, in my future, I can be as active as I want to be for as long as I want to be. That is great. I feel a sense of relief."

But Nelson is a rarity—an athlete who gets it when it comes to the Foundation. She thinks it's critical to educate athletes on the role of the Foundation so they can become de facto spokespersons for its invaluable research and education work. That tireless analysis led to microfracture surgery and its groundbreaking technique of tapping into the body's own stem cells to regenerate cartilage, but most athletes — and the general public for that matter — don't realize the depth of the Foundation's critical contributions. Miller, for example, likely does not fully grasp how the Foundation helped develop and validate healing response. He only knows that it helped get him back on skis in time for the Olympics.

"He got a great benefit from the Foundation," Steadman says. "Ten years from now he might be able to focus on it, but right now he's focused on his career." Indeed, with age comes wisdom. Phil Mahre's brother, Steve, who finished with a silver medal right behind his sibling at the 1984 Winter Olympics, clearly understands the importance of the work going on at the Foundation. Also an 11-time Steadman patient, he has had four microfracture surgeries.

"For me, what the Foundation is doing is studying physical well-being, trying to focus more on prevention and that side of things and get the message out to people that this is what you have to do to prolong the joint's health to make it work longer for you down the road," Steve Mahre says. "Also, they're trying to learn what is causing some of the injuries and how you can try to prevent them from happening."

It's definitely not as sexy as patching up John Elway's shoulder in time for him to finally win two Super Bowl rings late in his career. It's not as career-prolonging as getting All-Pro defensive lineman Bruce Smith back on the field for another five years so he could set the all-time quarterback-sack record. But it's important work nonetheless, particularly if you're a weekend duffer who can't stand the thought of not being able to go out to try and break a hundred on the local links.

A Lasting Legacy

In some respects, it's too late. The Steadman-Hawkins name will always be associated with greatness. When you resurrect or prolong the careers of such legendary athletes as tennis greats Martina Navratilova, Billy Jean King, and Lindsay Davenport, golf superstar Greg Norman, NFL Hall-of-Famer Dan Marino, singer/songwriter Judy Collins, and countless stars in every sport from skiing to baseball to hockey, it's bound to cement your reputation as the surgeons of the rich and famous.

Internationally, Steadman-Hawkins has become synonymous with soccer, or football as it's known outside our borders, for the Clinic's work on such global sensations as Ronaldo, Alessandro Del Piero, Oliver Kahn, and Lothar Matthaus. Hardly household names in the States, but only a visit by David Beckham would garner more worldwide media attention than that quartet.

But for all the glitz and glam of slicing and dicing celebs, the serious side of Steadman-Hawkins always finds its way to the forefront. Take, for example, a former Foundation fellow stationed at the Air Force Academy in Colorado Springs, Maj. John Tokish, M.D. He used his knowledge obtained at Steadman-Hawkins while commanding a Mobile Forward Surgical Team in Afghanistan, treating U.S. Special Forces troops shortly after the invasion.

Soldiers, civilians, elite athletes, or weekend warriors, everyone wants to stay mobile and active after injuries, Steadman says. Helping people realize that dream is what he wants as his lasting legacy.

"The more people realize that it's not just the famous people, the better," Dr. Steadman concludes. "I think there's just as much satisfaction getting somebody back who has had not a career-ending, but a recreation- or athletics-ending injury. A high-profile athlete can find 20 doctors who will take care of him, and fortunately for me, a lot of them come here. But the standard person who just wants to stay active, he or she doesn't have that access, so what we're trying to do is create that access."

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Al Perkins:

From Patient to Advocate

By Jim Brown, Ph.D.

Editor's Note: Jim Brown is the Executive Editor of the *Sports Performance Journal*, a publication of Athletes' Performance in Phoenix, and a contributing writer to *The Arthritis Advisor* and *Health News*.

He knew it was a serious injury the moment it happened. Al Perkins, a 215-pound defensive back at the University of New Hampshire, took a hit to the side of his left knee. It caused an anterior cruciate ligament tear and the loss of a piece of cartilage nearly the size of a quarter.

What Perkins didn't know was that the injury would be the beginning of a 25-year journey that led him to be a Steadman-Hawkins patient, then a member of the Steadman◆Hawkins Research Foundation Board of Directors, and now co-chairman of the Foundation's Development Committee.

"After the injury, we just let it sit for a few months," remembers Perkins. "Back then, treatment was based as much on a gut feeling as anything else. I went through the usual physical therapy routines, but there was just too much pain and I eventually had reconstructive knee surgery. After the surgery, I was looking at a life that would have been vastly diminished by severe arthritis. Within the next decade I was told to stop running and playing basketball, and to limit skiing. Bicycling and walking a golf course caused unbearable pain and swelling. The prognosis was bleak. After having been involved in sports all of my life, the thought of having a knee replacement at the age of 36 was depressing and unacceptable.

"By the 1990s, my activity was even more limited," says Perkins. "This was particularly disappointing because my son was becoming increasingly involved in skiing, soccer, and baseball. All I could do was hope that science would delay my need for a knee replacement and allow me to be active enough to share a few experiences with him."

While the condition of Al's knee was going downhill, the direction of his business career took off in a decidedly upward direction. In 1987, less than ten years out of college, he founded Darwin Partners, an information technology company based in Wakefield, Massachusetts. Darwin developed a national client base that included Nextel, Bank of America, Pfizer, Unisys, and AT&T Wireless, and his company surpassed the $100,000,000

"I eventually flew to Colorado and met with Dr. Steadman. He said simply, 'I think we can help you.' I got goose bumps over the possibilities. You can't imagine the relief I felt after being told so many times by doctors on the East Coast that there wasn't much that could be done about my condition."

revenue mark. In 1992, Perkins founded Edgewater Technology, an IT outsourcing firm that generated $20,000,000 in revenue within its first few years of operation. The company was sold in 1999, delivering significant value to its shareholders. Today, Perkins serves as chairman of Darwin Partners.

The Steadman-Hawkins Connection

Things began to change for Perkins' bad knee in the early '90s. "I knew a member of the U.S. Ski Team who told me about a Dr. Richard Steadman in Colorado. Patients were being treated by Dr. Steadman for knee injuries similar to mine with a procedure called microfracture, an arthroscopic technique used to repair cartilage through small incisions." To Perkins, the results seemed almost too good to be true. Athletes with potentially career-ending knee injuries were returning to compete at the highest levels in their sports.

"I eventually flew to Colorado and met with Dr. Steadman. He said simply, 'I think we can help you.' I got goose bumps over the possibilities. You can't imagine the relief I felt after being told so many times by doctors on the East Coast that there wasn't much that could be done about my condition."

The microfracture surgery was performed in 1996. "I'm never going to have a young knee again, but I am relatively pain free and I can ski with my son, play doubles in tennis, ride a bike, and do lots of things that never would have been possible without Dr. Steadman's help. His emphasis was not on joint replacement, but on joint preservation. I was so grateful, I just wanted to sit down and write a check to support the work being done in Vail."

A Different Idea

But the Steadman◆Hawkins Research Foundation had a different role in mind for Perkins. Five years ago, he was asked to serve on its Board of Directors. "I think they asked me because I bring an unbridled enthusiasm for spreading the message of research, service, and education that is being provided by the Foundation. Great things are coming out of its work, but more people need to know about it. The doctors are too modest to talk about it and too busy to promote it. Their time needs to be spent treating patients and supervising research that continues to produce medical breakthroughs, not in trying to raise money."

As co-chairman of the Development Committee (with Earl Graves, founder of *Black Enterprise* magazine), raising money for the Foundation's projects is one of Perkins' responsibilities. "People who support the Foundation can specify that their contributions go to one or more of several programs. It just depends on their particular interests. Money is needed for the Steadman-Hawkins Fellowship Program, to continue the development of the microfracture technique and the 'healing response' — an alternative to full ACL reconstruction, to find ways to treat or prevent osteoarthritis, and to support the Foundation's Basic Science, Biomechanics, and Clinical Research departments. There is a laundry list of programs from which to choose."

Lessons Learned

Perkins' contributions of time, money, and energy have not been a one-way street. He is quick to tell you about the valuable lessons learned in the non-profit environment of the Steadman◆Hawkins Research Foundation that he has taken back to his world of highly competitive business. "The biggest thing I've learned is compassion. An experience like this makes you step back, realize how lucky you are, and understand that there are things in life other than being successful in business. My professional success wouldn't have happened without the healthy lifestyle the Foundation's research provided me.

"There are many projects worthy of supporting," concludes Perkins, "but this is one you can put your hands on. The Foundation's programs are changing people's lives in a way that will affect generations to come. I've been fortunate enough to see it have a direct impact on my life, and I want others to be able to share the same experience."

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The Scientific Advisory Board consists of distinguished research scientists who represent the Foundation and serve as advisors in our research and education efforts, to our Fellowship Program, and to our professional staff.

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Steadman-Hawkins Clinic of the Carolinas
Spartanburg, S.C.

Charles Ho, M.D., Ph.D.
National Orthopaedic Imaging Associates
Sand Hill Imaging Center
Menlo Park, Calif.

Mininder Kocher, M.D., M.P.H.
Assistant Professor of Orthopaedic Surgery, Harvard Medical School, Harvard School of Public Health; Children's Hospital, Boston, Department of Orthopaedic Surgery
Boston, Mass.

C. Wayne McIlwraith, D.V.M., Ph.D.
Director of the Orthopaedic Research Laboratory
Colorado State University
Fort Collins, Colo.

Marcus Pandy, Ph.D.
Chair, Mechanical and Biomedical Engineering
Department of Mechanical Engineering
University of Melbourne
Melbourne, Australia

William G. Rodkey, D.V.M.
Director of Basic Science Research
Steadman◆Hawkins Research Foundation
Vail, Colo.

Juan J. Rodrigo, M.D.
Steadman-Hawkins Clinic of the Carolinas
Spartanburg, S.C.

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Steadman-Hawkins Clinic
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Steadman-Hawkins Clinic
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Ferguson Professor and Director
Musculoskeletal Research Center
University of Pittsburgh
Pittsburgh, Pa.

Congratulations, Distinguished Graduate

Steadman-Hawkins Scientific Advisory Board member and Emeritus Professor of Orthopaedics at Duke University, **John A. Feagin, M.D.,** was honored in May of 2004 by the Association of Graduates at West Point with the Distinguished Graduate Award. Dr. Feagin graduated from West Point in 1955. Nominated by the graduates in his class, Dr. Feagin has lived a lifetime of significant service to the nation. He is the first physician to receive the award and was joined on the dais by four, four-star generals. In October 2004, Dr. Feagin was again honored by West Point with the establishment of the John Feagin West Point Sports Medicine Fellowship Program. Dr. Feagin, often referred to as the father of modern sports medicine, helped establish the sports medicine program at West Point. The two-year fellowship program specializing in joint and soft-tissue trauma includes one year of basic science extremity trauma research at Brooke Army Medical Center in San Antonio, Texas, and one year of clinical practice at West Point.

Dr. Feagin authored and edited *The Crucial Ligaments*, a medical text now in its third printing. This book has been characterized by reviewers as "a must for orthopaedic surgeons" and "a major contribution to the subjects of cruciate anatomy, biomechanics, and principles of repair and reconstruction."

Friends of the Foundation

In 2004, we received contributions and grants from 838 individuals and foundations. This combined support, including special events, amounted to more than $1.4 million.

The Steadman◆Hawkins Research Foundation is grateful for this support and to those who have entrusted us with their charitable giving.

We are especially pleased to honor the following individuals, foundations and corporations that have provided this support.

Their gifts and partnership demonstrate a commitment to keep people active through innovative programs in medical research and education. Without this support, our work could not take place.

NFL Charities Awards $89,000 Grant for Orthopaedic Shoulder Research

For the twelfth year, NFL Charities, the charitable foundation of the National Football League, has awarded a substantial research grant to the Steadman◆Hawkins Research Foundation for new and continuing work on the causes, treatments, and prevention of sports-related injuries. The research project is titled "Three-Dimensional Analysis of In Vivo Shoulder Motion."

One of the most significant problems plaguing shoulder biomechanics research lies in the difficulty in tracking the motions of the upper arm, collarbone, and scapula. These motions are complex, three-dimensional, take place beneath the skin, and are difficult to quantify. The objective of this research is to measure the three-dimensional motion of the shoulder joint.

The study will provide valuable information that can later be utilized in 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.

The immediate benefits of the study's findings will provide the scientific knowledge to cause a paradigm shift in the manner in which shoulder rehabilitation is approached. The new information provided by this study will offer change in the health care provided to the shoulder patient, allowing better outcomes, as well as increasing quality of life in these patients.

The principal investigators are Michael R. Torry, Ph.D., Director of the Foundation's Biomechanics Research Laboratory; Kevin Shelburne, Ph.D., Assistant Director; and Staff Scientists Takashi Yanagawa, M.S., and Erik Giphart, Ph.D.

HALL OF FAME

The Steadman◆Hawkins Research Foundation is grateful to the following individuals, corporations, and foundations for their support of the Foundation in 2004 at a level of $50,000 or more. Their vision ensures the advancement of medical research, science, and care, as well as the education of physicians for the future. We extend our gratitude to these individuals for their generous support:

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Dr. and Mrs. J. Richard Steadman
Vail Valley Medical Center

GOLD MEDAL CONTRIBUTORS

We are grateful to the following individuals, foundations, and corporations that contributed $20,000-$49,999 to the Foundation in 2004. Their continued generosity and commitment helps fund research such as gene therapy. This potentially innovative treatment will help preserve the body's own joints and tissues by leading to improved quality and quantity of "repair" cartilage produced by the microfracture technique, a procedure impacting multitudes worldwide.

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SILVER MEDAL CONTRIBUTORS

Silver Medal donors contribute $5,000-$19,999 annually to the Foundation. Their support makes it possible to fund research to determine the effectiveness of training programs to prevent arthritis, identify those who are most at risk for arthritis, and provide a basic foundation to improve post-surgical rehabilitation programs, thus improving the long-term success of surgical procedures. We extend our deep appreciation to the following individuals for their generous support in 2004:

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The Founders' Legacy Society

Over the years, the Steadman◆Hawkins Research Foundation has been privileged to receive generous and thoughtful gifts from friends and supporters who remembered the Foundation in their estate plans. In fact, many of our friends—strong believers and supporters of our work today—want to continue their support after their lifetimes.

Through the creation of bequests, charitable trusts and other creative gifts that benefit both our donors and the Foundation, our supporters have become visible partners with us in our mission to keep people physically active through orthopaedic research and education in arthritis, healing, rehabilitation, and injury prevention.

To honor and thank these friends, the Founders' Legacy Society was created to recognize those individuals who have invested not only in our tomorrow, but in the health and vitality of tomorrow's generations.

Our future in accomplishing great strides—from understanding degenerative joint disease, joint biomechanics, and osteoarthritis, to providing education and training programs—is assured by the vision and forethought of friends and supporters who include us in their estate plans. The Foundation's planned giving program was established to help donors explore a variety of ways to remember the Foundation. We are most grateful to these individuals for their support in becoming members of the Founders' Legacy Society:

Mr. and Mrs. Robert M. Fisher
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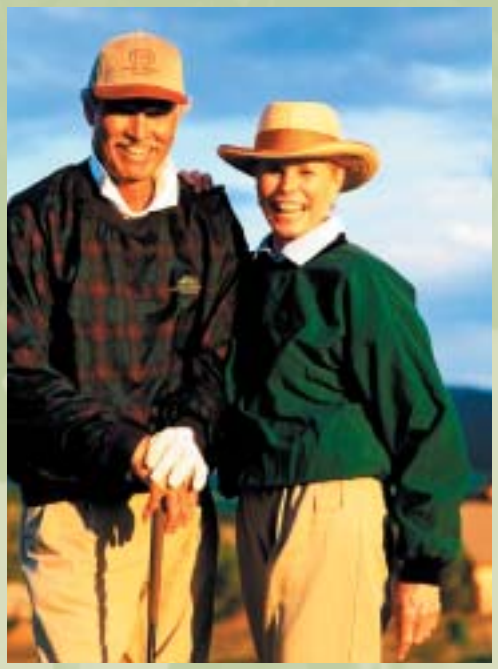

Chairs Support Foundation Work

The education of orthopaedic surgeons is a critically important mission of the Steadman◆Hawkins Research Foundation. Academic Chairs provide the continuity of funding necessary to train physicians for the future, thus ensuring the continued advancement of medical research. Currently, more than 130 Steadman-Hawkins Fellows practice around the world. We wish to express our gratitude and appreciation to the following individuals and foundations that have made a five-year $125,000 commitment to the Fellowship Program to support medical research and education. In 2004, five chairs provided important funding for the Foundation's research and educational mission. We are most grateful for the support from the following:

Mr. and Mrs. Harold Anderson
Mr. and Mrs. Lawrence Flinn, Jr.
Mr. and Mrs. Jay Jordan
Mr. and Mrs. Peter Kellogg
Mr. and Mrs. Steven Read

BRONZE MEDAL CONTRIBUTORS

Medical research and education programs are supported by gifts to the Steadman◆Hawkins Research Foundation's annual fund. The Bronze Medal level was created to recognize those patients and their families, trustees, staff, and foundations who contribute $10 - $4,999 annually to the Foundation. Donors at this level support many programs, including the Foundation's research to validate the success of new treatments for degenerative arthritis and identify factors that influence success. We thank the following for their support in 2004:

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Fellowship Benefactors fund the research of one Fellow for one year at a level of $10,000. This is a fully tax-deductible contribution that provides an opportunity for the benefactor to participate in a philanthropic endeavor by not only making a financial contribution to the educational and research year but also to get to know the designated Fellow. Each benefactor is assigned a Fellow, who provides written reports and updates of his or her work. We extend our gratitude to the following individuals for their generous support:

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Winter Winemaker Festival

Wine connoisseurs had an unparalleled opportunity to not only sample rare French wines but also to meet their winemakers and winery executives, January 16-17, as the Steadman◆Hawkins Research Foundation hosted "An Extraordinary Winemaker Evening" and "Evening in Bordeaux," hosted by Dr. and Mrs. J. Richard Steadman and Mr. and Mrs. Jim Shpall. We wish to extend a special thanks and appreciation to the following wineries, winemakers, executives, chefs, and restaurants for creating two very special evenings:

Mr. Hubert de Boüard
Château Angélus
Mr. Frédéric Engerer
Château Latour
Mr. Paul Ferzacca
La Tour Restaurant, Vail
Mr. Gildas d'Ollone
Château Pichon-Longueville-Comtesse de Lalande
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Applejack Wine and Spirits

Steadman-Hawkins Sanctuary Golf Tournament, September 13

The Steadman◆Hawkins Research Foundation was selected by RE/MAX International, a global real estate firm, to hold the first Steadman-Hawkins Golf Classic at the Sanctuary, a premier golf resort located south of Denver. Proceeds from the tournament support the development of new procedures and methodology to battle degenerative arthritis. The tournament was open to the public and included participants from the Denver Broncos and Colorado golf pros.

The Steadman◆Hawkins Research Foundation is grateful to Dave and Gail Liniger, owners and co-founders of RE/MAX International, who created this unique opportunity for the Foundation to develop and enhance relationships with those who support our mission. In addition, we wish to express our sincere appreciation to the following sponsors and participants:

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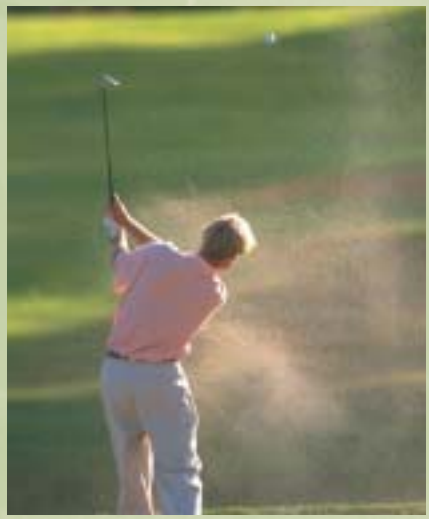

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Foundation Celebrates "Colorado Classic," August 14-16

A lifetime of excellence was on display during August in Vail as the Steadman◆Hawkins Research Foundation hosted the "Colorado Classic," a two-day athletic and culinary extravaganza presented by PepsiCo. Proceeds from the Classic support the research and educational programs of the Foundation.

The "Colorado Evening" presented by WestStar Bank featured superb cuisine, courtesy of some of the Vail Valley's finest restaurants; award-winning wines from Shafer Vineyards and Chappellet Winery; and opportunities to bid on dreams of a lifetime.

The Colorado Classic Golf Tournament, presented by American Express, was held at the Sonnenalp Golf Club at Singletree.

We wish to express our sincere appreciation to the following sponsors and participants:

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"Colorado Evening" auction items.

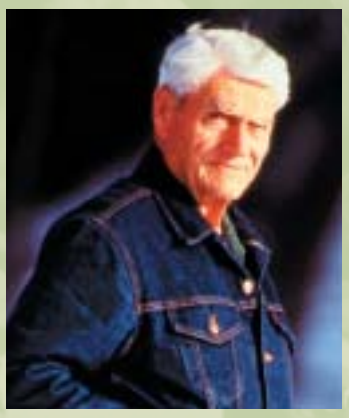
Grants

In addition to the National Football League Charities Grant (see pg 14), the Foundation has recently been awarded four grants to support its education and research programs.

Wyeth Pharmaceuticals provided a grant to support two symposiums for the public, titled *Non-Surgical Management of the Arthritic Knee.* Dr. Jason Folk, on behalf of the Foundation, conducted two symposiums on how people can take care of their arthritic knees without facing surgery. Arthritis and chronic joint problems will plague 50 percent of all Americans over the age of 65, making it one of the most prevalent diseases in the United States. The painful effects of arthritis limit physical activity more frequently than heart disease, cancer, or diabetes.

Dr. Folk spoke at the Vail Valley Medical Center in August and again in September at Keystone Resort. "I discussed the many innovative techniques designed to manage pain associated with arthritis in the knee," says Dr. Folk. "Among these topics were bracing techniques, medications, injections, and visco-supplementations."

For 15 years, the Steadman◆ Hawkins Research Foundation in Vail has established itself as a world leader in osteoarthritis research dedicated to preventing arthritis and to reducing its burden on people.



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The Steadman◆Hawkins Research Foundation is grateful for the generous support of our corporate donors. In 2004, we received $700,000 in corporate support to help fund the Foundation's research and education programs in Vail, Colorado, and at six University sites. This work will benefit patients and physicians for generations to come.

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Center of Excellence

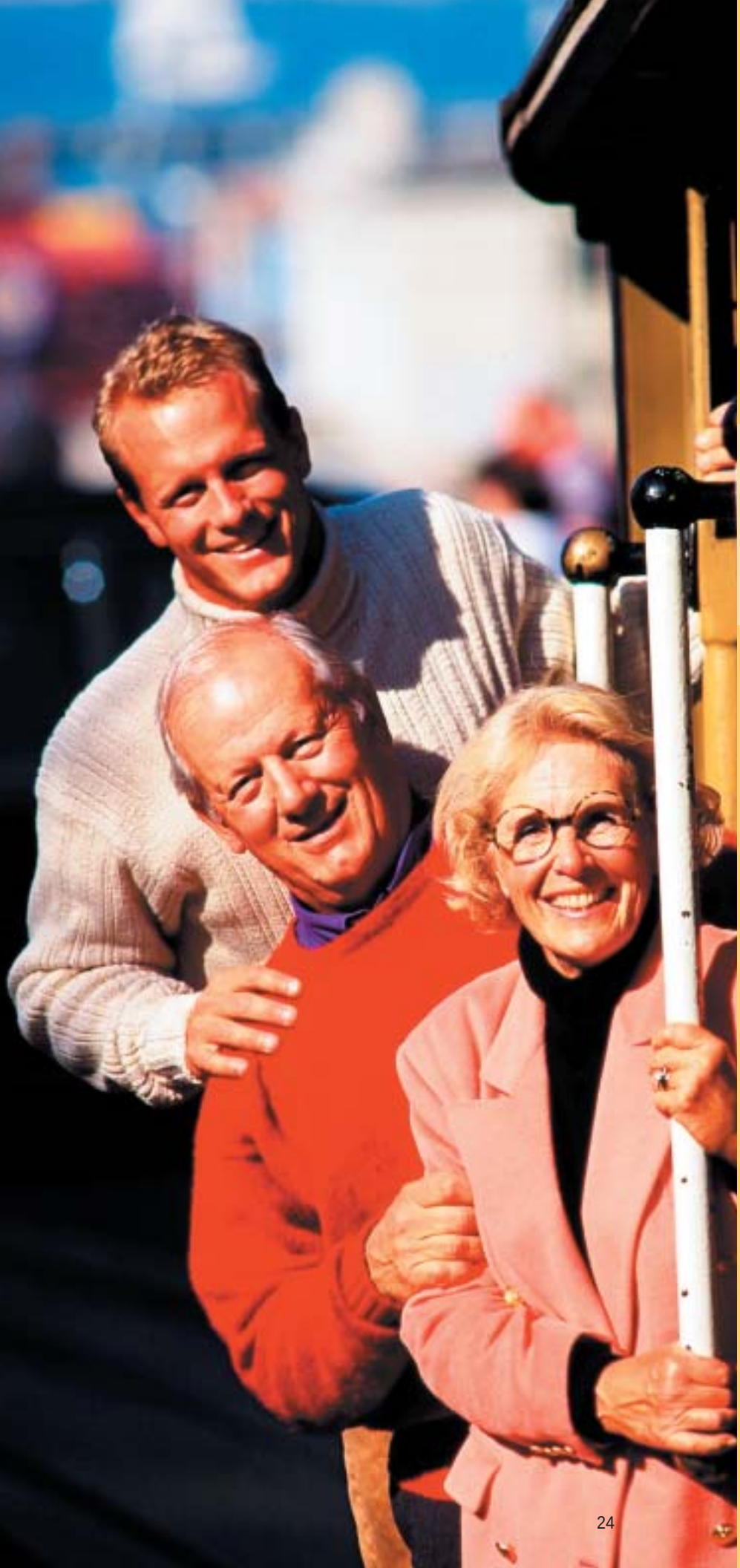
John Allard, Pfizer district manager, left, and Doug Webb, Pfizer speciality representative, right, present inSCOPE award certificate to Steadman-Hawkins Fellow Jason Dragoo, M.D., center.

The Foundation has been selected by Pfizer, Inc., through its inSCOPE Awards Program, as a Center of Orthopaedic Excellence. This designation will allow the Foundation to apply for research and education grant support from Pfizer. In 2004, inSCOPE grants supported three projects.

The first project was an educational grant to support a preceptorship October 28 and 29 for 13 Pfizer sales representatives. The two-day preceptorship consisted of instructional sessions, surgery observations, and rehabilitation clinic rounds. Dr. J. Richard Steadman, Dr. William I. Sterett, and Dr. David C. Karli made presentations that addressed many of the current treatments in the changing field of orthopaedics.

Pfizer also supported a study directed by Dr. Michael Torry investigating the efficacy of selective COX-2 inhibitors in chronic treatment of golf-related osteoarthritic back pain. Preliminary results are encouraging.

The third project was funded through the inSCOPE Orthopaedic Fellowship Awards Program. The program is designed to support fellowship programs at leading centers of orthopaedic excellence. The grant is to be used to support the research project *Clinical and Biomechanical Analysis of Patellar Tendon Adhesion*. Steadman-Hawkins Fellow Dr. Jason Dragoo is the principal investigator. The purpose of this research is to describe and determine the treatment as well as the clinical outcomes of a well-recognized yet poorly understood condition that is often observed in chronic knee osteoarthritic patients. These data will provide the scientific foundation for a new clinical tool that could be utilized to diagnose and assess many forms of knee disorders. It could also be used to evaluate the surgical repair and/or the conservative drug treatment therapies often employed in orthopaedics to avert advanced stages of knee arthritis.



BASIC SCIENCE RESEARCH

We have been working in the promising area of gene therapy in collaboration with Drs. Wayne McIlwraith and David Frisbie at Colorado State University. The following provides some background information and a summary of our most recent findings. This work is ongoing, and the encouraging results presented here will allow us to continue to focus on this work in the coming years.

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

The purpose of our Basic Science Research is to gain a better understanding of factors that lead to degenerative joint disease and osteoarthritis. Our focus is to develop new surgical techniques, innovative adjunct therapies, rehabilitative treatments, and related programs that will help prevent the development of degenerative joint disease. In 2004, we collaborated with various educational institutions, predominantly Colorado State University and Michigan State University. We believe that our combined efforts will lead directly to slowing the degenerative processes, as well as finding new ways to enhance regeneration of injured tissues.

The area of regenerative medicine is an exciting one. There are many new and innovative techniques under investigation by scientists around the world. In 2004 we focused our efforts almost exclusively on regeneration of an improved tissue for resurfacing of articular cartilage (chondral) defects that typically lead to degenerative osteoarthritis. We have been working in the promising area of gene therapy in collaboration with Drs. Wayne McIlwraith and David Frisbie at Colorado State University. The following provides some background information and a summary of our most recent findings. This work is ongoing, and the encouraging results presented here will allow us to continue to focus on this work in the coming years.

Osteoarthritis is a debilitating, progressive disease characterized by the deterioration of articular cartilage and accompanied by changes in the bone and soft tissues of the joint. Traumatic injury to joints is also often associated with acute damage to the articular cartilage. Unfortunately, joint cartilage is a tissue with very poor healing potential. Once damaged, cartilage typically does not heal, or it may heal with fibrous tissue that serves no purpose. This tissue does not possess the properties of the original cartilage, so the integrity of the articular surface and normal joint function are compromised. The result is often osteoarthritis.

The significance of osteoarthritis must not be underestimated. The Centers for Disease Control and Prevention estimate that in the next 25 years, at least 71 million Americans (15 percent to 20 percent of the population) will have arthritis, including degenerative arthritis that developed after the original injury to the joint. Osteoarthritis is the most significant cause of disability in the United States and Canada, moving ahead of low back pain and heart disease. By the year 2020, more than 60 million Americans and six million Canadians will be affected by some degree of osteoarthritis of the knee. The economic impact is enormous. Osteoarthritis alone consumes $85 billion of direct and indirect costs to the American public. The intangibles of this terrible disease include the chronic pain and psychological distress on the individual and the family unit. We believe that our research can have far-reaching effects by greatly enhancing the resurfacing of damaged or arthritic joints before the disease process reaches the advanced and debilitating state.

MICROFRACTURE

Several of our earlier studies have shown that a technique called microfracture is a successful method to promote cartilage healing. Microfracture consists of making small perforations in the bone to gain access to the cells and growth factors in the underlying bone marrow. The technique relies on the existing cell population and healing proteins present in the marrow to promote healing, thus avoiding concerns of immune reactions to transplanted tissues or the need for a second surgery to collect grafts or cells. When we evaluated the healing of full-thickness cartilage defects in horses, we were able to show that the use of microfracture increases the amount of repair tissue present in the defect and that it improved the quality of cartilage repair by increasing the amount of collagen present in that repair tissue. Although microfracture was able to increase the major component of articular cartilage extracellular matrix, it did not enhance the production of proteoglycans, which is the other major component of cartilage thought to be necessary for long-term joint health. Also, we have found that the mechanical aspect of removing a deep layer of the cartilage is critical for the formation of repair tissue and healing to the bone.

We re-evaluated our earlier work on removal of the calcified cartilage and made additional observations. Incomplete removal of calcified cartilage appears to be associated with less-than-optimal repair tissue attachment. Furthermore, evaluation of cartilage tissue removed by arthroscopy demonstrated that removal of calcified cartilage was not obvious using standard arthroscopic equipment. We compared chondral healing with and without the removal of calcified cartilage in experimentally created chondral defects.

Our observations confirmed significantly better repair tissue at 12 months after surgery in defects where the calcified cartilage layer (CCL) had been removed, compared to defects where the CCL remained intact. MRI results revealed thinner and more incomplete repair tissue filling defects where the CCL remained intact, compared to when it had been removed. This study suggests that care should be taken in the removal of clinical cartilage lesions to ensure complete removal of calcified cartilage. Removal of the CCL significantly improves the healing of cartilage defects.

GENE THERAPY

We are investigating the potential of genetic medicine to activate the body's own restorative power in enhancing the growth and quality of repaired cartilage. This innovative approach to healing will greatly empower researchers and physicians in their quest for ways to preserve the body's own joints and tissues.

The imbalance between the synthesis and degradation of cellular components may be responsible for the inability of cartilage to heal itself. Interleukin-1 (IL-1), an inflammatory molecule, is considered the predominant factor involved in cartilage degradation. Blocking IL-1's inflammatory effects and simultaneously using interleukin-1 receptor antagonist protein (IRAP) seemed like an attractive approach. In addition, insulin-like growth factor-1 (IGF-1) has been demonstrated to enhance cartilage healing and appeared to be another logical candidate to promote healing. Unfortunately, the use of these molecules has been limited by a lack of an effective delivery system to the joint. Even with direct injections into the cartilage tissue, these molecules are rapidly cleared from the joint and necessitate repeated injections, increasing the risk of joint injection complications and the cost of treatment.

An alternative method to the repeated injection of these proteins is the use of gene therapy. Viral vectors carrying the genes of IRAP and IGF-1 can be injected into the diseased joint after arthroscopic removal and microfracture of the lesion. The modified virus would infect the cells of the membrane and use the cellular machinery to produce large amounts of IRAP and IGF-1 and, hopefully, improve cartilage healing. The advantage of this technique is the relatively long-term existence of the molecules (three to four weeks), which eliminates the need for repeated injections. Therefore, we undertook the task of evaluating the effect of the one-time injection of viral vectors carrying the genes of IRAP and IGF-1 on the healing of cartilage defects treated by microfracture. Our hypothesis was that the combined anti-inflammatory effects of IRAP and the growth-promoting activities of IGF-1 delivered to the joints by gene transfer would significantly improve the quality of the repair tissue found in cartilage defects.

We have completed all of the laboratory and data analyses. In summary, the measurement of IRAP concentration in the synovial fluid confirmed that the joints that received gene therapy produced significantly more IRAP protein than the joints not treated. These results indicate that the viral vectors were able to infect the cells of the joint and use the cell machinery to produce the proteins encoded by the transferred gene and to persist for a period of three weeks.

Overall, gene therapy did not affect the composition or the amount of repair tissue found in the defects and had no effects on the bone porosity. We did observe increased amounts of proteoglycans in the repair tissue of the treated joints as well as in the non-treated ones, probably because the growth-

enhancing properties of IGF-1 were able to increase the synthesis of proteoglycans by the cells present in the repair tissue. The IGF-1 may have increased cell growth and facilitated differentiation into chondrocytes of cells recruited into the defect from the bone marrow. This process would have increased the number of cells capable of producing proteoglycans. For the first time, we were able to demonstrate in an experimental model that gene therapy using a growth factor that stimulates matrix synthesis and an anti-inflammatory molecule blocking the degradation effects of IL-1 can be used successfully to enhance cartilage repair.

While positive effects were demonstrated, there were indications of possible immune response within the joints. We also observed considerable reaction in the synovial fluid to a second injection of IL-1Ra using the viral vector. Thus, we recognized the need for an improved vector that will provide less reaction, or at least if it can only be administered once, will last longer than the one seen with the vector described above. The reason for developing an improved vector is that not only will it allow gene therapy to be used clinically in the horse, but that it will offer a realistic clinical option for human patients. Consequently, our next study will be to develop and refine a more acceptable viral vector for use in gene therapy.

HEALING RESPONSE

The "healing response" (HR) technique developed and validated by the Foundation serves as an alternative to anterior cruciate ligament (ACL) reconstruction in the knee in certain instances. The healing response provides treatment for certain types of ACL injuries arthroscopically, which reduces surgical risk and immobilization.

The HR uses microfracture holes in both the bone where the injured ligament connects as well as in the ligament itself to induce a "super clot." This clot stimulates an enriched environment for tissue healing. The ligament end then gradually reunites with the bone on its own without the necessity for mechanically attaching it. By avoiding a more invasive procedure, this straightforward method greatly reduces recovery time and health-care costs.

Our laboratory model work on the appearance of the healing response is now complete. This work was done with Dr. Steven Arnoczky at Michigan State University. The manuscript was submitted to a peer-reviewed journal and was accepted late in 2004. It will be published in 2005. In order to help answer further questions of the orthopaedic community about this procedure, we need to carry out an additional study designed to assess the strength and biomechanical properties of the healing tissues. Information obtained will help us better understand the time frame needed for healing and at what point full activity should be encouraged. This information will also help other orthopaedic surgeons be more comfortable with this procedure, making them more likely to use it in their practices. In so doing, fewer patients will require the expense and time of a formal ACL reconstruction. Additionally, patients unwilling to have ACL reconstruction can be offered an alternative with fewer potential problems.

Arthritis

A chronic, debilitating disease, arthritis breaks down the cartilage in the joints causing pain, stiffness, swelling, deformity, and sometimes outright disability. The toll on both the individual and this country's economy is enormous, as the statistics below indicate.

- One in every three adults is affected by arthritis and chronic joint problems, making it one of the most prevalent diseases in the United States.
- America spends $65 billion annually on treating arthritis, its complications, and the disability it causes. This includes the indirect costs associated with wage losses and an estimated medical bill of $15 billion each year for doctor visits and hospitalizations.
- The painful effects of arthritis limit everyday physical activity more than cancer, heart disease, or diabetes.
- Arthritis is the most frequent cause of lost wages in the country.
- At least 50 percent of people age 65 or older will be afflicted with arthritis.
- With the aging of America's population, the number of individuals suffering from this disease will increase dramatically.

For arthritis caused by certain joint and cartilage disorders, the Foundation's innovative — and now widely used — surgical techniques that enlist the body's ability to grow "repair" cartilage can bring significant relief from painful symptoms. At the Foundation, we understand the negative impact that arthritis has on the individual, which is why we focus so much of our resources on preventing and treating this destructive disease.

CLINICAL RESEARCH:

"Outcomes" and "Process"

There is a great opportunity to learn from patients before and after they have surgery. Future research will focus on predictors of disability caused by arthritis, predictors of successful surgery, predictors of patient satisfaction, patient expectation of treatment, and patient outcomes following surgery.

Karen K. Briggs, M.P.H., M.B.A., Director; Marilee Horan, Research Associate; Amanda Ciotti, Research Associate; Sophia Hines, Intern; Aaron Black, Intern.

Outcomes research provides a tool to link the patient's perspective and the effectiveness of health treatment. In Clinical Research, we strive to improve the quality of patient-reported outcomes following surgical procedures. Our department focuses on results based on physician/patient assessment of improvement of the function and quality of life. Our goal is to learn from the experiences of patients to validate treatment protocols and assist patients in making decisions regarding their health care.

Clinical Research at the Steadman◆Hawkins Research Foundation gathers data from patients who seek treatment for knee and shoulder disorders. Information is stored in a database and is the key to our research. There is a great opportunity to learn from patients before and after they have surgery. Future research will focus on predictors of disability caused by arthritis, predictors of successful surgery, predictors of patient satisfaction, patient expectation of treatment, and patient outcomes following surgery. The goal of this research program is to carry out clinical outcomes research in the area of orthopaedic medicine that will aid both physicians and patients in making better-informed decisions regarding medical treatment.

OSTEOARTHRITIS

According to the Centers for Disease Control and Prevention (www.cdc.gov/nccdphp/arthritis), 43 million Americans have been diagnosed with arthritis or other rheumatic conditions, with an additional 23 million having chronic joint symptoms undiagnosed as arthritis. This makes arthritis one of the most prevalent diseases in the U.S. and the leading cause of disability.

Osteoarthritis is a chronic disease causing deterioration of the joint cartilage (the softer parts of bones, which cushion their connections to each other) and the formation of new bone (bone spurs) at the margins of the joints. As the population continues to age, the prevalence of osteoarthritis will increase. With increased numbers comes increased health-care expenditures. The CDC estimated that arthritis costs are approaching $100 billion per year in total costs.

To decrease the burden of arthritis, early diagnosis and management of arthritis is necessary. If individuals seek early treatment, they may decrease pain, improve function, stay more productive, and lower the cost of treating the arthritis. The CDC recommends several steps for individuals to take an active role in the management of arthritis.

Arthroscopic Treatment of the Osteoarthritic Knee to Delay Total Knee Replacement

The goal of arthroscopy in the degenerative knee is to help patients continue their active lifestyle, decrease disability, and delay the need for total knee replacement. Surgical management of the arthritic knee in active patients presents a challenge to the orthopaedic surgeon. Few procedures have been developed to address the degenerative knee arthroscopically. However, in response to a negative report about arthroscopic treatment of the degenerative knee in the *New England Journal of Medicine*, the Arthroscopy Association of North America stated that, given a conscientious orthopaedic surgeon and appropriate patient selection criteria, arthroscopic surgery in the degenerative knee is capable of producing long-lasting relief. In an effort to help define the proper patient selection criteria, we looked at factors that predict success or failures following arthroscopic treatment of the degenerative knee. As this research continues, we hope to aid patients in making decisions regarding management of osteoarthritis of the knee prior to total knee replacement.

We evaluated the outcomes of patients with severe osteoarthritis of the knee who underwent a comprehensive arthroscopic treatment regimen. Arthroscopic treatment includes joint insufflation (a technique to stretch the contracted joint lining), lysis of adhesions (removal of scar tissue), anterior interval release (removal of scar tissue behind the patella tendon), contouring of

Key Self-Management Activities for Individuals with Arthritis
(www.cdc.gov/arthritis/key)

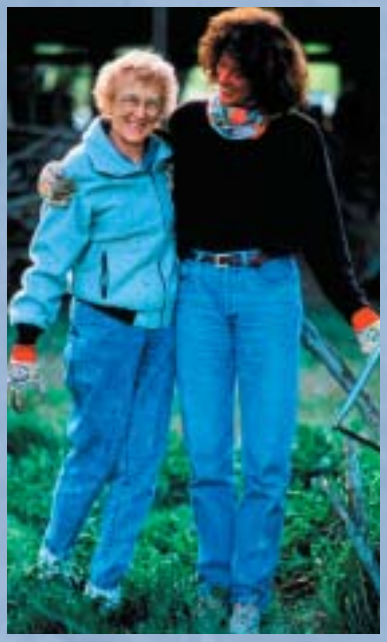
See Your Doctor – Although there is no cure for most types of arthritis, early diagnosis and appropriate management is important, especially for inflammatory types of arthritis.

Learn What You Can Do – Self-management education has been shown to reduce pain even 4 years after participating in the class.

Be Active – Research has shown that physical activity decreases pain, improves function, and delays disability.

Watch Your Weight – The prevalence of arthritis increases with increasing weight. Research suggests that maintaining a healthy weight reduces the risk of developing arthritis and may decrease disease progression.

Protect Your Joints – Joint injury can lead to osteoarthritis. Avoid joint injury to reduce your risk of developing osteoarthritis.



cartilage defects and meniscus tears to a stable rim, synovectomy (removal of part or all of the synovial membrane), removal of loose bodies, and removal of osteophytes (bony outgrowths) that affect extension. In these patients, with an average age of 57, all had been told by other physicians that they needed a total knee replacement. At a two-year follow-up, 83 percent had not had a knee replacement. Patients experienced improvement in function and activity level, and they were highly satisfied. Our initial analysis showed that patients with worse preoperative function and knee alignment problems had less improvement in function. This comprehensive, arthroscopic treatment regimen improved function and activity levels in patients with end-stage osteoarthritis. More long-term results are needed to determine what factors are associated with success and how long knee replacement can be delayed by treatment with this protocol.

Measuring the Severity of Arthritis with Radiographs

In order to compare treatment protocols, it is necessary to determine how severe the patients' arthritis is for different treatment groups. The Kellgren Lawrence (K-L) grading system was developed in 1957 and accepted by the World Health Organization in 1961 as the gold standard for cross-sectional and longitudinal epidemiological studies. It is the most widely used radiographic classification of osteoarthritis. Studies have shown that the radiographic score can differentiate the severity of osteoarthritis when using an MRI as a standard. However, correlation of the K-L score with arthroscopic findings has not been done. We completed a study to correlate arthroscopic findings of knees with severe osteoarthritis with the K-L grade. Patients' radiographs were examined by two orthopaedic surgeons and arthroscopic data were collected. Grade IV is the worst score, while a Grade I is minimal arthritis. In our study we saw that Grade IV knees had more chondral damage and were more likely to have meniscus abnormalities. Grade IV Kellgren-Lawrence scores correlated with more severe chondral degeneration and meniscal pathologies. The study showed that the K-L scale can differentiate between moderate and severe osteoarthritis.

High Tibial Osteotomy

Medial opening wedge high tibial osteotomy is a procedure for treatment of varus (knock-knee) malalignment of the knee. Malalignment in the knee is a condition that leads to premature deterioration of the cartilage and meniscus of the knee joint. For the past ten years, Dr. Sterett has been performing these procedures on patients who are young and active and who would like to postpone total knee replacements as long as possible.

Prior to high tibial osteotomy surgery, determining the amount of correction needed is essential to obtaining accurate postoperative alignment. Preoperative planning consists of using x-rays to calculate the millimeters necessary to restore appropriate realignment of the leg and clinically evaluate the patient's gait. X-rays are taken from the hip to the ankle with either a double-leg stance or a single-leg stance. Controversy exists as to whether the patient should be standing on one leg or both legs, as the weight-bearing change may alter the "bow-leggedness" of the patient. Therefore, we asked the question: What is the variability, if any, between single- and double-leg stance x-rays and does a varus thrust contribute to this variability?

We looked at radiographs of over 50 patients who underwent a high tibial osteotomy. They were evaluated on both single- and double-leg stance x-rays. We found that patients who had a varus thrust had differences on measurements between their single-leg and double-leg stance x-rays. For example, patients with a varus thrust were estimated to need a greater correction on single-leg stance x-rays than on double-leg stance x-rays.

We concluded that patients who are undergoing a high tibial osteotomy and show evidence of a varus thrust should have single-leg stance x-rays routinely incorporated in their preoperative planning.

Because of the anatomy of the tibia, an opening wedge osteotomy may produce correction in two planes. We conducted a study to find out if we are changing the posterior slope of the tibia by performing a high tibial osteotomy. In addition, if we are changing the posterior slope, does this change have an effect on range of motion or functional outcome scores?

We found out that by performing a high tibial osteotomy, we are significantly increasing the posterior slope of the tibia. We then focused on whether or not this change affects the range of motion of the knee or the functional outcome of the patient. We concluded that an increase in posterior slope of the tibia did not have a negative effect on range of motion or changes in functional outcomes scores.

GLENOHUMERAL ARTHRITIS

Glenohumeral arthritis or arthritis of the shoulder is common, affecting up to 20 percent of patients over 65. Osteoarthritis of the glenohumeral joint is a common cause of shoulder pain and can lead to total shoulder replacement. It can result in restricted range of motion and loss of function. Arthritis in the shoulder can develop following trauma, shoulder surgery, or an inflammatory joint condition.

Association Between Glenohumeral Arthritis and the Degree of Long-Standing Anterior Instability of the Shoulder

There are many potential causes for glenohumeral arthritis, the most common being a traumatic injury to the surface of the cartilage and inflammatory arthritis. There is a large subset of patients who develop shoulder arthritis in which the mechanism is unknown. The cause is generally ascribed to "wear and tear." Wear and tear is described as microtrauma and shear stress across the cartilage surface as a result of excessive movement in the shoulder. It results in progressive cartilage loss and the eventual development of arthritis. We hypothesized that patients with longer-standing symptoms of instability and excessive movement within the shoulder documented at surgery would have more severe arthritis.

To test our hypothesis we evaluated the degree of shoulder arthritis present in over 200 patients with varying degrees of anterior shoulder instability. All patients had symptoms for more than three months and had not had a prior surgery on the affected shoulder. Data collected at the time of surgery included the grade of damage, as well as the grade and direction of instability.

Our study found an association between increasing grades of instability and the development of arthritis. Patients with more severe instability were at highest risk for the development of arthritis. This risk increased with the presence of a labral tear called a Bankart lesion. Independent predictors of arthritis were age, duration of instability, and increased level of translation.

Chronic shoulder instability is a potential contributor to the development of shoulder arthritis. The patient noted to be at highest risk for the development of glenohumeral arthritis were those over age 35 with long-standing instability, a Bankart lesion, and higher levels of translation. These patients were nearly five times more likely to have arthritis.

INJURY TREATMENT TO MAINTAIN FUNCTION AND ACTIVITY

Microfracture Update

More that 20 years ago, Dr. Steadman began performing the microfracture technique for the treatment of cartilage defects. The technique was developed to enhance chondral resurfacing by providing a suitable environment for new tissue formation and to take advantage of the body's own healing potential. The rehabilitation program following treatment of chondral defects of the knee by microfracture is also crucial to optimizing the results of surgery.

Over the last several years, the Department of Clinical Research has completed and published several studies to help with the validation of the use of the microfracture technique for full-thickness chondral defects in the knee. Microfracture was shown to be effective in athletes, including professional football players. The athletes had improvement in their symptoms and were able to return to their sport. Another study showed that microfracture can reduce symptoms and improve function over several years. One study documented improvement in patients on average of 10 years, with the longest follow-up being 17 years.

Recently, other institutions have begun to study the outcome of microfracture. A study funded by the Norwegian Ministry of Health and published in the *Journal of Bone and Joint Surgery* compared autologous chondrocyte implantation (using the body's own articular cartilage tissue) with microfracture. This was a randomized trial that compared 40 patients who had microfracture and 40 patients who had autologous chondrocyte implantation. Both groups showed improvement in function and decrease in pain. However, for physical functioning, the microfracture group had more improvement. The microfracture group also had fewer failures and fewer patients needed additional arthroscopic removal of the tissue. This study helped validate the microfracture technique as a treatment option for articular cartilage defects of the knee.

Anterior Interval Release

Pain in front of the knee has been a common postoperative complication in ACL reconstruction patients. Many of these patients have extensive scar tissue formation within the region between the patellar tendon and the anterior tibia. This scarring causes decreased knee motion and patellar mobility. A Department of Basic Science study sponsored by the Foundation showed that this scar tissue altered both patellar and tibial movements and contact, potentially resulting in arthritis. To address this problem, an arthroscopic procedure to release the scar tissue within the anterior interval was adopted and termed Anterior Interval Release (AIR).

Currently, we are conducting a study tracking the outcomes of patients who have undergone the AIR procedure. We will compare pre- and postoperative scores of both activity level and knee function. Preliminary results show improvement in function and activity. Due to the highly specific criteria, we have a limited patient population. However, with the increasing number of patients who have this type of scarring and who require AIR, we are optimistic that adequate numbers of patients will be followed to show the effectiveness of this procedure.

Is the Meniscus Harmed With an ACL-Deficient Knee?

Tears of the meniscus are commonly found in association with anterior cruciate ligament injuries. Recent studies have shown that patients requiring meniscus treatment in addition to ACL reconstruction have worse outcomes than patients who do not require meniscus treatment. We completed a study to determine the factors associated with meniscus damage in the ACL-deficient knees. More than 2,900 patients were identified from our database who had a torn ACL. Analysis of the data showed that the presence of a meniscus tear was not associated with age. Time from injury to surgery was significantly higher in patients with meniscus tears as compared to patients without meniscus tears. Time from injury to surgery was also associated with increasing severity of meniscus damage. A patient with a degenerative tear of the meniscus had a significantly longer time from injury compared to a simple tear.

Unstable knees demonstrated more degenerative and complex tears than stable knees. This study showed that the presence of meniscus tears in the ACL-deficient knee was associated with time from injury to surgery and the degree of knee stability. These factors were also associated with the severity of meniscus damage. The findings of this study suggest that stabilization should be performed as soon as possible. Furthermore, stabilization of unstable knees may lead to fewer meniscus tears and potentially improve patient outcome following the procedure.

Factors Associated With Location of Complete Tears of the Anterior Cruciate Ligament

The anterior cruciate ligament is like a rope that connects the femur to the tibia and it provides stability. When an injury happens, this ligament can tear at different places. The most common tear is a tear in the middle of the ligament — a mid-substance tear. Few studies have reported the prevalence of tears near the femur (proximal tears). We analyzed over 2,000 knees in our database to see where the ACL had been torn. The prevalence of complete proximal tears was 44 percent. Women were more likely to have a proximal tear and the younger patient was more likely to have a mid-substance tear. Mid-substance tears were associated with a competitive sports injury and proximal tears were associated with skiing injuries. In conclusion, the prevalence of proximal tears in this study was higher than previously reported. Pre-injury factors associated with the location of tears included gender, age, and type of sporting injury, specifically skiing. Post-injury factors associated with tear location included instability, meniscus abnormality, and plica. These factors may have implications on the diagnosis and treatment of ACL tears and associated injuries.

Clinical Outcome After Revision Anterior Shoulder Stabilization Procedures

Much has been published on the results of open and arthroscopic surgical techniques for the management of the unstable shoulder. It is generally accepted in the orthopaedic literature that the recurrence rates for open surgery techniques are between 2 percent and 8 percent, with results for arthroscopic procedures far more wide-ranging. However, relatively few studies report the outcomes of patients who have failed a primary surgical intervention. Determining the exact cause of failure can be difficult for the treating physician. In addition, patients are frequently and

understandably apprehensive after having undergone a previous surgery for the same problem with poor results. The purpose of this study is to assess clinical results following revision surgery for anterior instability of the shoulder.

From 1992 through 2001 the senior surgeon performed 404 surgeries for anterior instability. Forty-nine patients met the requirements for this study. Patients with major co-pathologies at the time of revision surgery, such as full-thickness rotator cuff tears or shoulder replacements, were excluded. Patients who had a third instability surgery on the revised shoulder were classified as failures.

The criteria for inclusion in the study were having had anterior instability surgery followed by continuing symptoms and treatment of the same problem with a minimum two-year follow-up. To determine whether the patients had successful or unsuccessful outcomes, we set the criteria for failures as any of the following: (1) a third surgery for instability, (2) American Shoulder and Elbow Surgeons score of less than 75 out of 100 points, or (3) repeat dislocation following the revision procedure.

Minimum two-year data were obtained on 39 patients (80 percent). Sixteen of 39 patients, or 41 percent, failed the revision procedure. Those patients who required a third procedure went an average of 1.6 years between their second and third procedures. Of the patients who did not require a third instability procedure, there was an average follow-up of 3.9 years. In this group of non-failures, 18 procedures were performed using open techniques and five used arthroscopic techniques. The average ASES score in this group was 93 out of a possible 100 points and satisfaction with surgical outcomes averaged 9.5 on a 10-point scale.

Current published clinical outcomes studies of revision instability procedures report fair to poor results that range from 0 percent to 35 percent. Failures of surgical

intervention can be numerous and quite complex due to misdiagnosis, technical errors, re-injury, and other patient factors, all of which can influence outcomes.

In this study, the failure rate was 41 percent. This demonstrates the challenge and complexity of treating an unstable shoulder that has already failed one procedure. But patients with successful outcomes generally functioned at a high level with very little, if any, limitations in their lifestyles. The main goal of both types of surgical repair of the unstable shoulder is focusing on the tendon-ligamentous complex.

PSYCHOMETRIC PROPERTIES OF OUTCOME SCORES

In previous studies, the Department of Clinical Research has investigated the psychometric properties of several different outcome scores. The ASES was developed for the shoulder and the results of this study will be published in *The Journal of Bone and Joint Surgery*. The Lysholm score has been validated for use with ACL injuries, cartilage injuries, and meniscus injuries. The properties we use include the content validity, criterion validity, construct validity, and responsiveness of the Lysholm score. Test-retest reliability is determined by having a group of patients complete an original questionnaire, followed by a retest of the same questionnaire within four weeks of the original test. The Lysholm score demonstrated overall acceptable psychometric performance for outcomes assessment of meniscus injuries of the knee. However, in the original development of the Lysholm score, it was recommended that it be used with a measure of activity — the Tegner activity scale. We determined the psychometric properties of the Tegner score in patients with meniscus pathology.

The Tegner activity scale is numerical, with values of 0 to 10. An activity level of 10 corresponds to competitive sports including soccer, football, and rugby at the elite level. An activity level of six corresponds to recreational sports, and a level of zero

corresponds to a person on sick leave or disability pension because of knee problems. Activity levels of five to 10 can be achieved only if the patient participates in recreational or competitive sports.

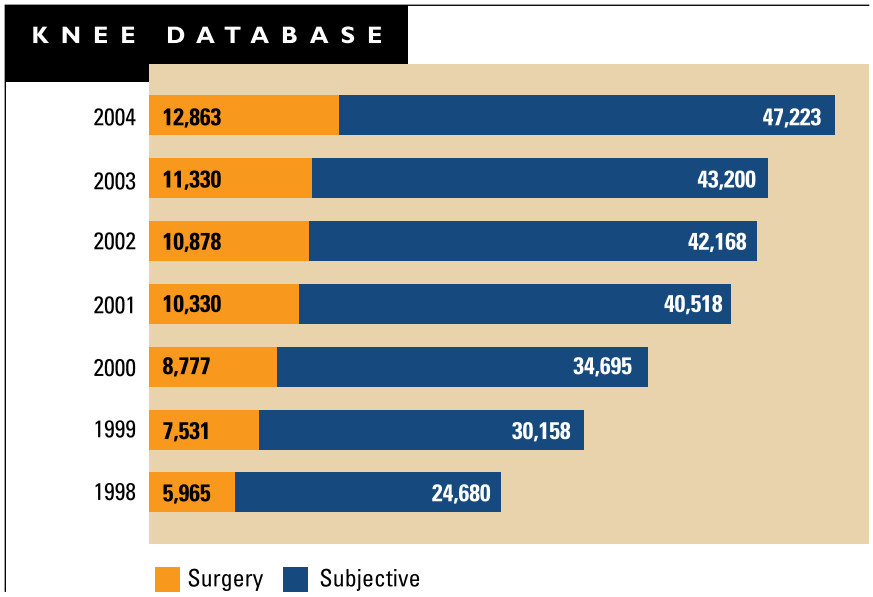
In our study, the Tegner activity scale generally demonstrated acceptable psychometric parameters to justify its use in outcome measures for meniscus pathologies of the knee.

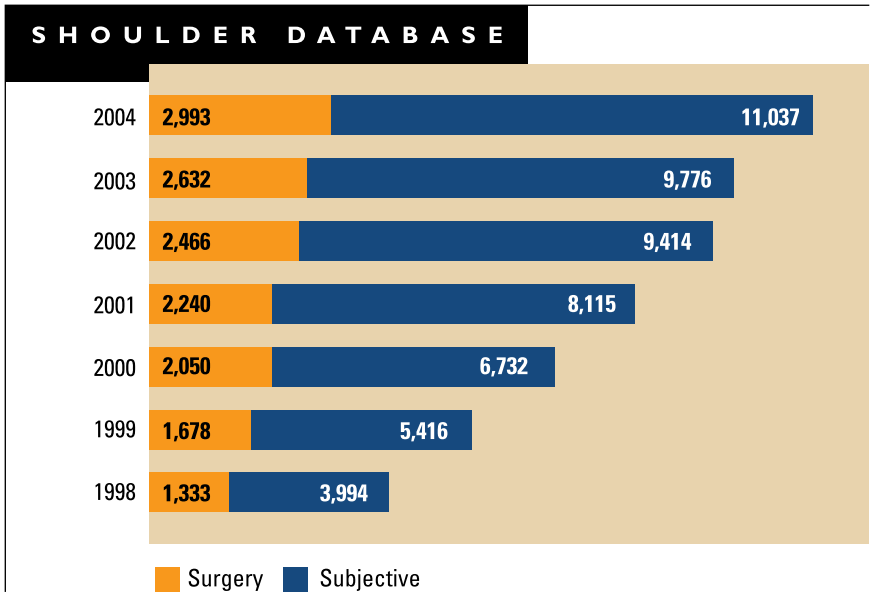
Clinical Database

The key to successful research is effective management of data. For Clinical Research, patient and physician data must be collected, stored, and reported in an appropriate manner. At the Foundation, data are collected on all knee and shoulder patients. These data consist of both patient and physician assessment of improvement over the preoperative status. The goal of the database is to collect accurate data in a timely manner. These data allow us to do research and help define changes in the patients who participate in our studies.

The key to any system is for it to be both stable and adaptable. In Clinical Research at the Steadman◆Hawkins Research Foundation, the data collection system is an "in-house" process. This allows us to update the system, add new questions, and develop new forms. This flexibility lets us expand our research without having to wait for system update. We develop the scannable forms and program computers that the physicians use to record data. This process has led to the development of the Steadman-Hawkins Clinical Research Database.

Currently, the database holds more than ten million data points. This includes over 4.5 million data points for knee surgeries, over three million for knee subjective, over one million for shoulder subjective, and more than 400,000 for shoulder surgery. One subjective data point is one patient's assessment of pain or function for one factor. These data have resulted in 18 publications during the last two years.





BIOMECHANICS RESEARCH LABORATORY

The programs provided by the Biomechanics Research Laboratory are unique, diverse, and encompass a complete range of services for the physically active or those wishing to return to an active lifestyle after injury.

Michael R. Torry, Ph.D., Director; J. Erik Giphart, Ph.D., Staff Scientist; Takashi Yanagawa, M.A., Staff Scientist; and Kevin Shelburne, Ph.D., Senior Staff Scientist

The Foundation's Biomechanics Research Laboratory is a multidisciplinary laboratory in which the principles of mathematics and engineering are applied to solving complex problems in orthopaedic medicine. A main objective of the laboratory is to explain the *how* and *why* injuries occur and treatments, surgeries, and various therapies work for some individuals and not for others.

MISSION AND GOALS

The Biomechanics Research Laboratory's mission is to further the scientific understanding of basic biological processes and to develop innovative approaches for the understanding, prevention, diagnosis, and treatment of musculoskeletal disease.

Our goals are to:

(1) Foster excellence in teaching, research, scholarship, and service in orthopaedic biomedical engineering.
(2) Prepare orthopaedic medical doctors with functional capabilities to utilize biomedical technology that will enhance patient care.
(3) Educate the medical profession on the uses of such technical equipment in the clinical decision-making process.
(4) Serve as a center for education and research in biomedical engineering.
(5) Prepare students for careers in biomedical engineering characterized by leadership and communication skills and a commitment to lifelong learning.
(6) Educate the public about the uses of biomedical engineering in orthopaedic medicine.
(7) Publish scholarly research in scientific, peer-reviewed journals in order to increase the quality of orthopaedic care in general.

OVERVIEW

The Foundation's Biomechanics Research Laboratory (BRL) is a multidisciplinary laboratory in which the principles of engineering are applied to solving problems in orthopaedic medicine. It applies quantitative, analytical, and integrative methods to the field of orthopaedic medicine. The staff of kinesiologists, biomechanists, and mechanical and biomedical engineers integrates clinical care, research, and education with the resources of world-renowned medical doctors in order to improve the treatment of musculoskeletal diseases. This focused approach is designed to maintain and enhance athletic performance, health, and quality of life for the professional, semi-professional, collegiate, high school, and the recreationally active individual. The programs provided by the Biomechanics Research Laboratory are unique, diverse, and encompass a complete range of services for the physically active or those wishing to return to an active lifestyle after injury.

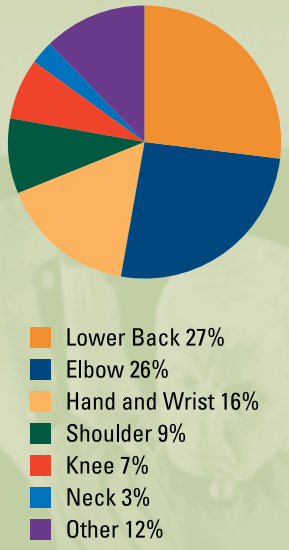
With the statement *helping physicians make clinical decisions* as its doctrine, the Biomechanics Research Laboratory also seeks to enhance a world-renowned medical doctor Fellowship Program by providing quality research education, guidance, support, and consultation to the partners and medical Fellows of the Steadman-Hawkins Clinic.

The work production of the BRL for the year 2004 has been exemplary, with seven refereed abstracts presented at four national and international conferences. The group has also produced 10 original full-length research papers (seven publications, three in press). The quantity of the work is backed by substantial quality. "Each year our research gets stronger and we are receiving recognition from our peers for the quality of our work," states Dr. Michael Torry. Some of the research that the BRL has initiated and/or completed in the year 2004 is described below.

Determination of How the Knee Carries Load During Activities

Many individuals suffer from osteoarthritis of the knee. The degeneration of the knee joint often becomes more painful during activities of daily living such as walking or hiking. Joint degeneration often begins with an injury or mild malalignment at the knee that alters its normal load bearing. Many conservative and surgical treatments for osteoarthritis are based on the theory that restoring the normal load-bearing capability of the knee will delay the onset and progression of the disease. However, until recently, it was not known what types of mechanical

Figure 1: Distribution of injuries in amateur golfers.



Adapted from J.R. McCarroll, A.C. Rettig and K.D. Shelbourne.

loads are distributed throughout the knee. Dr. Kevin Shelburne, assistant director, and Dr. Marcus Pandy at the University of Melbourne, Australia, have developed a computer model of the knee and lower extremity that can determine loads inside the knee joint during walking.

Dr. Shelburne presented an abstract to the Orthopaedic Research Society that details where and how loads in the knee joint are distributed during a walking cycle. The model has shown that most of the load-bearing area arises on the medial side (inside) of the knee. This is not surprising, as our doctors often observe more severe osteoarthritic conditions on the (medial) inside side than on the (lateral) outer side. A unique finding of this research is that the total load in the knee can reach upwards of 449 pounds during simple walking, with nearly 334 pounds distributed on the medial side. Furthermore, the distribution of force at the knee, largely determined by the alignment of the leg (malalignments include bow-leggedness and knock-knees), can shift more or less load to the medial or lateral side of the knee joint, as well as shifting the force in the muscles spanning the knee. Ligaments have a role as well, but it is the muscles and structure of the bones that keep the knee stable during activity. This study only investigated loads in a knee that is considered to have normal alignment. However, ongoing work is focused on how ligament injuries and knee malalignment affect knee loads during a variety of activities.

Dr. Shelburne's research helps physicians better understand how and why conservative and surgical treatments are effective in restoring normal load bearing at the knee. This research also provides a basic understanding of the loads that a knee must be able to withstand, which allows physicians to select surgical procedures most appropriate to meet those demands in the active individual.

Analysis of the Golf Swing Mechanics in the Amateur Golfer Aged 60+

In amateur golfers, back injuries and back pain constitute 27 percent of golf injuries requiring loss of playing time and medical treatment. The incidence of back injury is followed closely by elbow injury and to a lesser extent, hand, wrist, shoulder, and knee maladies (Figure 1).

Golf is one of the most popular sports among older adults. Unfortunately, golf also requires excessive and repetitive rotary motion about the spine. This motion frequently develops into low back pain that is often made worse by the presence of spine osteoarthritis in this age group. Although some clinicians believe the rotary motion may cause spine-related osteoarthritis, this has not been proven. Very little information exists to describe the motion of the body in the aging golfer. The Biomechanics group is spearheading a large project to investigate the golf swing mechanics in the golfer over the age of 60. The study includes building an indoor swing center that allows for unrestricted swing analysis using high-speed video. With this technology, we can actually see if the golfer keeps his or her lead arm straight, when he/she breaks the hips, and we can even measure the popular X-factor, a leading variable that teaching professionals use to define trunk rotation. The study was initiated in August 2003, and any golfer over age 55 who wishes to have his/her swing analyzed can call Dr. Torry for more details. "Once we understand more about what happens to the knees, hips, shoulder, and back in the senior golfer, we will be able to focus on specific injuries that often plague this age group at each joint," states Dr. Torry. "If you want to participate in our golf program I can't promise I'll make you a better golfer, but I'll promise a good time trying!" encourages Dr. Torry.

Determining How ACL Injuries Occur During Landing From a Jump and Why Females Tear Their ACL More Than Males

Since the inception of Title IX in 1979, the incidence of females tearing their ACL in non-contact sports such as soccer has been alarming, with some reports estimating women to be four to eight times more likely to tear their ACL than their male counterparts in comparable sports. Understanding how and why this gender disparity occurs has been a three-year endeavor for the Steadman-Hawkins Biomechanics group. Most recently, the group published a paper that detailed specific landing-from-a-jump differences that exist between age and activity level-matched male and female athletes. In short, women land in a more erect position (less knee flexion), which would tend to create higher loads on the ACL.

However, measuring a person's performance in the laboratory has disadvantages because the landings cannot be harmful in any way. In addition, the landing problem only answers part of the question. To further understand how and why the ACL is sometimes injured in both men and women, Kevin Shelburne, Ph.D., and Michael Torry, Ph.D., in conjunction with Marcus Pandy, Ph.D., have conducted a study in which the landing data measured on subjects in the laboratory were used to guide a computer model of the motion. With the computer model, the scientists are able to determine what is happening inside the knee during the motion, which tissues are being loaded, and the factors that are contributing most to the injury. Unlike testing human subjects, the model can be made to perform in a manner that actually tears its ACL. "How people tear their ACL when landing from a jump is a very hot topic in research right now. This study represents a tremendous leap forward in technology and in the understanding of just how this injury might occur," says Dr. Torry. Dr. Torry has been recognized as a leader in studying female ACL injuries, serving on three scientific committees that discuss and provide leadership for research being conducted in this area. Dr. Torry's work was also showcased in the October 2004 issue of *Shape Magazine* in an article titled "Take a Soft Approach to Landings."

Determining How and Why Little League Baseball Pitchers Get Injured

After four years of investigating major league baseball pitching mechanics and injuries, Dr. Torry and the BRL team have focused their efforts on understanding the mechanics behind the Little League pitchers' throwing patterns and how these patterns contribute to their injury potential. Clinically, the injuries seen in younger pitchers are much different from those observed in professional pitchers.

This observation led us to believe that the pitching mechanics are most likely very different as well. Recently, the BRL has published several abstracts and papers that detail the pitching mechanics of Little Leaguers and, in conjunction with our professional pitching database, we are able to compare throwing patterns of developing young pitchers to successful, mature pitchers. Although significant differences do exist, there are many more similarities.

For instance, the Little Leaguers only throw about 50-65 mph fastballs. However, given the shorter distance from home plate to the pitcher's mound, this translates into a professional pitch velocity equivalent of 80-95 mph to the batter. Our research has also shown that Little League pitchers actually execute the pitch sequence in a similar manner, with major differences from the pros being partly attributed to height, weight, and physical strength. So why are the injuries patterns so different? This is most likely due to the physical strength and the skeletal maturity of the athletes. As we mature, the tissues become more rigid and able to withstand higher forces. An outcome of our research clearly shows that young players (as early as 13 years old) need to have proper techniques

Figure 2

Scapula upward ratation for four trials during humerus elevation (0º = arm straight down, 180º = arm above head)

Patient-specific shoulder model with three-dimensional bone pin tracking markers.

taught to them because, at this age, these kids are already developing pitching mechanics they will carry with them into adolescence.

Understanding 3-D Motion of the Shoulder Complex

The first step in preventing and determining how shoulder injuries occur is to understand and quantify normal motion of the shoulder complex: the clavicle, scapula, and humerus. However, conventional biomechanics research methods are ineffective, primarily because the scapula and clavicle motions are three-dimensional and are obscured by the surrounding muscle and tissue. The Biomechanics Research Laboratory has overcome these obstacles by performing a unique set of experiments. Rather than the traditional method of attaching reflective markers to the skin, markers are attached to a pin drilled into the clavicle, scapula, and humerus. High-speed cameras then record the motion of the markers, which are duplicating the exact motion of the shoulder bones.

This method allows the investigators to clearly identify how each bone is moving relative to another bone during basic movements such as raising the arm, as well as during skilled activities such as throwing a football or hitting a golf ball. Data from one subject has already been collected and analyzed. For example, as the arm was elevated from 20° to 135°, the scapula rotated upward a total of 35° (Figure 2) and tilted back 12°. Five more subjects have volunteered and will be tested within the next several months.

These motion data are important and numerous research centers around the world are anxiously awaiting our results. Furthermore, these data will be instrumental in helping advance our theoretical model of the shoulder.

Interested readers can see a computer animation of these data by visiting http://www.shsmf.org/Flash/abduction_model_x.swf.

The Virtual Shoulder

Like the virtual knee model, the Biomechanics Research Laboratory (under Dr. Kevin Shelburne and Takashi Yanagawa), in association with Dr. Marcus Pandy at the University of Melbourne, Australia, are leading the way in the development of a revolutionary virtual shoulder model. After the knee joint, a shoulder joint is next in terms of being prone to injury because of its complexity. It has four joints and involves four bones and many muscles that surround it. Many other structures also contribute to the joint stability of the shoulder. Determining just how each of these structures contributes or fails to contribute to the shoulder joint stability is paramount to being able to surgically treat the shoulder more successfully.

The virtual shoulder model allows for many individualized research questions to be asked and investigated. For instance, we may ask how much force is applied to the glenohumeral joint if one of the rotator cuff (or

any combination of) muscles is weak or injured? Thus, the shoulder model can be applied to nearly any "what if" scenario that an orthopaedic surgeon could ask. Engaging in this type of research would be financially impractical utilizing conventional methods with cadavers.

As with any virtual model, prior to being applied clinically, it must be validated. "Takashi Yanagawa has been working very hard in validating our current model," states Dr. Torry, "and this validation process is no small endeavor because the computational process is very tedious. We are close to applying the model in a very useful and clinically relevant manner. I have no doubt that this model will revolutionize our basic understanding of how the shoulder really moves and which muscles and ligaments are involved."

Clinical and Mechanical Validation of Lysis of Knee Adhesion Surgical Procedures

Knee adhesions, often referred to as "scarring" of the knee joint, cause changes in the way the knee joint normally moves. This altered motion leads to abnormal loading inside the knee joint that can eventually degrade the cartilage of the knee and result in the development of osteoarthritis. In the United States alone, the cost for treating osteoarthritis and its complications is almost $65 billion. When considering its worldwide economic impact, this figure is estimated to be over $750 billion annually. Although most orthopaedic surgeons acknowledge the presence of these adhesions in persons who are experiencing pain at the front part of their knee, it has been difficult to surgically address this condition because the science behind the treatment is lacking. Getting rid of the adhesions may require a surgical procedure to promote normal motion and spare the joint from further degeneration.

This proposed project would be conducted using a multidisciplinary approach. It will integrate engineering as well as radiological and surgical experts from some of the world's most renowned orthopaedic and bioengineering research institutes in order to determine the best approach to alleviate knee adhesions. The results of this investigation will serve to improve the quality of life of millions worldwide.

This study aims to provide surgical, clinical, and scientific validation that the knee adhesion surgical technique can spare the knee joint from excessively high loads that would otherwise cause degenerative osteoarthritis.

The proposal will integrate international leaders in musculoskeletal experimentation, modeling, MRI, and clinical medicine to describe and determine the anatomy, dynamic imaging, biomechanics, clinical diagnosis, and arthroscopic treatment, plus assessment of clinical outcomes at various intervals. These goals will be accomplished by a three-step research approach involving two research centers and three departments: Musculoskeletal Research Center (MSRC), Department of Bioengineering, University of Pittsburgh; Department of Clinical Research, Steadman◆Hawkins Research Foundation; and Department of Biomechanics, Steadman◆Hawkins Research Foundation. The MSRC will integrate with orthopaedic surgeons of the Steadman-Hawkins Clinic to identify, enroll, test, and track the treatment and rehabilitation of patients undergoing dissolution of adhesions for the relief of knee pain. Moreover, the MSRC and the Department of Biomechanics at the Steadman◆Hawkins Research Foundation will collaborate in experiments and computational mechanics designed to describe the mechanical influences of knee adhesions on internal loading and knee joint function.

We think the identification and description of the successful surgical treatment of knee adhesions will provide knowledge that identifies the significant factors of the disease based on the altered knee. Then, appropriate treatment strategies can be designed. We will also be able to demonstrate changes in knee motion and mechanics associated with the successful treatment of this disease by utilizing computer modeling techniques developed as part of the investigation.

At the conclusion of this study, we anticipate the identification and description of the successful surgical treatment of patellar tendon adhesions. Additionally, we will provide biomechanical evidence that identifies the significant factors that determine the pre-treatment mechanics associated with knee pain due to the adhesions. In this pre-treatment, post-treatment design, we will also be able to demonstrate changes in knee kinematics and mechanics associated with the successful treatment of this disease utilizing the dynamic MRI technique.

There is the appeal of both clinical and scientific impact associated with this research project. Clinically, this research will have wide-reaching appeal across the field of orthopaedics, as this clinical problem is encountered across most of the sub-disciplines of orthopaedics. Many surgeons will benefit from the knowledge gained in both surgical treatment and patient satisfaction after these procedures. Although we have focused on the knee, this research may also allow experts working within other joints (shoulder, wrist, etc.) to apply and expand upon the techniques developed in this proposal to their own needs. This would allow for addressing issues of adhesions across a wider range of patients. Scientifically, we feel that the development and application of a dynamic MRI technique that employs new 3-D computer modeling methods will have a great impact on clinical use of dynamic MRI for diagnostic purposes related to the knee. It will also allow for technological advances in the non-invasive measurement of human motion.

The future direction of this research lies in the ability of scientists to generate subject-specific, anatomically correct, 3-D images of each patient. It will also apply motion to integrate that anatomy with computer modeling and simulation techniques that can show precise bone segment rotations and translations and estimate intra-articular forces as they occur. Once established and validated, these methods can be applied before and after medical treatment. This will allow for the assessment of subtle post-treatment changes in anatomic motions, as well as for advances in computer modeling to explain and even predict successful surgical outcomes.

NEW RESEARCH INITIATIVE: A STEP INTO THE FUTURE

The Biomechanics Research Laboratory has excelled over the past four years, winning five international and national research awards in acknowledgment of its pioneering work in orthopaedic research. "Conducting research is easy, but to excel and remain at the cutting-edge level in our research, we must persistently develop new technology to meet the needs of the orthopaedic surgeon and ultimately the patient. That is the hard part," states Dr. Torry. This 2004 Annual Report constitutes a major turning point in our research agenda. In the last four years, we have successfully accomplished all our planned five-year goals. Thus, for the next five-year plan, the Biomechanics group is proposing an ambitious, innovative research initiative that will keep its work at the forefront of orthopaedic technology. Titled *A Step Into the Future*, the Biomechanics Research Laboratory proposes the development of a 3-D Dynamic Motion Imaging System to investigate human motion at a level of detail and scrutiny that has not been possible until recently.

Why is this advancement in technology required and how will it help patients? Nearly everyone reading this report has experienced a trip to the orthopaedic surgeon's office. This visit is most often associated with an additional stop at the MRI station or x-ray station so the doctors can get a "view" of what is inside the joint. While taking the MRI or x-ray scan, the imaging technician tells us to remain perfectly still. This is a major problem and it is in stark contrast to the doctor's assessment in which the clinician often requires the patient to bend or flex the joint in an attempt to reproduce and localize the pain. Thus, most often the pain a patient feels in a joint actually occurs while moving, not while lying still during an MRI or x-ray procedure.

So the fundamental basis for this new research initiative is quite simple — to combine the MRI and x-ray data with patient's motion and report the movements of the bones while the patient is actually moving, thus creating a set of 3-D dynamic motion images that can be viewed from any perspective. The potential for this information in its practical application to orthopaedic surgery is limitless. "We will start with simple motion such as walking (hence the title, *A Step Into the Future*) and then progress into more dynamic motions. But this project offers a unique opportunity to investigate numerous research questions that are persistently plaguing the orthopaedic practice," remarks Dr. Torry.

This new development will also allow for collaboration with such noted researchers as Dr. Savio Woo at the University of Pittsburgh, and it will allow us to compete at the top tier for National Institutes of Health and National Science Foundation grants.

EDUCATION

The Foundation currently maintains a network of more than 130 Fellows who share advanced ideas and inspire each other to higher levels. We are fortunate in Vail to work with the best and the brightest young physicians in the world. Their insight and enthusiasm during this rewarding program has demonstrated to us many times over that we, too, learn as we teach.

Richard J. Hawkins, M.D.; Greta Campanale, coordinator; Dina Proietti, assistant

The Foundation's primary mission is to conduct research that can be applied directly to orthopaedic medicine. To this end, education is also an important part of our work. We offer training throughout the year to physicians in residence, visiting medical personnel, and participants at international medical meetings. In addition, the Education Department produces videotapes and educational programs on the Internet. Members of the staff report their research through publications, presentations and posters. The Education Department provides administrative support for educational programs and conferences, responds to the press, and teaches high school students about human anatomy and injury.

FELLOWSHIP PROGRAM: Learning As We Teach

Considered one of the most prominent and rigorous academic fellowship programs in orthopaedics, the Steadman-Hawkins Fellowship Program is at the core of the Foundation's educational effort. Each year, six young orthopaedic surgeons are chosen from more than 100 candidates to become Steadman-Hawkins Fellows. They are with us for an intensive 12-month training period to refine their skills in orthopaedic surgery and to investigate the causes, prevention, and cures of degenerative arthritis as well as the treatment and prevention of injuries. Our goal is to prepare our Fellows to be the leaders in the field of orthopaedic medicine for the remainder of their careers.

The Foundation currently maintains a network of more than 130 Fellows who share advanced ideas and inspire each other to higher levels. We are fortunate in Vail to work with the best and the brightest young physicians in the world. Their insight and enthusiasm during this rewarding program has demonstrated to us many times over that we, too, learn as we teach.

2004-05 FELLOWS

The six new fellowship surgeons spend their year refining skills and learning new surgical techniques, as well as participating in research with Foundation scientists. Each Fellow has the opportunity to be actively involved in Clinical Research, Basic Science, and Biomechanics Research. They also experience hands-on medical coverage of major league baseball's Colorado Rockies, the NFL's Denver Broncos, The U.S. Ski Team, and Eagle County High School sports teams.

The stream of knowledge and information flows both ways. The Fellows, having completed their formal training in leading orthopaedic programs, share knowledge they have gained from years of training with the physicians and scientists of the Foundation.

Kevin Crawford, M.D.

Dr. Crawford attended Baylor University as an undergraduate student of biology. He continued his studies at the University of Texas Southwestern Medical School to earn his medical degree and was named to the Alpha Omega Alpha Medical Honor Society. He completed his orthopaedic residency at the University of Texas Southwestern Medical Center. Dr. Crawford has been practicing with Lubbock Sports Medicine Associates in Texas.

Reaching Out to the World

The Foundation's research findings are shared with physicians and scientists around the world. We offer training throughout the year to physicians-in-residence, visiting medical personnel, and participants at the international medical conferences we host.

To reach professionals who are unable to come to us, Foundation scientists and physicians report their research worldwide through peer-reviewed publications and presentations. We have produced more than 400 papers, 1,000 presentations, and 60 teaching videos—many award winning—that have been accepted by medical and scientific journals and organizations worldwide.

We disseminate our findings to the general public and school students as well, through videotapes, educational programs, the Internet, and media outlets.

Where are they now. . .

The graduating class of 2003/2004 Steadman-Hawkins Fellows are busy establishing new careers in orthopaedics.

Timothy Bollom, M.D., joined the Orthopaedic and Neurosurgical Center of the Cascades in Bend, Oregon.

Andrew Chen, M.D., is practicing at the Littleton Orthopaedics in Littleton, New Hampshire.

Doug Lowery, M.D., moved to Evansville, Indiana, and is practicing with the Orthopaedic Associates.

Charles May, M.D., joined the Orthopaedic & Sports Medicine Center of Northwest Georgia in Rome, Georgia.

Arun Ramappa, M.D., is a member of the faculty at Harvard and a sports medicine physician at Beth Israel Deaconess Medical Center.

Michael Terry, M.D., returned to the University of Chicago to practice medicine as Assistant Professor of Surgery and Sports Medicine.

Drs. J. Richard Steadman, William I. Sterett, and Richard J. Hawkins with 2004/2005 fellows. Front, left to right: Austin Yeargan, M.D.; Kevin Crawford, M.D.; Sanjitpal Gill, M.D.; Jason L. Dragoo, M.D.; R. Matthew Dumigan, M.D.; and Allston J. Stubbs, M.D.

He is currently a member of several organizations, including the American Orthopaedic Society for Sports Medicine and the American Academy of Orthopaedic Surgery.

Jason L. Dragoo, M.D.

Dr. Dragoo graduated summa cum laude from Cal Poly State University with a degree in biological sciences/sports medicine and then studied medicine at the University of Arizona Medical School, where he was named Top Medical Student by the University of Arizona Foundation. He completed his residency in orthopaedic surgery at the University of California, Los Angeles. Dr. Dragoo has received numerous awards for his work in basic science and clinical research. He has been published in the *Journal of Bone and Joint Surgery, American Journal of Sports Medicine, Arthroscopy,* and *Tissue Engineering.*

Matthew Dumigan, M.D.

Dr. Dumigan graduated magna cum laude from Louisiana State University, where he earned a degree in microbiology. He continued his studies at Louisiana State University School of Medicine and was named to the Alpha Omega Alpha National Honor Medical Society. He received the award for outstanding student in orthopaedic surgery and graduated fourth in his class. Dr. Dumigan completed his residency in orthopaedic surgery at the University of Texas Southwestern Medical Center in Dallas.

Sanjitpal (Sonny) Gill, M.D.

Dr. Gill graduated summa cum laude from Boston University with a degree in medical science. He attended Boston University School of Medicine and graduated cum laude. He completed his residency in orthopaedic surgery at the University of

Virginia in Charlottesville. Dr. Gill has won numerous research awards, including the 2003 Albert Trillat Young Investigator's Award by the International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine Committee. He has presented his research at numerous forums and has been published in journals such as *Arthroscopy* and *Journal of Bone and Joint Surgery*. He recently completed a prestigious spine fellowship at Emory University.

Allston J. Stubbs, M.D.

Dr. Stubbs earned an undergraduate degree in biology and a master of business administration in finance/biotechnology at the University of North Carolina. He continued his studies at the Duke University School of Medicine. Dr. Stubbs completed his orthopaedic residency at Duke University Medical Center, where he was awarded the Herodicus Society Award for Orthopaedic Research in 2002.

S. Austin Yeargan, M.D.

Dr. Yeargan studied chemistry as an undergraduate at the University of North Carolina at Chapel Hill. He attended medical school at the East Carolina University School of Medicine, where he was named to the Alpha Omega Alpha National Honor Medical Society. Dr. Yeargan completed his orthopaedic residency at the John A. Burns School of Medicine at the University of Hawaii.

Foundation Ranks First in Production of Scientific Journal Publications

By Mininder S. Kocher, M.D., M.P.H.

Editor's Note: Dr. Kocher, a former Steadman-Hawkins Fellow, is a member of the Scientific Advisory Committee of the Steadman◆Hawkins Research Foundation. He is an Assistant Professor of Orthopaedic Surgery at Harvard Medical School/Harvard School of Public Health, the Assistant Director of the Division of Sports Medicine at Children's Hospital Boston, and the Director of the Clinical Effectiveness Research Unit at Children's Hospital Boston.

Academic medicine has three primary focuses: patient care, research, and teaching. The benchmark for performance in medical research is publication in major medical journals. The number of publications in major medical journals is a primary consideration in assessing the strength of an academic department or organization and in the promotion of an academic physician.

The three major medical journals in orthopaedic sports medicine are the *Journal of Bone and Joint Surgery*, the *American Journal of Sports Medicine*, and *Arthroscopy*. The Steadman◆Hawkins Research Foundation tracked its number of publications in these three journals from 2002 through 2004 and compared the results to four other top academic sports medicine programs: The Cleveland Clinic, The Hospital for Special Surgery in New York City, The University of Pittsburgh, and Methodist Sports Medicine in Indianapolis (see Table). The Steadman◆Hawkins Research Foundation ranked first in number of publications in these three major medical journals.

Medical journals disseminate state-of-the-art research findings to physicians. Physicians may change the way they treat patients based on articles in medical journals. The process of publication in major medical journals is very rigorous. After a research study has been completed and presented at major medical meetings, the study is written as a scientific manuscript. The manuscript conforms to a standardized style: introduction, methods, results, discussion, references, and figures. The manuscript is then submitted to a medical journal. The editors of the medical journal review the manuscript and send it to three or more experts for review. This peer review process is the key in ensuring quality research. The reviewers are "blinded" to the identity of the authors and the authors are blinded to the identity of the reviewers. The editors of the journal consider the reviewers' comments and either reject or accept the manuscript. Once accepted, the manuscript undergoes several revisions based on comments and suggestions from the editors and reviewers.

Such benchmarking in terms of number of publications in major medical journals is very important in assessing the quality and quantity of medical research produced by an academic department or organization. In addition to the superior educational strength of the Fellowship Program, the Steadman◆Hawkins Research Foundation is the leader among academic sports medicine programs in terms of quality and quantity of research publications.

Knee and Shoulder Publications: 2002 - 2004

	Journal of Bone and Joint Surgery	American Journal of Sports Medicine	Arthroscopy	Total
Steadman◆Hawkins Research Foundation	2	8	2	**12**
Cleveland Clinic	1	2		**3**
University of Pittsburgh	1	3	2	**6**
Hospital for Special Surgery, New York City	2	4	4	**10**
Methodist Sports Medicine, Indianapolis	1	6	1	**8**

PRESENTATIONS AND PUBLICATIONS

A primary goal of the Foundation is to distribute the results of its research. In 2004, principal investigators and Fellows published 28 papers in scientific and medical journals and delivered 136 presentations to a variety of professional and lay audiences worldwide.

2004 PRESENTATIONS

Briggs, K.K., M.P.H., M.B.A.; Steadman, J.R., M.D.; Wing, D.; O'Brien, T., M.D.:
"Factors Associated with Disability and Activity in Patients Seeking Care for Osteoarthritis," Poster Presentation, *American Academy of Orthopaedic Surgeons 71st Annual Meeting*, San Francisco, Calif., March 2004. [1st Place Rehabilitation Section Poster]

Briggs, K.K., M.P.H., M.B.A.; Cameron, M.L., M.D.; Steadman, J.R., M.D.:
"The Prevalence of Severe Chondral Damage in Patients with ACL Deficiency," Poster Presentation, *American Orthopaedic Society for Sports Medicine Annual Meeting,* Quebec City, Canada, June 2004.

Corenman, D.S., M.D., D.C.:
"The Biomechanics of the Spine," *2003-04 Steadman-Hawkins Orthopaedics and Spine Lecture Series,* Vail, Colo., May 10, 2004.

Farley, T.D., M.D.; Sterett, W.I., M.D.; Dennett, C., A.T.C.; Briggs, K.K., M.P.H., M.B.A.; Steadman, J.R., M.D.:
"Functional Bracing in Preventing Injury in ACL Reconstructed Professional Skiers," *American Academy of Orthopaedic Surgeons 71st Annual Meeting*, San Francisco, Calif., March 2004.

Farley, T.D., M.D.; Sterett, W.I., M.D.; Briggs, K.K., M.P.H., M.B.A.; Dennett, C., A.T.C; Steadman, J.R., M.D.:
"Functional Bracing in Preventing Injury in ACL Reconstructed Professional Skiers," *American Orthopaedic Society for Sports Medicine Specialty Day*, San Francisco, Calif., March 2004.

Folk, J.W., M.D.:
"Knee Injuries, Anatomic Considerations; Cadaveric Knee Dissection," *Keystone Ski Patrol*, Keystone, Colo., March 2004.

"Knee Injuries, Anatomic Considerations; Cadaveric Knee Dissection," *Breckenridge Ski Patrol*, Breckenridge, Colo., March 2004.

"Evaluation and Treatment of Foot and Ankle Injuries," *2003-04 Steadman-Hawkins Orthopaedics and Spine Lecture Series*, Vail, Colo., March 3, 2004.

"Knee Injuries, Anatomic Considerations; Cadaveric Knee Dissection," *Eagle County EMT Association*, Edwards, Colo., April 2004.

"Non-operative Management of the Arthritic Knee," *Steadman◆Hawkins Sports Medicine Foundation Symposium*, Vail, Colo., August 23, 2004.

"Non-operative Management of the Arthritic Knee," *Steadman◆Hawkins Sports Medicine Foundation Symposium*, Keystone, Colo., September 1, 2004.

"Complementary and Alternative Medicine; Ergogenic Aids," *Steadman◆Hawkins Sports Medicine Foundation Symposium*, Keystone, Colo., September 2004.

"Evaluation and Treatment of Lower Extremity Injuries," *Keystone Ski Patrol Annual Medical Update*, Keystone, Colo., October 2004.

Hawkins, R.J., M.D., F.R.C.S. (C):
"The Complex Shoulder," Up Close and Personal: Scientific Program, *American Academy of Orthopaedic Surgeons 71st Annual Meeting*, San Francisco, Calif., March 10, 2004.

"The Principles and Techniques of Heat Application for Shoulder Instability with and without Plication," Moderator, ICL 229 Open and Arthroscopic Instability Repairs, *American Academy of Orthopaedic Surgeons 71st Annual Meeting*, San Francisco, Calif., March 10, 2004.

"Treatment of Failures after Instability Repair," *ReFixation Update*, Munster, Germany, March 25-27, 2004.

"Complications in Shoulder Arthroplasty," *ReFixation Update*, Munster, Germany, March 25-27, 2004.

"Partial Cuff Tears," *ReFixation Update*, Munster, Germany, March 25-27, 2004.

"Update on Instability," *22nd Annual Mid-America Orthopaedic Association*, La Quinta, Calif., April 14-18, 2004.

"Biceps Update," *Southern Orthopaedic Specialists Current Concepts in Shoulder and Knee Disorders*, Stockbridge, Ga., April 29, 2004.

"Massive Rotator Cuff Tears," *Southern Orthopaedic Specialists Current Concepts in Shoulder and Knee Disorders*, Stockbridge, Ga., April 29, 2004.

"Shoulder Instability in the NFL Athlete," *NFL Coaches Career Development*, Orlando, Fla., May 11, 2004.

"Examination of the Shoulder," *18th Annual Advances on the Knee and Shoulder Conference*, Cincinnati, Ohio, May 25, 2004.

"Comprehensive Examination of the Shoulder. A breakout session," *19th Annual Advances on the Knee and Shoulder Conference*, Cincinnati, Ohio, May 30, 2004.

"Internal Impingement," *19th Annual Advances on the Knee and Shoulder Conference*, Cincinnati, Ohio, May 30, 2004.

"Methods of Treatment for the Irreparable Rotator Cuff," *19th Annual Advances on the Knee and Shoulder Conference*, Cincinnati, Ohio, May 30, 2004.

"Examination of the Shoulder. A breakout session," *19th Annual Advances on the Knee and Shoulder Conference*, Cincinnati, Ohio, May 30, 2004.

"Arthroscopic Treatment of Rotator Cuff Tears. A breakout session," *19th Annual Advances on the Knee and Shoulder Conference*, Cincinnati, Ohio, May 30, 2004.

"Arthroscopic Knot Tying and Suture Passing Laboratory. A breakout session," *19th Annual Advances on the Knee and Shoulder Conference*, Cincinnati, Ohio, May 30, 2004.

"Open Treatment of Posterior Shoulder Instability," *19th Annual Advances on the Knee and Shoulder Conference*, Cincinnati, Ohio, May 26, 2004.

"Advances in Arthroscopic Shoulder Procedures. A breakout session," *19th Annual Advances on the Knee and Shoulder Conference*, Cincinnati, Ohio, May 26, 2004.

"Update on Rotator Cuff Disease," *IOC Grand Rounds*, Chicago, Ill., September 8-9, 2004.

"Update on Instability Classification," *American Orthopaedic Society for Sports Medicine Surgical Skills Course, Advanced Surgery for the Athlete's Shoulder*, Chicago, Ill., September 17-19, 2004.

"Open Posterior Shoulder Stabilization," *American Orthopaedic Society for Sports Medicine Surgical Skills Course, Advanced Surgery for the Athlete's Shoulder*, Chicago, Ill., September 17-19, 2004.

"Open Bankart Demonstration," *American Orthopaedic Society for Sports Medicine Surgical Skills Course, Advanced Surgery for the Athlete's Shoulder*, Chicago, Ill., September 17-19, 2004.

"Arthroscopic Anterior Instability Repair: Current Concepts," *University of Calgary Shoulder & Elbow Course,* Calgary, Alberta, Canada, September 23-26, 2004.

"Hemi-arthroplasty for Fractures: Tuberosities and Technique," *University of Calgary Shoulder and Elbow Course*, Calgary, Alberta, Canada, September 23-26, 2004.

"Humeral Head Replacement," *Mini-Debate, American Shoulder and Elbow Surgeons Biennial Meeting*, Monterey, Calif., October 14-17, 2004.

"Clavicle Fractures, Malunions and Non-unions," *American Shoulder and Elbow Surgeons Biennial Meeting*, Monterey, Calif., October 14-17, 2004.

"Thermal Capsulorrhaphy: Why, When and How," *American Shoulder and Elbow Surgeons Biennial Meeting*, Monterey, Calif., October 14-17, 2004.

"Rehabilitation of the Athlete's Shoulder," *American Shoulder and Elbow Surgeons Biennial Meeting*, Monterey, Calif., October 14-17, 2004.

Hummel, S.A., M.S.; Yanagawa, T., M.A.; Shelburne, K.B., Ph.D.; Hawkins, R.J., M.D.; Tokish, J.T., M.D.; Torry, M.R., Ph.D.:
"In Vivo 3D Measurement of the Clavicle, Scapula and Humerus Motion during Shoulder Abduction and Flexion," *51st American College of Sports Medicine Meeting*, Indianapolis, Ind., June 2004.

Karli, D.C., M.D.:
"The Role of Spine Injections in Diagnosis and Treatment," *2003-04 Steadman-Hawkins Orthopaedics and Spine Lecture Series*, Vail, Colo., January 12, 2004.

O'Holleran, J.D., M.D.; Kocher, M.S., M.P.H., M.D.; Horan, M.P.; Zurakowski, D.; Briggs, K.K., M.P.H., M.B.A.; Hawkins, R.J., M.D.:
"Predictors of Satisfaction with Outcome after Anterior Shoulder Surgery," *Poster Presentation, American Academy of Orthopaedic Surgeons 71st Annual Meeting*, San Francisco, Calif., March 2004.

O'Holleran, J.D., M.D.; Kocher, M.S., M.P.H., M.D.; Horan, M.P.; Zurakowski, D.; Briggs, K.K., M.P.H., M.B.A.; Hawkins, R.J., M.D.:
"Predictors of Satisfaction with Outcome after Anterior Shoulder Surgery," *Poster Presentation, American Orthopaedic Society for Sports Medicine Annual Meeting*, Quebec City, Canada, June 24, 2004.

Kocher, M.S., M.P.H., M.D.; Horan, M.P.; Briggs, K.K., M.P.H., M.B.A.; Richardson, T.R.; O'Holleran, J.D., M.D.; Hawkins, R.J., M.D.:
"Reliability, Validity, and Responsiveness of the American Shoulder and Elbow Surgeons Shoulder Scale in Patients with Shoulder Instability, Rotator Cuff Disease, and Glenohumeral Arthritis," *Poster Presentation, American Orthopaedic Society for Sports Medicine Annual Meeting*, Quebec City, Canada, June 24, 2004.

Noonan, T.J., M.D.:
"The Diagnosis and Management of Ulnar Collateral Ligament Injuries of the Elbow," *Injury Prevention and Treatment Techniques Baseball Medicine Conference,* Baltimore, Md., January 2004.

"Shoulder Injuries in the Overhead Athlete," *Steadman-Hawkins Clinic Denver Symposium on Injuries of the Shoulder and Elbow in the Throwing Athlete*, Denver, Colo., February 2004.

"Degenerative Biceps Lesions in Throwing Athletes," *Professional Baseball Athletic Trainers Society Spring Meeting*, Tucson, Ariz., March 2004.

"The Diagnosis and Treatment of Ulnar Collateral Ligament Injuries of the Elbow," *Combined Meeting of the Rocky Mountain and Western Slope Chapters of the Western Orthopaedic Association Annual Summer Meeting*, Avon, Colo., August 6-7, 2004.

"Rib Stress Fractures in a Professional Baseball Pitcher," *Major League Baseball Team Physicians Association Annual Meeting*, Anaheim, Calif., December 2004.

Pandy, M.G., Ph.D.; Shelburne, K.B., Ph.D.; Torry, M.R., Ph.D.:
"Model Simulations of Load Bearing at the Knee During Walking," *Biomedical Engineering Society Annual Meeting*, Philadelphia, Pa., October 13-16, 2004.

Goodwin, C.; Pandy, M.G., Ph.D.; Yanagawa, T., M.A.; Shelburne, K.B., Ph.D.; Torry, M.R., Ph.D.; Maitland, M.; Frankle, M.:
"Computation of Muscle and Joint Reaction Forces at the Shoulder During Forward Flexion," *6th International Symposium on Computer Methods in Biomechanics and Biomedical Engineering*, Madrid, Spain, February 21-26, 2004.

Ramappa, A.J., M.D.; Wilson, D.R.; Apreleva, M.; Harrold, F.; Fitzgibbons, P.J.; Gill, T.J., M.D.:
"The Effects of Medialization and Anteromedialization of the Tibial Tubercle on Patellofemoral Mechanics and Kinematics," *Poster Presentation, American Academy of Orthopaedic Surgeons 71st Annual Meeting, Scientific Session*, San Francisco, Calif., March 2004.

Yian, E., M.D.; Ramappa, A.J., M.D.; Gerber, C., M.D.:
"The Constant Score in Normal Shoulders," *Poster Presentation, American Academy of Orthopaedic Surgeons 71st Annual Meeting, Scientific Session,* San Francisco, Calif., March 2004.

Ramappa, A.J., M.D.; Gill, T.J., M.D.; Briggs, K.K., M.P.H., M.B.A.; Buckley, K., M.D.; Ho, C., M.D., Ph.D.; Steadman, J.R., M.D.:
"The Use of MRI to Assess Knee Cartilage Repair Tissue after Microfracture of Chondral Defects," *Podium Presentation, American Academy of Orthopaedic Surgeons 71st Annual Meeting, Scientific Session*, San Francisco, Calif., March 2004.

Ramappa, A.J., M.D.; McFarland, E.; Richardson, T.R.; Briggs, K.K., M.P.H., M.B.A.; Hawkins, R.J., M.D.:
"Clinical Features and Associated Pathologies of Type III and Type IV SLAP Lesions," *Poster Presentation, Arthroscopy Association of North America 2004 Annual Meeting*, Orlando, Fla., April 2004.

Ramappa, A.J., M.D.; McFarland, E., M.D.; Richardson, T.R.; Briggs, K.K., M.P.H., M.B.A.; Hawkins, R.J., M.D.:
"Clinical Features and Associated Pathologies of Type III and Type IV SLAP Lesions," *Poster Presentation, 9th International Congress on Surgery of the Shoulder,* Washington, D.C., May 2004.

Yian, E.H.; Werner, C., M.D.; Nyffeler, R., M.D.; Ramappa, A.J., M.D.; Pfierrman, C.; Gerber, C., M.D.:
"Glenoid Loosening in Total Shoulder Replacement," *Proceedings of the 9th International Congress on Surgery of the Shoulder*, Washington, D.C., May 2004.

Ramappa, A.J., M.D.; Steadman, J.R., M.D.; Bollom, T.S., M.D.; Briggs K.K., M.P.H., M.B.A.; Rodkey, W.G., D.V.M.:
"Kellgren-Lawrence (K-L) Scores and Arthroscopic Findings in the Degenerative Knee," *Poster Presentation, 5th International Cartilage Repair Society Symposium*, Ghent, Belgium, May 2004.

Ramappa, A.J., M.D.; Gill, T.J., M.D.; Bradford, C., M.D.; Briggs, K.K., M.P.H., M.B.A.; Ho, C., M.D., Ph.D.; Steadman J.R., M.D.:
"The Use of MRI to Assess Knee Cartilage Repair Tissue after Microfracture of Chondral Defects," *Podium Presentation, American Orthopaedic Society for Sports Medicine 2004 Annual Meeting, Scientific Session*, Quebec City, Canada, June 2004.

Rodkey, W.G., D.V.M.:
"The Surgical Treatment of Articular Cartilage Defects of the Knee: Microfracture Technique," *American Academy of Orthopaedic Surgeons 71st Annual Meeting, Instructional Course*, San Francisco, Calif., March 10-14, 2004.

"Collagen Meniscus Implants: Observations and Questions," *Biology of the Meniscus Specialty Group, in conjunction with the American Academy of Orthopaedic Surgeons 71st Annual Meeting*, San Francisco, Calif., March 10-14, 2004.

"Articular Cartilage: Basic Science and Rationale for Chondral Resurfacing," *Invited Presidential Guest Lecturer. 10th Brazilian Congress of Knee Surgery and 11th Brazilian Congress of Arthroscopy*, Iguassu Falls, Brazil, April 14-17, 2004.

"Collagen Meniscus Implants (CMI): A New Device to Reconstruct the Damaged Meniscus," *Invited Presidential Guest Lecturer. 10th Brazilian Congress of Knee Surgery and 11th Brazilian Congress of Arthroscopy*, Iguassu Falls, Brazil, April 14-17, 2004.

"Future of Meniscus Surgery: Repair, Regeneration, or Replacement," *Invited Presidential Guest Lecturer, 10th Brazilian Congress of Knee Surgery and 11th Brazilian Congress of Arthroscopy*, Iguassu Falls, Brazil, April 14-17, 2004.

"Tendinosis and Tendinitis: Pathophysiology and Etiologic Factors," *Invited Presidential Guest Lecturer, 10th Brazilian Congress of Knee Surgery and 11th Brazilian Congress of Arthroscopy*, Iguassu Falls, Brazil, April 14-17, 2004.

"Biology of the Healing ACL Graft: Implications of Rehabilitation on Graft Remodeling," *11th European Society of Sports Traumatology, Knee Surgery and Arthroscopy; and 4th World Congress on Sports Trauma*, Athens, Greece, May 5-8, 2004.

"Thermal Modification of Connective Tissue: Basic Science Facts You Need to Know," *11th European Society of Sports Traumatology, Knee Surgery and Arthroscopy; and 4th World Congress on Sports Trauma*, Athens, Greece, May 5-8, 2004.

"Correlation Between Kelgren-Lawrence Scores, Chondral Degeneration, and Meniscal Pathology in the Degenerative Knee," *International Cartilage Repair Society,* Ghent, Belgium, May 26-29, 2004.

"Why the Healing Response Technique Works: Basic Science," ACL Study Group, Sardinia, Italy, May 29, 2004 and June 2004.

"A Minimally Invasive Technique (Healing Response) to Treat Proximal ACL Injuries in the Skeletally Immature Patient," *American Orthopaedic Society for Sports Medicine Annual Meeting*, Quebec City, Canada, June 24-27, 2004.

"A Less Invasive Alternative to ACL Reconstruction: The Healing Response Technique," *IV Congresso Internacional de las Ciencias del Fútbol (The Sciences of Football)*, Real Madrid Football City, Las Rozas, Madrid, Spain, September 16-18, 2004.

"Collagen Meniscus Implants (CMI): A Resorbable Device to Reconstruct Damaged Menisci," *IV Congresso Internacional de las Ciencias del Fútbol (The Sciences of Football)*, Real Madrid Football City, Las Rozas, Madrid, Spain, September 16-18, 2004.

"Treatment of Patellar Tendinosis and Tendinitis in Professional Athletes," *IV Congresso Internacional de las Ciencias del Fútbol (The Sciences of Football)*, Real Madrid Football City, Las Rozas, Madrid, Spain, September 16-18, 2004.

"Microfracture Technique to Treat Full-thickness Chondral Defects: Rationale, Surgical Technique, Clinical Outcomes, and Ongoing Research," *Visiting Professor, Grand Rounds, University of Florida Department of Orthopaedics and Rehabilitation*, Gainesville, Fla., October 1, 2004.

Rudman, D.P., M.D.; Schlegel, T.F., M.D.; Boublik, M., M.D.; Hawkins, R.J., M.D.; Keller J., A.T.C.; Antonopulos, S., A.T.C.:
"Elbow Dislocations in the NFL: Epidemiology, Treatment Trends and Criteria for Early Return to Play," *National Football League Physicians Society Annual Sports Science Symposium*, Indianapolis, Ind., February 20, 2004.

Rudman, D.P., M.D.; Schlegel, T.F., M.D.; Boublik, M., M.D.; Hawkins, R.J., M.D.; Keller, J., A.T.C.; Antonopulos, S., A.T.C.:
"On Field Evaluation and Treatment of Cervical Spine Injuries," *National Football League Physicians Society Annual Sports Science Symposium*, Indianapolis, Ind., February 20, 2004.

Schlegel, T.F., M.D.:
"Treatment of Acromioclavicular Separations in Overhead Throwing Athletes," *Shoulder and Elbow Injuries in the Throwing Athlete*, Englewood, Colo., February 7, 2004.

"Shoulder Instability in the NFL Athlete," *NFL Owner's Meeting*, Palm Beach, Fla., March 29, 2004.

"Advancements in Rotator Cuff Repair Technology," *Orthopedic Grand Rounds, New England Baptist Hospital,* Boston, Mass., April 14, 2004.

"The AutoCuff System — Basic Science Research," *Advanced Shoulder Technology Meeting*, Hilton Head Island, S.C., May 21-23, 2004.

"Basic Science of Tendon Healing," *Advanced Shoulder Technology Meeting*, Hilton Head Island, S.C., May 21-23, 2004.

"New Advances in Rotator Cuff Technology," *Grand Rapids Orthopaedic Surgery Residency Annual Alumni Conference*, Grand Rapids, Mich., June 4, 2004.

"Transition from Mini-Open to Totally Arthroscopic Rotator Cuff Repair," *Orthopaedic Surgery Residency Annual Alumni Conference*, Grand Rapids, Mich., June 4, 2004.

McFarlund, E.G., M.D.; Saffer, D.; Schlegel, T.F., M.D.:
"The Biceps, the Cuff Interval and Partial Subscapularis Tears: Controversies and Solutions," *Instructional Course. The American Orthopaedic Society for Sports Medicine 2004 Annual Meeting*, Quebec City, Canada, June 24-27, 2004.

Shelburne, K.B., Ph.D.:
"Exploring Knee Mechanics with Musculoskeletal Modeling," *Keynote, 51st Annual Meeting of the American College of Sports Medicine*, Indianapolis, Ind., 2004.

Shelburne, K.B., Ph.D.; Pandy, M.G., Ph.D.; Yanagawa, T., M.A.; Torry, M.R., Ph.D.:
"Model Predictions of Tibiofemoral Compartmental Loading in Normal Gait," *50th Annual Meeting of the Orthopaedic Research Society*, San Francisco, Calif., 2004.

Steadman, J.R., M.D.:
"The Role of Microfracture in the Treatment of Degenerative Knee," *International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine*, Napa, Calif., March 9, 2004.

"ACL Reconstruction with Patellar Tendon," *Clinical Counterpoints: New Techniques and Controversies in Orthopaedic Surgery and Pain Management*, San Francisco, Calif., March 2004.

"Microfracture," *Arthroscopy Association of North America Specialty Day*, San Francisco, Calif., March 2004.

"Articular Cartilage Injury in the Athlete: Treatment Options in 2004," *American Academy of Orthopaedic Surgeons 71st Annual Meeting, Instructional Course*, San Francisco, Calif., March 2004.

Steadman, J.R., M.D.; Cameron, M.L., M.D.; Briggs, K.K., M.P.H., M.B.A.; Rodkey, W., D.V.M.:
"The Healing Response Technique to Treat Proximal ACL Injuries in the Skeletally Immature Patient," *Poster Presentation, American Academy of Orthopaedic Surgeons 71st Annual Meeting*, San Francisco, Calif., March 2004.

"Patellar Tendinosis and Tendinitis," *10th Brazilian Congress of Knee Surgery and 11th Brazilian Congress of Arthroscopy*, Iguassu Falls, Brazil, April 14-17, 2004.

"Treatment of Degenerative Joint Disease of the Knee: Methods to Delay TKA," *10th Brazilian Congress of Knee Surgery and 11th Brazilian Congress of Arthroscopy*, Iguassu Falls, Brazil, April 14-17, 2004.

"The Healing Response Technique," *10th Brazilian Congress of Knee Surgery and 11th Brazilian Congress of Arthroscopy*, Iguassu Falls, Brazil, April 14-17, 2004.

"The Microfracture Technique to Treat Full Thickness Chondral Defects in Athletes," *10th Brazilian Congress of Knee Surgery and 11th Brazilian Congress of Arthroscopy*, Iguassu Falls, Brazil, April 14-17, 2004.

"ACL Reconstruction in the Professional Athlete," *10th Brazilian Congress of Knee Surgery and 11th Brazilian Congress of Arthroscopy*, Iguassu Falls, Brazil, April 14-17, 2004.

"Update on U.S. Clinical Trials of the Collagen Meniscus Implant," *11th European Society of Sports Traumatology Knee Surgery and Arthroscopy Congress, CMI Symposium*, Athens, Greece, May 2004.

"Microfracture," *11th European Society of Sports Traumatology Knee Surgery and Arthroscopy Congress*, Athens, Greece, May 2004.

"Conservative Treatment of Post Meniscectomy Early Arthritic Knee," *11th European Society of Sports Traumatology Knee Surgery and Arthroscopy Congress Instructional Course Lecture*, Athens, Greece, May 2004.

"Why I Use Patellar Tendon Graft for ACL Reconstruction in High-Competitive Athletes," *11th European Society of Sports Traumatology Knee Surgery and Arthroscopy Congress*, Athens, Greece, May 2004.

"Personal Philosophy and Experience of Rehabilitation after Surgical Repair or Regeneration of the Meniscus," *11th European Society of Sports Traumatology Knee Surgery and Arthroscopy Congress, CMI Panel Meeting*, Athens, Greece, May 2004.

"Partial Tears of the ACL in Young Athletes," *Moderator, Round Table. ACL Study Group Meeting*, Sardinia, Italy, June 2004.

"Why Partial ACL Tears Are a Problem," *Round Table. ACL Study Group Meeting*, Sardinia, Italy, June 2004.

"Healing Response: Philosophy and Experience," *Round Table. ACL Study Group Meeting*, Sardinia, Italy, June 2004.

Steadman, J.R., M.D.; Cameron, M.L., M.D.; Briggs, K.K., M.P.H., M.B.A.; Rodkey, W., D.V.M.:
"The Healing Response Technique to Treat Proximal ACL Injuries in the Skeletally Immature Patient," P*oster Presentation, American Orthopaedic Society for Sports Medicine Annual Meeting*, Quebec City, Canada, June 2004.

"Arthroscopy in the Degenerative Knee," *Current Issues of MRI 13th Annual Meeting 2004*, San Francisco, Calif., August 2004.

"Microfracture—Patient Selection and Indications," *Orthopaedics Today Update Course*, New York, N.Y., November 2004.

"Microfracture—Technique and Results," *Orthopaedics Today Update Course*, New York, N.Y., November 2004.

"Microfracture—Rehabilitation and Patient Compliance," *Orthopaedics Today Update Course*, New York, N.Y., November 2004.

"Current Non-Operative Approaches," Panel Discussion.*Orthopaedics Today Update Course*, New York, N.Y., November 2004.

"ACL Rehabilitation and Outcomes," *Orthopaedics Today Update Course*, New York, N.Y., November 2004.

"Role of Unloader Brace and Osteotomy in Active Patient with DJD," *Orthopaedics Today Update Course*, New York, N.Y., November 2004.

Sterett, W.I., M.D.:
"Chondral Lesions in Patients Treated with Microfracture and Medial Opening Wedge HTO," *Poster Presentation. American Academy of Orthopaedic Surgeons 71st Annual Meeting*, San Francisco, Calif., March 11, 2004.

"Determining Composite Likelihood Ratios in Prediction of Meniscal Tears," *Poster Presentation. American Academy of Orthopaedic Surgeons 71st Annual Meeting*, San Francisco, Calif., March 11, 2004.

"Complication Rates Following High Tibial Osteotomy," *Poster Presentation. American Academy of Orthopaedic Surgeons 71st Annual Meeting*, San Francisco, Calif., March 11, 2004.

"Determinants of Patient Satisfaction and Outcome after Medial Opening Wedge High Tibial Osteotomy," *American Academy of Orthopaedic Surgeons 71st Annual Meeting*, San Francisco, Calif., March 11, 2004.

"Partial Knee Replacement, HTO, and Other Joint Preservation Techniques," *2003-04 Steadman-Hawkins Orthopaedics and Spine Lecture Series*, Vail, Colo., April 12, 2004.

"Combined ACL/HTO for the ACL Deficient Varus Degenerative Knee," *Poster Presentation. Arthroscopy Association of North America 23rd Annual Meeting*, Orlando, Fla., April 23-25, 2004.

"Osteotomies Around the Knee," *American Orthopaedic Society for Sports Medicine 2004 Annual Meeting*, Quebec City, Canada, June 24-27, 2004.

"Joint Preservation Techniques," *Flying Physicians Meeting*, Vail, Colo., July 7, 2004.

"Determining Positive Predictive Values in the Prediction of Meniscal Tears Based on Patient Exams; Effect of Functional Bracing on ACL-r Skiers," *Western Orthopaedic Association Annual Meeting*, San Francisco, Calif., September 29-October 2, 2004.

"Winter Sports Orthopaedic Traumatic Injuries—Common/Uncommon," *Ski and Snowboard Medical Emergencies CME Course*, Beaver Creek, Colo., November 27-December 5, 2004.

Strauch, E., PA-C:
"Evaluation and Treatment of Thoracolumbar Fractures," *2004-05 Steadman-Hawkins Orthopaedics and Spine Lecture Series*, Vail, Colo., November 8, 2004.

"Clearance of the Cervical Spine," *Vail Valley Medical Center Journal Club CME Course*, Vail, Colo., November 16, 2004.

Kelly, B.T., M.D.; Turner, A.S., D.V.M.; Bansal, M.; Terry, M.A., M.D.; Deng, X.H., M.D.; Warren, R.F., M.D.; Allen, A.A.; Altchek, D.W., M.D.:
"In vivo Healing Response after Capsular Placation in the Bovine Shoulder Model," *Orthopaedic Research Society Annual Meeting,* San Francisco, Calif., March 7-10, 2004.

"Hip Arthroscopy," *The American College of Surgeons and Illinois Association of Orthopaedic Surgeons Fall Scientific Meeting*, Chicago, Ill., 2004.

"Hip Disorders in Athletes," *University of Chicago Combined Sports Medicine and Physical Therapy Conference*, Chicago, Ill., 2004.

"Valgus Elbow Instability," *Grand Rounds, University of Chicago*, Chicago, Ill., 2004.

Torry, M.R., Ph.D.; Pflum, M., M.S.; Shelburne, K.B., Ph.D.; Steadman, J.R., M.D.; Sterett, W.I., M.D.:
"The Effect of Quadriceps Weakness on the Adductor Moment during Gait," *51st American College of Sports Medicine Meeting*, Indianapolis, Ind., June 2004.

Kernozek, T., Ph.D.; Van Hoof, H., P.T.; Torry, M.R., Ph.D.; Cowley, H., P.T.; Tanner, S., P.T.:
"Kinematic and Kinetic Landing Patterns of Recreational Athletes," *51st American College of Sports Medicine Meeting*, Indianapolis, Ind., June 2004.

Van Hoof, H., P.T.; Kernozek, T., Ph.D.; Torry, M.R., Ph.D.; Hinman, J., P.T.:
"Effects of Fatigue on the Landing Mechanics of the Female Recreational Athlete," *51st American College of Sports Medicine Meeting*, Indianapolis, Ind., June 2004.

"Structure, Function, Injury and Reconstruction of the ACL," *University of Colorado, Department of Applied Physiology and Integrative Biology*, Boulder, Colo., September 11, 2004.

Torry, M.R., Ph.D.; Hawkins, R.J., M.D.; Shelburne, K.B., Ph.D.; Tanagawa, T., M.A.; Hummel, S., M.S.; Giphart, J.E., Ph.D.:
"Shoulder Biomechanics — It All Hinges on the Motion," *Rockies Professional Baseball Trainers Meeting*, Vail, Colo., November 6-8, 2004.

Wyland, D.J., M.D.:
"Persistent Ankle Pain after Injury and Treatment," *Grand Rounds. Swedish Medical Center*, Englewood, Colo., April 23, 2004.

2004 PUBLICATIONS

Decker, M.J., M.S.; Torry, M.R., Ph.D.; Noonan, T.J., M.D.; Sterett, W.I., M.D.; Steadman, J.R., M.D.:
"Gait retraining after anterior cruciate ligament reconstruction," *Archives of Physical Medicine and Rehabilitation*, 2004; 85:848-856.

Kocher, M.S., M.P.H., M.D.; Steadman, J.R., M.D.; Briggs, K.K., M.P.H., M.B.A.; Sterett, W.I., M.D.; Hawkins, R.J., M.D.:
"Reliability, validity, and responsiveness of the Lysholm knee scale for various chondral disorders of the knee," *Journal of Bone and Joint Surgery [Am]*, 2004; 86:1139-1145.

Kocher, M.S., M.P.H., M.D.; Steadman, J.R., M.D.; Briggs, K.K., M.P.H., M.B.A.; Sterett, W.I., M.D.; Hawkins, R.J., M.D.:
"Relationships between objective assessment of ligament stability and subjective assessment of symptoms and function after anterior cruciate ligament reconstruction," *American Journal of Sports Medicine*, 2004; 32:629-634.

Krishnan, S.G., M.D.; Hawkins, R.J., M.D.; Horan, M.P.; Dean, M., M.D.; Kim, Y.K., M.D.:
"A soft tissue attempt to stabilize the multiply operated glenohumeral joint with multidirectional instability," *Clinical Orthopedics and Related Research*, 2004 Dec.; 1(429): 256-261.

Krishnan, S.G., M.D.; Hawkins, R.J., M.D.; Warren, R.F., M.D.:
"The shoulder and the overhead athlete," edited by Krishnan, S.G.; Hawkins, R.J.; Warren, R.F. Published by Lippincott Williams & Wilkins, Philadelphia, Pa., 2004.

Luke, T.A., M.D.; Rovner, A.D., M.D.; Karas, S.G., M.D.; Hawkins, R.J., M.D.; Plancher, K.D., M.D.:
"Volumetric change in the shoulder capsule after open inferior capsular shift versus arthroscopic thermal capsular shrinkage: A cadaveric model," *Journal of Shoulder and Elbow Surgery*, 2004; 13:146-149.

Mair, S.D., M.D.; Isabelle, W., M.D.; Gill, T.J., M.D.; Schlegel, T.F., M.D.; Hawkins, R.J., M.D.:
"Triceps tendon ruptures in professional football players," *American Journal of Sports Medicine*, 2004; 32:431-434.

Mair, S.D., M.D.; Schlegel, T.F., M.D.; Gill, T.J., M.D.; Hawkins, R.J., M.D.; Steadman, J.R., M.D.:
"Incidence and location of bone bruises after acute posterior cruciate ligament injury," *American Journal of Sports Medicine*, 2004; 32:1681-1687.

Mair, S.D., M.D.; Viola, R.W., M.D.; Gill, T.J., M.D.; Briggs, K.K., M.P.H., M.B.A.; Hawkins, R.J., M.D.:
"Can the impingement test predict outcome after arthroscopic subacromial decompression?" *Journal of Shoulder and Elbow Surgery* 2004; 13:150-153.

Miller, B.S., M.D.; Steadman, J.R., M.D.; Briggs, K.K., M.P.H., M.B.A.; Rodrigo, J.J., M.D.; Rodkey, W.G., D.V.M.:
"Patient satisfaction and outcome after microfracture of the degenerative knee," *Journal of Knee Surgery*, 2004; 17:13-17.

Millett, P.J., M.D.; Pennock, A.T., M.D.; Sterett, W.I., M.D.; Steadman, J.R., M.D.:
"Early ACL reconstruction in combined ACL-MCL injuries," *Journal of Knee Surgery*, 2004; 17:94-98.

Pflum, M., M.S.; Shelburne, K.B., Ph.D.; Torry, M.R., Ph.D.; Decker, M.J., M.S.; Pandy, M.G., Ph.D.:
"Model predictions of anterior cruciate ligament force during drop landings," *Medicine and Science in Sports and Exercise*, 2004; 36:1949-1958.

Rodkey, W.G., D.V.M.; Bartz, R.L., M.D.:
"The meniscus: Basic biology and response to injury," *Sports Medicine and Arthroscopy Review,* 2004; 12:2-7.

Rodkey, W.G., D.V.M.; Steadman, J.R., M.D.:
"El implante meniscal de colágeno," *Rev Ortop Traumatol*, 2004; 48(Supl. 1):57-60.

Sabick, M.B., Ph.D., Torry, M.R., Ph.D.; Kim, Y.K., M.D.; Hawkins, R.J., M.D.:
"Humeral torque in professional baseball pitchers," *American Journal of Sports Medicine*, 2004; 32:892-898.

Sabick, M.B., Ph.D.; Torry, M.R., Ph.D.; Lawton, R.L., M.D.; Hawkins, R.J., M.D.:
"Valgus torque in youth baseball pitchers: A biomechanical study," *Journal of Shoulder and Elbow Surgery*, 2004; 13:349-355.

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"Pattern of anterior cruciate ligament force during normal walking," *Journal of Biomechanics*, 2004; 37:797-805.

Shelburne, K.B., Ph.D.; Pandy, M.G., Ph.D.; Torry, M.R., Ph.D.:
"Comparison of shear forces and ligament loading in the healthy and ACL-deficient knee during gait," *Journal of Biomechanics*, 2004; 37:313-319.

Steadman, J.R., M.D.; Rodkey, W.G., D.V.M.; Briggs, K.K., M.P.H., M.B.A.:
"Microfracture arthroplasty is an effective means to treat full thickness cartilage lesions of the knee," In: Williams RJ, Johnson DP, eds. *Sports Injuries to the Knee*. Oxford University Press, Oxford, UK, 2004:425-437. Chapter 25.

Steadman, J.R., M.D.; Rodkey, W.G., D.V.M.:
"Tissue-engineered collagen meniscus implants: 5 to 6-year feasibility study results," *Arthroscopy* (In press).

Steadman, J.R., M.D.; Rodkey, W.G., D.V.M.:
"Microfracture in the pediatric and adolescent knee," In: Micheli LJ, Kocher M, eds. *The Pediatric & Adolescent Knee*. WB Saunders, Philadelphia, Pa. (In press).

Sterett, W.I., M.D.; Steadman, J.R., M.D.:
"Chondral resurfacing and high tibial osteotomy in the varus knee," *American Journal of Sports Medicine*, 2004; 32:1243-1249.

Terry, M.A., M.D.; Steadman, J.R., M.D.; Rodkey, W. G., D.V.M.; Briggs, K.K., M.P.H., M.B.A.:
"Microfracture/chondroplasty for chondral lesions," In: Sekiya JK, EL Attrache N, Mirzayan R, eds. *Surgical Techniques in Sports Medicine*, Philadelphia, Pa. Lippincott Williams and Wilkins (In press).

Tokish, J.M., M.D.; Kocher, M.S., M.D.; Hawkins, R.J., M.D.:
"Ergogenic Aids: A review of basic science, performance, side effects, and status in sports," *American Journal of Sports Medicine*, 2004; 32:1543-1553.

Torry, M.R., Ph.D.; Decker, M.J., M.S.; Ellis, H.B.; Shelburne, K.B., Ph.D.; Sterett, W.I., M.D., Steadman, J.R., M.D.:
"Mechanisms of compensating for anterior cruciate ligament deficiency during gait," *Medicine and Science in Sports and Exercise*, 2004; 36:1403-1412.

Torry, M.R., Ph.D.; Decker, M.J., M.S.; Millett, P.J., M.D.; Steadman, J.R., M.D.; Sterett, W.I., M.D.:
"The effects of knee joint effusion on quadriceps electromyography during jogging." *Journal of Sports Science and Medicine*, 2004; 4:1-8.

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"Gait retraining after ACL reconstruction," *Archives Physical Medicine and Rehabilitation*, 2004; 85:848-856.

Torry, M.R., Ph.D.:
"Take a soft approach to landings," *Shape Magazine*, 2004 October, p 138.

RECOGNITION

The Steadman◆Hawkins Research Foundation is proud of the many advances it has made in 2004. These achievements are examples of the quality contributions made to orthopaedics and science.

American Academy of Orthopaedic Surgeons Recognizes Award-Winning Poster

After months of reviewing 3,300 submitted poster abstracts, members of the Program Committee of the American Academy of Orthopaedic Surgeons selected the poster presentation *Factors Associated with Disability and Activity in Patients Seeking Care for Osteoarthritis* as one of 12 prestigious award winners. The authors of the peer-reviewed poster are Karen K. Briggs, M.P.H., M.B.A.; J. Richard Steadman, M.D.; Tim O'Brien, M.D.; and Dave Wing. This study identified decreased range of motion and patient-reported stiffness as determinants of decreased activity and function in patients with osteoarthritis.

"Karen came to me and presented the data from our database," said Dr. Steadman of Karen Briggs, the lead author of the study. "She did this all on her own."

"The criteria for the scientific posters have become much more stringent through the years," said Jon J.P. Warner, M.D., chair of the Central Program Committee. Posters are judged on several criteria, including originality, soundness of scientific reasoning, whether the conclusions are supported by data, and whether the poster presents any new information that makes a difference in the quality of care.

AP/Wide World Photos

MEDIA

"I have been playing this game a long time," said the 40-year-old, who wore a burgundy robe with the inscription "All Time" on the front. "I've had a lot of surgeries. A lot of very important people were instrumental in prolonging my career."

FUTURE PRO FOOTBALL HALL OF FAMER BRUCE SMITH SETS CAREER SACK RECORD — CREDITS DR. STEADMAN

The long awaited moment came for the Washington Redskins' Bruce Smith in a game against the New York Giants in East Rutherford, New Jersey, when he sacked quarterback Jesse Palmer for a record-setting 199th career sack. Reggie White held the old mark of 198.

"I have been playing this game a long time," said the 40-year-old, who wore a burgundy robe with the inscription "All Time" on the front. "I've had a lot of surgeries. A lot of very important people were instrumental in prolonging my career."

Immediately following the game and from the locker room, Smith called Dr. Steadman at home to express his appreciation. Smith, voted the National Football League's 1996 Defensive Player of the Year, knew back in 1992 that his 29-year-old knees were quickly deteriorating from his years on the college and pro gridiron. He had one surgery on his left knee earlier, but he tried to come back too early and his knee started giving way again, this time with major fragments breaking away.

"Then," said Smith, "I decided to pay Dr. Steadman a visit." Smith had heard about Dr. Steadman's work from his agent and from the Bills' staff. "I decided to go to Dr. Steadman because he was operating on people—skiers mostly—with knees far worse than mine. The first time I met him and saw the way he was built—like me, he's a little knock-kneed and we're pretty much similar from the waist down—I knew he was my man."

After that day in March 1992 (and his microfracture surgery that same month), Smith was back at his peak. Said former Buffalo Bills quarterback and Foundation board member Jack Kemp, "That surgery added at least five years to Bruce's life."

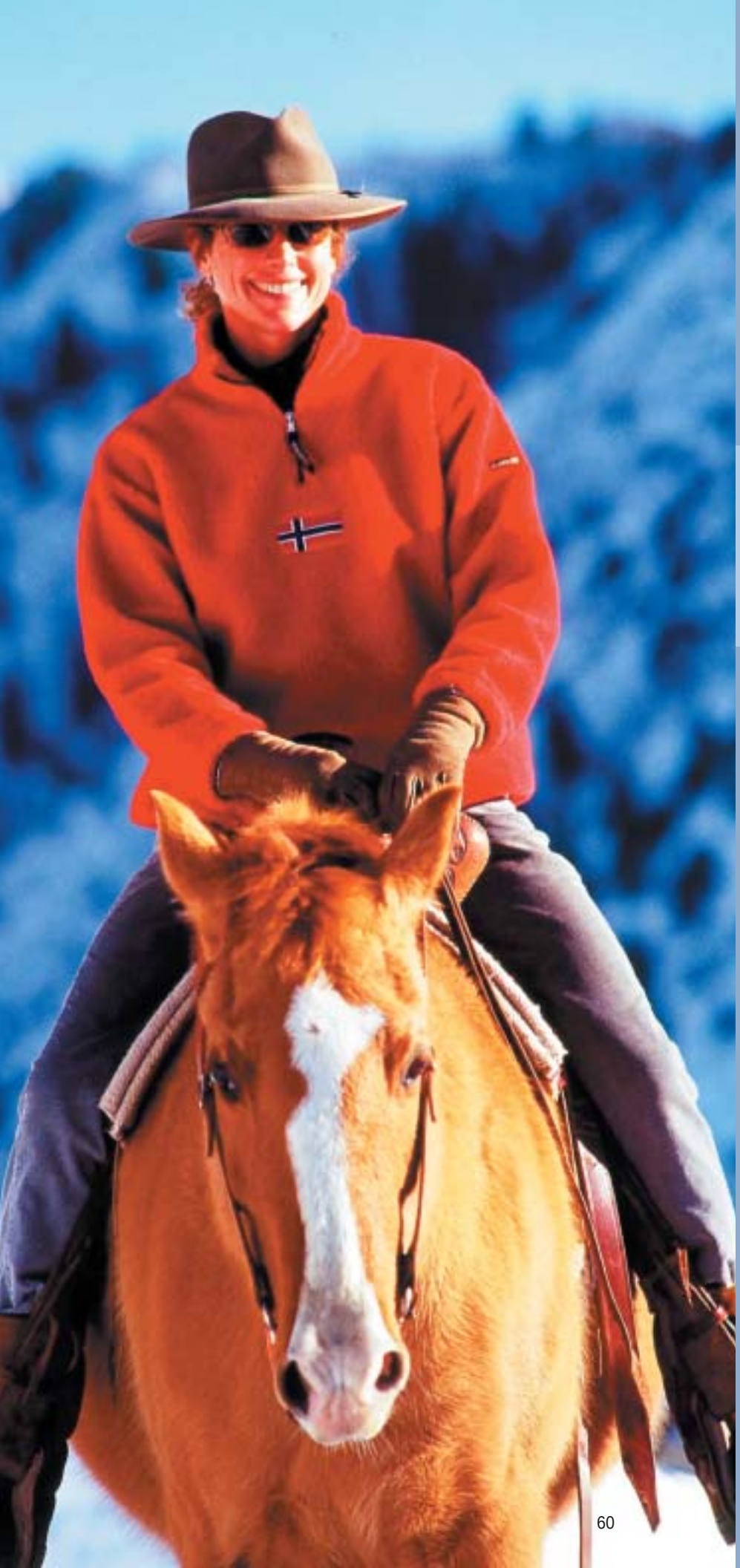
Smith has now undergone two microfractures. The first was in March 1992 and it was followed by another, on his right knee, in February 1996. He agrees with Jack Kemp. "If I hadn't met Dr. Steadman, there's a good chance my career would have come to an end."

Smith was honored during halftime of the Redskins final home game, December 27, 2003, at FedEx Stadium in Washington, D.C. He was introduced by Jack Kemp. Smith was presented with a life-size plaque designed in his 6-foot-4, 262-pound form. In front of 76,000 fans, he expressed appreciation to Dr. Steadman for saving his career. "This is a very humbling experience," said Smith, surrounded by a dozen or so family members. "Thank you from the bottom of my heart."

[Source: David Elfia, *The Washington Times;* Adam Schefter, *The Denver Post*.]

Ten years ago, less than 1 percent of the world's orthopaedic surgeons performed microfracture, a procedure that encourages cartilage regeneration in the knee joint. Today, this technique is the one most often used by surgeons as the first treatment for articular cartilage defects.

Microfracture, an arthroscopic technique used to repair cartilage tissue through small incisions, was pioneered and validated by the Steadman◆Hawkins Research Foundation's Basic Science and Clinical Research departments. These and other procedures developed and validated by the Foundation can postpone the need for joint replacement surgery.



DEVELOPMENT

The annual Steadman-Hawkins Colorado Classic generated $100,000. Held August 14-16, the Colorado Classic, presented by PepsiCo, featured an evening of fine wine and world-class dining, along with the American Express Colorado Classic Golf Tournament.

Administration: John Welaj, Amy Ruther, Norm Waite, and Karyll Nelson.

Development and Educational Program Staff: John McMurtry, Rachele Palmer, Dina Proietti, and Greta Campanale.

The Development Department is responsible for managing all fund-raising aspects of the Foundation as well as patient outreach, public relations, media relations, and special events.

The Foundation maintained a steady pace during a challenging year in 2004, adding new donors and bringing the total for the year to 816 individuals or foundations contributing gifts.

SPECIAL EVENTS

The Foundation organized three special events in 2004:

The winter winemaker dinner series, "An Evening In Bordeaux," at Vail's La Tour Restaurant and Larkspur Restaurant included some of the best wines ever produced in France. The January 16-17 event featured the vineyards, winemakers, and executives of Château Latour, Château Pichon-Longueville-Comtesse de Lalande, Château L'Angélus, and Château Cos d'Estournel.

The annual Steadman-Hawkins Colorado Classic generated $100,000. Held August 14-16, the Colorado Classic, presented by PepsiCo, featured an evening of fine wine and world-class dining, along with the American Express Colorado Classic Golf Tournament.

The Colorado Evening Winemaker Dinner, presented by WestStar Bank, kicked off the festivities at the Ritz-Carlton, Bachelor

Gulch, highlighted by award-winning Napa Valley wines from Chappellet Winery and Shafer Vineyards, as well as culinary delights from nine of the Vail Valley's premier restaurants, including Beano's Cabin, The French Press, Grouse Mountain Grill, Larkspur Restaurant, La Tour Restaurant, Remington's at the Ritz, Splendido at the Chateau, Terra Bistro Restaurant, and The Wildflower.

Rachele Palmer, Development Coordinator

Rachele Palmer joined the staff of the Development Department at the Steadman◆ Hawkins Research Foundation in May 2001. The Development Department is instrumental in raising the much-needed funds that ensure the research and educational programs will continue to prosper and grow.

She helps with five major mail solicitations produced throughout the year, maintains the donor database, manages all the donations that are received, and is instrumental in the planning of our fund-raising events.

Rachele, a native of Great Falls, Montana, comes from a military family and has four sisters. Being fourth in line, she learned early on the virtue of appreciation. "I enjoy the very simple pleasures that life has to offer. It doesn't take much to make me happy."

In 1987, she and her family (husband Brad and sons Dustin and Nicklas) left Montana for Denver to seek a new future. After eight years in Denver, they felt the "big city" was too big for raising children. Having an opportunity to live in the mountains, they moved to the smaller community of Leadville, Colorado, about 45 miles south of Vail.

Dustin has since graduated from high school and is currently serving in the Navy aboard the USS Abraham Lincoln aircraft carrier. Nicklas is a senior in high school and a few months after graduation he will be heading off to the U.S. Marine Corps. "You just have to love them. I'm so proud of my boys!"

After working five years at a neighboring ski resort as a staff accountant, she found her way to the Steadman◆Hawkins Research Foundation. "I love working at the Foundation. I learn something almost every day and that makes me happy that I work here. Everyone is 'first class' in my book!"

Steadman-Hawkins Golf Classic at Sanctuary.

In September, the Foundation hosted its first Steadman-Hawkins Golf Classic, presented by RE/MAX International, at the Sanctuary, a premier golf resort located south of Denver. Sanctuary organizes and hosts charitable events to support organizations devoted to the arts, children, health care, and crisis management. More than 75 charities have raised more than ten million dollars to benefit the constituents they serve. The Steadman◆ Hawkins Research Foundation is grateful to Dave and Gail Liniger, owners and co-founders of RE/MAX International, who created this unique opportunity for the Foundation to develop and enhance relationships with those who support our mission.

The Foundation also hosted two receptions on both coasts for friends and supporters, and to raise awareness and funding. In March, an appreciation event was held in San Francisco during the annual meeting of the American Academy of Orthopaedic Surgeons for corporate sponsors, donors, and former Steadman-Hawkins Fellowship surgeons. In November, the Foundation hosted a fund-raising event in New York City. In addition to private donations from the event tallying upwards of $45,000, NFL Charities announced an $89,000 donation to the Foundation. NFL Charities was represented by Joe Brown, senior vice president of communications, NFL Hall of Famer Jim Kelly, and Edward Rutkowski. Kelly and Rutkowski both played for the Buffalo Bills.

ASSOCIATES

The Steadman◆Hawkins Research Foundation is proud to recognize its team of associates, who carry out the Foundation's research and educational mission in Vail. The staff has been selected for its diverse training and background in biomechanics, engineering, clinical research, veterinary science, and computer science. Together, the staff members take a multidisciplinary approach to their work in solving orthopaedic problems.

ADMINISTRATION

Norm Waite. Jr.
Chief Executive Officer

John Welaj, M.B.A.
Chief Operations Officer

Amy Ruther
Human Resources Manager

Karyll Nelson
BioSkills Laboratory Director and Executive Assistant

DEVELOPMENT

John G. McMurtry, M.A., M.B.A.
Vice President for Program Advancement

Rachele Palmer
Development Coordinator

BASIC SCIENCE

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

CLINICAL RESEARCH

Karen K. Briggs, M.P.H., M.B.A.
Director

Amanda Ciotti
Research Associate

Marilee Horan
Research Associate

BIOMECHANICS RESEARCH LABORATORY

Michael Torry, Ph.D.
Director

Kevin B. Shelburne, Ph.D.
Senior Staff Scientist

J. Erik Giphart, Ph.D.
Staff Scientist

Takashi Yanagawa, M.A.
Staff Scientist

EDUCATION

Greta Campanale
Educational/Fellowship Coordinator

Dina Proietti
Educational/Development Program Assistant

OFFICE OF INFORMATION SYSTEMS

Jean Claude Moritz
Director

VISUAL SERVICES

Joe Kania
Audio-Visual/Multi-Media Manager

STEADMAN◆ HAWKINS RESEARCH FOUNDATION FINANCIAL REPORTS 2004

INDEPENDENT ACCOUNTANTS' REPORT

Board of Directors
Steadman◆Hawkins Research Foundation
Vail, Colorado

We have audited the accompanying statements of financial position of Steadman◆Hawkins Research Foundation as of December 31, 2004 and 2003, and the related statements of activities, cash flows and functional expenses for the years then ended. These financial statements are the responsibility of the Foundation's management. Our responsibility is to express an opinion on these financial statements based on our audits.

We conducted our audits in accordance with auditing standards generally accepted in the United States of America. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management as well as evaluating the overall financial statement presentation. We believe that our audits provide a reasonable basis for our opinion.

In our opinion, the financial statements referred to above present fairly, in all material respects, the financial position of Steadman◆Hawkins Research Foundation as of December 31, 2004 and 2003, and the changes in its net assets and its cash flows for the years then ended in conformity with accounting principles generally accepted in the United States of America.

BKD, LLP

March 22, 2005
Colorado Springs, Colorado

STATEMENTS OF FINANCIAL POSITION

DECEMBER 31, 2004 AND 2003

ASSETS

	2004	2003
Cash	**$ 892,598**	$ 255,752
Accounts receivable	**88,752**	357,067
Accounts receivable, related party	**12,721**	1,434
Investments	**2,517,302**	2,260,949
Contributions receivable	**–**	115,833
Contributions receivable, related party	**1,900**	31,500
Prepaid expenses and other	**26,667**	39,823
Property and equipment, net	**242,219**	313,969
Total assets	**$ 3,782,159**	$ 3,376,327

LIABILITIES AND NET ASSETS

Liabilities		
Accounts payable	**$ 47,519**	$ 20,267
Accrued expenses	**91,046**	67,871
Deferred revenue	**–**	18,900
Total liabilities	**138,565**	107,038
Net Assets		
Unrestricted	**3,446,661**	2,901,361
Temporarily restricted	**196,933**	367,928
Total net assets	**3,643,594**	3,269,289
Total liabilities and net assets	**$ 3,782,159**	$ 3,376,327

See Notes to Financial Statements

STATEMENTS OF ACTIVITIES

YEAR ENDED DECEMBER 31, 2004

	Unrestricted	Temporarily Restricted	Total
REVENUES, GAINS AND OTHER SUPPORT			
Corporate partner support	$ 696,750	$ 3,000	$ 699,750
Contributions	887,413	216,438	1,103,851
Grants	12,754	46,052	58,806
Fundraising events, net of $257,969 of expenses	312,121	–	312,121
Fellows and other meetings	11,025	–	11,025
Video income	39,565	–	39,565
Other income	13,231	–	13,231
Net assets released from restrictions	436,485	(436,485)	0
Total revenues, gains and other support	2,409,344	(170,995)	2,238,349
EXPENSES			
Biomechanics research program	389,090	–	389,090
Basic science program	222,085	–	222,085
Clinical research program	314,403	–	314,403
Education program	204,176	–	204,176
Office of Information Services	174,797	–	174,797
Management and general	414,875	–	414,875
Fundraising	442,434	–	442,434
Total expenses	2,161,860	–	2,161,860
OTHER INCOME			
Investment income	297,816	–	297,816
CHANGE IN NET ASSETS	545,300	(170,995)	374,305
NET ASSETS, BEGINNING OF YEAR	2,901,361	367,928	3,269,289
NET ASSETS, END OF YEAR	$ 3,446,661	$ 196,933	$ 3,643,594

See Notes to Financial Statements

STATEMENTS OF ACTIVITIES

YEAR ENDED DECEMBER 31, 2003

	Unrestricted	Temporarily Restricted	Total
REVENUES, GAINS AND OTHER SUPPORT			
Corporate partner support	$ 886,223	$ 27,000	$ 913,223
Contributions	730,199	477,490	1,207,689
Grants	1,825	219,625	221,450
Fundraising events, net of $376,038 of expenses	90,114	–	90,114
Fellows and other meetings	8,100	–	8,100
Video income	55,224	–	55,224
Other income	16,876	–	16,876
Net assets released from restrictions	815,144	(815,144)	0
Total revenues, gains and other support	2,603,705	(91,029)	2,512,676
EXPENSES			
Biomechanics research program	400,040	–	400,040
Basic science program	156,125	–	156,125
Clinical research program	346,243	–	346,243
Education program	259,457	–	259,457
Office of Information Services	248,614	–	248,614
Management and general	577,243	–	577,243
Fundraising	394,042	–	394,042
Total expenses	2,381,764	–	2,381,764
OTHER INCOME			
Investment income	446,301	–	446,301
CHANGE IN NET ASSETS	668,242	(91,029)	577,213
NET ASSETS, BEGINNING OF YEAR	2,233,119	458,957	2,692,076
NET ASSETS, END OF YEAR	$ 2,901,361	$ 367,928	$ 3,269,289

See Notes to Financial Statements

STATEMENTS OF CASH FLOWS

YEARS ENDED DECEMBER 31, 2004 AND 2003

	2004	2003
OPERATING ACTIVITIES		
Change in net assets	**$ 374,305**	$ 577,213
Items not requiring (providing) cash		
Depreciation	**83,314**	87,633
Realized and unrealized gains on investments	**(262,249)**	(418,128)
In-kind contributions of investments	**(116,309)**	(116,280)
Changes in		
Accounts receivable	**257,028**	(64,729)
Contributions receivable	**145,433**	(44,999)
Prepaid expenses	**13,156**	(26,744)
Accounts payable	**27,252**	(25,956)
Accrued expenses	**23,175**	10,044
Deferred revenue	**(18,900)**	18,900
Net cash provided by (used in) operating activities	**526,205**	(3,046)
INVESTING ACTIVITIES		
Purchase of property and equipment	**(11,564)**	(281,062)
Purchases of investments	**(131,800)**	(1,006,813)
Sales of investments	**254,005**	1,102,605
Net cash provided by (used in) investing activities	**110,641**	(185,270)
INCREASE (DECREASE) IN CASH	**636,846**	(188,316)
CASH, BEGINNING OF YEAR	**255,752**	444,068
CASH, END OF YEAR	**$ 892,598**	$ 255,752

See Notes to Financial Statements

STATEMENTS OF FUNCTIONAL EXPENSES

YEAR ENDED DECEMBER 31, 2004

	Programs								
	Biomechanics Research	Basic Science	Clinical Research	Education	Office of Information Services	Total	Management and General	Fundraising	Total
Salary and benefits	$ 301,345	$ 23,067	$ 229,704	$ 95,819	$ 97,750	$ 747,685	$ 282,912	$ 177,011	$ 1,207,608
Payroll taxes	19,002	1,711	15,391	6,151	6,535	48,790	19,572	10,840	79,202
Entertainment	–	–	–	–	–	0	–	–	0
Travel	6,381	1,824	4,364	15,253	5,857	33,679	6,831	25,591	66,101
Utilities	3,578	2,880	2,688	2,304	4,224	15,674	3,891	1,728	21,293
Telephone	3,271	243	2,139	586	1,519	7,758	3,586	1,772	13,116
Consulting and contract labor	15,413	89,658	15,304	–	–	120,375	6,866	60,098	187,339
Legal and accounting	5,540	429	5,334	935	2,960	15,198	3,711	2,994	21,903
Postage and freight	2,825	226	3,887	1,231	2,162	10,331	1,543	3,666	15,540
Exhibits and meetings	935	–	110	46,978	100	48,123	244	200	48,567
Research projects	800	80,000	454	8,345	–	89,599	–	–	89,599
Facility rent	10,460	5,203	4,950	4,156	7,566	32,335	7,320	3,059	42,714
Promotion	–	–	–	90	228	318	25,000	45,005	70,323
Repair, maintenance and equipment	3,737	442	2,384	545	2,454	9,562	1,561	1,322	12,445
Board and SAC meeting	–	–	–	5,403	–	5,403	–	685	6,088
Dues, subscriptions, books and journals	869	–	–	8,440	20	9,329	100	1,101	10,530
General insurance	918	71	883	177	530	2,579	27,539	424	30,542
Printing	1,431	65	4,504	–	520	6,520	735	61,054	68,309
Supplies	8,088	7,314	11,974	407	8,751	36,534	4,417	5,563	46,514
Program support	201	15	193	39	116	564	116	18,726	19,406
Depreciation	4,171	8,937	10,116	7,317	33,491	64,032	10,428	8,854	83,314
Other	125	–	24	–	14	163	8,503	12,741	21,407
	$ 389,090	$ 222,085	$ 314,403	$ 204,176	$ 174,797	$ 1,304,551	$ 414,875	$ 442,434	$ 2,161,860

See Notes to Financial Statements

STATEMENTS OF FUNCTIONAL EXPENSES

YEAR ENDED DECEMBER 31, 2003

	Programs								
	Biomechanics Research	Basic Science	Clinical Research	Education	Office of Information Services	Total	Management and General	Fundraising	Total
Salary and benefits	$ 272,908	$ 21,560	$ 229,289	$ 98,127	$ 148,232	$ 770,116	$ 263,355	$ 175,183	$ 1,208,654
Payroll taxes	16,357	1,627	14,659	6,295	8,444	47,382	11,465	10,329	69,176
Entertainment	–	–	–	422	–	422	–	–	422
Travel	6,277	5,573	6,559	40,609	6,661	65,679	15,532	4,326	85,537
Utilities	4,768	3,785	2,142	2,150	4,620	17,465	4,506	2,004	23,975
Telephone	5,871	326	6,339	1,712	3,855	18,103	6,012	2,901	27,016
Consulting and contract labor	22,839	92,384	26,033	5,072	5,146	151,474	203,990	45,733	401,197
Legal and accounting	6,296	266	5,435	1,546	4,180	17,723	4,065	4,057	25,845
Postage and freight	2,661	300	2,852	1,211	2,380	9,404	2,186	3,145	14,735
Exhibits and meetings	850	–	2,414	61,493	83	64,840	189	359	65,388
Research projects	32,142	–	698	10,722	–	43,562	–	–	43,562
Facility rent	9,564	6,842	21,397	3,888	8,247	49,938	3,637	4,106	57,681
Promotion	189	3	703	528	136	1,559	826	44,390	46,775
Repair, maintenance and equipment	4,183	189	4,736	812	2,471	12,391	3,998	1,682	18,071
Board and SAC meeting	–	–	–	5,322	–	5,322	1,191	1,059	7,572
Dues, subscriptions, books and journals	766	–	–	7,689	–	8,455	74	1,418	9,947
General insurance	–	–	–	–	–	0	30,917	–	30,917
Printing	1,828	245	6,947	1,410	1,172	11,602	1,273	46,101	58,976
Supplies	7,912	3,241	6,602	1,502	15,861	35,118	3,618	4,453	43,189
Program support	307	19	283	66	189	864	311	22,004	23,179
Depreciation	3,526	19,704	6,638	7,034	36,318	73,220	7,236	7,177	87,633
Other	796	61	2,517	1,847	619	5,840	12,862	13,615	32,317
	$ 400,040	$ 156,125	$ 346,243	$ 259,457	$ 248,614	$ 1,410,479	$ 577,243	$ 394,042	$ 2,381,764

See Notes to Financial Statements

NOTES TO FINANCIAL STATEMENTS

YEARS ENDED DECEMBER 31, 2004 AND 2003

NOTE 1: NATURE OF OPERATIONS AND SUMMARY OF SIGNIFICANT ACCOUNTING POLICIES

Nature of Operations
Steadman◆Hawkins Research Foundation (the Foundation) is a not-for-profit foundation located in Vail, Colorado that is organized for educational and scientific purposes to advance medical science and research. The Foundation's primary sources of support are public donations, grants and corporate partners.

Corporate Partners
The Foundation has agreements with several corporations where the Foundation's research and product development is provided to the corporation in exchange for an annual payment to the Foundation. These agreements are recorded as income in the year payment is due.

Contributions
Gifts of cash and other assets received without donor stipulations are reported as unrestricted revenue and net assets. Gifts received with a donor stipulation that limits their use are reported as temporarily or permanently restricted revenue and net assets. When a donor-stipulated time restriction ends or purpose restriction is accomplished, temporarily restricted net assets are reclassified to unrestricted net assets and reported in the statements of activities as net assets released from restrictions.

Gifts of land, buildings, equipment and other long-lived assets are reported as unrestricted revenue and net assets unless explicit donor stipulations specify how such assets must be used, in which case the gifts are reported as temporarily or permanently restricted revenue and net assets. Absent explicit donor stipulations for the time long-lived assets must be held, expirations of restrictions resulting in reclassification of temporarily restricted net assets as unrestricted net assets are reported when the long-lived assets are placed in service. Unconditional gifts expected to be collected within one year are reported at their net realizable value. Unconditional gifts expected to be collected in future years are reported at the present value of estimated future cash flows. The resulting discount is amortized using the level-yield method and is reported as contribution revenue.

Cash
At December 31, 2004, the Foundation's cash accounts exceeded federally insured limits by approximately $535,000.

Accounts Receivable
Accounts receivable are stated at the amount billed to customers. The Foundation provides an allowance for doubtful accounts, which is based upon a review of outstanding receivables, historical collection information and existing economic conditions. Accounts receivable are ordinarily due 30 days after the issuance of the invoice. Accounts past due more than 120 days are considered delinquent. Delinquent receivables are written off based on individual credit evaluation and specific circumstances of the customer.

Property and Equipment
Property and equipment are depreciated over the estimated useful life of each asset. Leasehold improvements are depreciated over the shorter of the lease term plus renewal options or the estimated useful lives of the improvements.

Investments and Investment Return
Investments in equity securities having a readily determinable fair value and all debt securities are carried at fair value. Investment return includes dividend, interest and other investment income and realized and unrealized gains and losses on investments carried at fair value. Investment return is reflected in the statements of activities as unrestricted or temporarily restricted based upon the existence and nature of any donor or legally imposed restrictions.

Use of Estimates
The preparation of financial statements in conformity with accounting principles generally accepted in the United States of America requires management to make estimates and assumptions that affect the reported amounts of assets and liabilities and disclosure of contingent assets and liabilities at the date of the financial statements and the reported amounts of revenues, expenses, gains, losses and other changes in net assets during the reporting period. Actual results could differ from those estimates.

Income Taxes
The Foundation is a qualifying organization under Section 501(c)(3) of the Internal Revenue Code and a similar provision of state law. Consequently, no provision for income taxes has been made in the financial statements.

Reclassifications
Certain reclassifications have been made to the 2003 financial statements to conform to the 2004 financial statement presentation. These reclassifications had no effect on the change in net assets.

NOTE 2: INVESTMENTS AND INVESTMENT RETURN

Investments at December 31 consist of the following:

	2004	2003
Stock and equity funds	**$ 1,165,759**	$ 1,042,178
Equity securities	**1,064,970**	903,094
Fixed income funds	**185,806**	177,600
Money market funds	**100,767**	138,077
	$ 2,517,302	$ 2,260,949

At December 31, 2004 and 2003, approximately 89% and 86%, respectively, of the Foundation's investments consisted of equity securities and equity mutual funds.

Investment income during 2004 and 2003 consists of the following:

	2004	2003
Interest and dividend income	**$ 35,567**	$ 28,173
Net realized and unrealized gains on investments	**262,249**	418,128
Investment income	**$ 297,816**	$ 446,301

NOTE 3: CONTRIBUTIONS RECEIVABLE

Contributions receivable at December 31 are due as follows:

	2004	2003
Due in less than one year	**$ 1,900**	$ 104,000
Due in one to five years	**–**	50,000
	1,900	154,000
Less unamortized discount	**–**	(6,667)
Due from related parties	**(1,900)**	(31,500)
	$ 0	$ 115,833

Approximately 100% and 37% of total contributions receivable at December 31, 2004 and 2003, respectively, are from one donor.

The Foundation receives support and pledges from members of the Board of Directors and employees. These pledges receivable are included in contributions receivable, related party.

NOTE 4: PROPERTY AND EQUIPMENT

Property and equipment at December 31 consists of the following:

	2004	2003
Equipment	**$ 710,715**	$ 734,979
Furniture and fixtures	**22,326**	22,326
Leasehold improvements	**263,793**	258,736
	996,834	1,016,041
Less accumulated depreciation	**754,615**	702,072
	$ 242,219	$ 313,969

NOTE 5: TEMPORARILY RESTRICTED NET ASSETS

Temporarily restricted net assets at December 31 are available for the following purposes:

	2004	2003
Education	**$ 165,550**	$ 185,200
Unrestricted contributions receivable	**1,900**	87,333
Biomechanics research	**–**	65,912
Administration	**4,483**	29,483
Information systems	**25,000**	–
	$ 196,933	$ 367,928

NOTE 6: RELEASE OF TEMPORARILY RESTRICTED NET ASSETS

Net assets were released from donor restrictions by incurring expenses satisfying the restricted purposes or by occurrence of other events specified by donors as follows:

	2004	2003
Purpose restrictions accomplished		
Biomechanics research	**$ 116,287**	$ 345,269
Education	**204,175**	234,816
Administration	**25,000**	192,739
Basic science programs	**3,690**	27,319
	349,152	800,143
Time restrictions expired		
Collection of contributions receivable	**87,333**	15,001
Total restrictions released	**$ 436,485**	$ 815,144

NOTE 7: OPERATING LEASES

Noncancellable operating leases for property and equipment expire in various years through 2006. Two of the property leases require the Foundation to pay all executory costs (property taxes, maintenance and insurance).

Future minimum lease payments at December 31, 2004 are:

2005	$56,628
2006	2,787
	$59,415

Rental expense of $73,512 and $97,603 for the years ended December 31, 2004 and 2003, respectively, is recorded in the statements of activities.

NOTE 8: PENSION PLAN

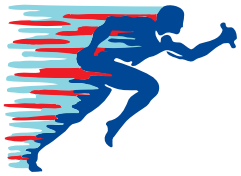
The Foundation has a defined contribution retirement plan under IRS Section 401(k). The plan is open to all employees after one year of employment. The Foundation's contributions to the plan are determined annually. The Foundation elected to match 50% of participants' contributions up to 6% during 2004 and 2003. Under this formula, the Foundation made contributions of $17,515 and $14,488 for the years ended December 31, 2004 and 2003, respectively.

NOTE 9: SIGNIFICANT ESTIMATES AND CONCENTRATIONS

Accounting principles generally accepted in the United States of America require disclosure of certain significant estimates and current vulnerabilities due to certain concentrations. Those matters include the following:

CORPORATE PARTNERS

During 2004 and 2003, approximately 46% and 70%, respectively, of all corporate partner support was received from two corporate partners and three corporate partners, respectively.



Steadman◆Hawkins Research Foundation

A 501(c)(3) nonprofit organization

181 WEST MEADOW DRIVE, SUITE 1000
VAIL, COLORADO 81657
970-479-9797
FAX: 970-479-9753

http://www.shsmf.org