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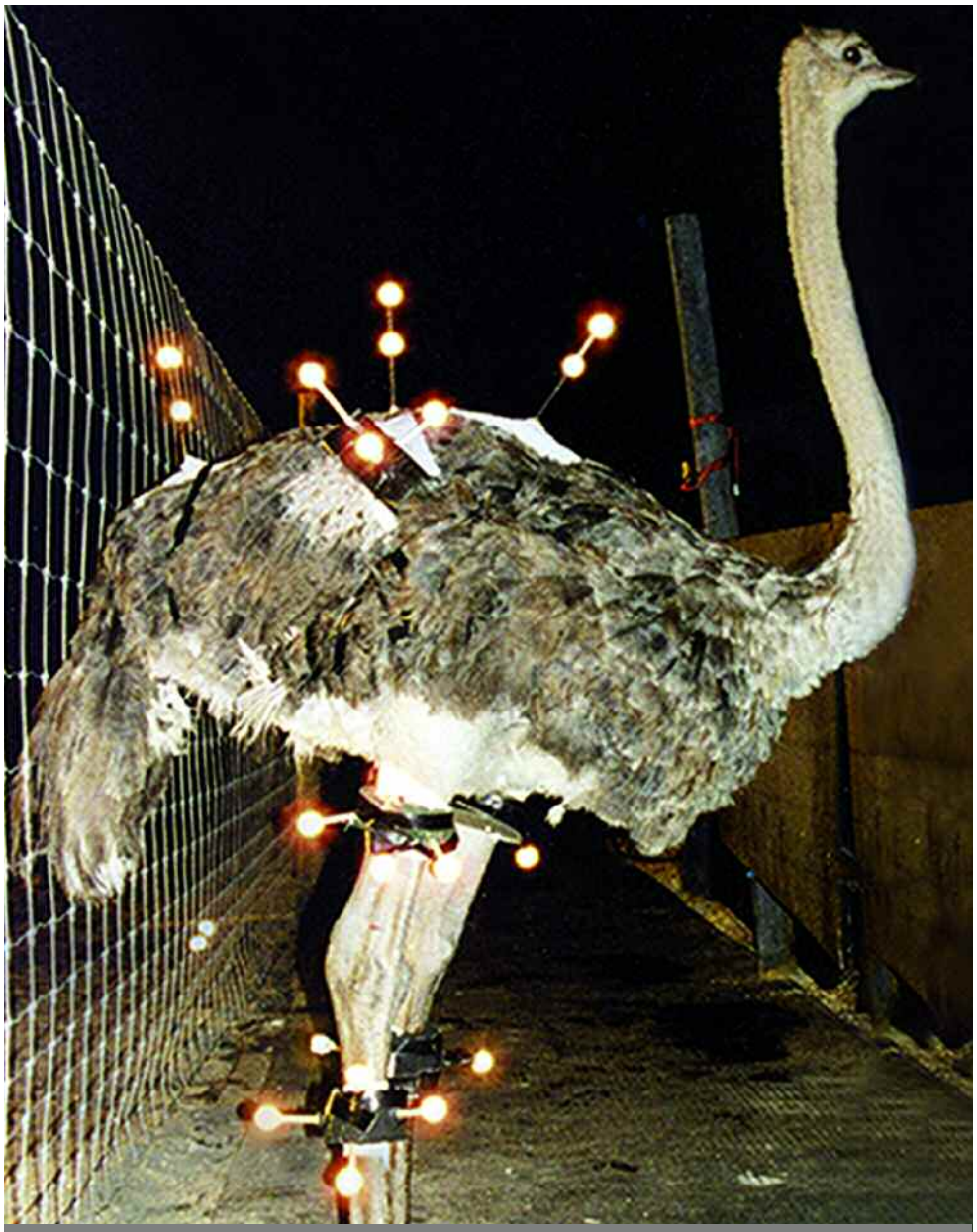


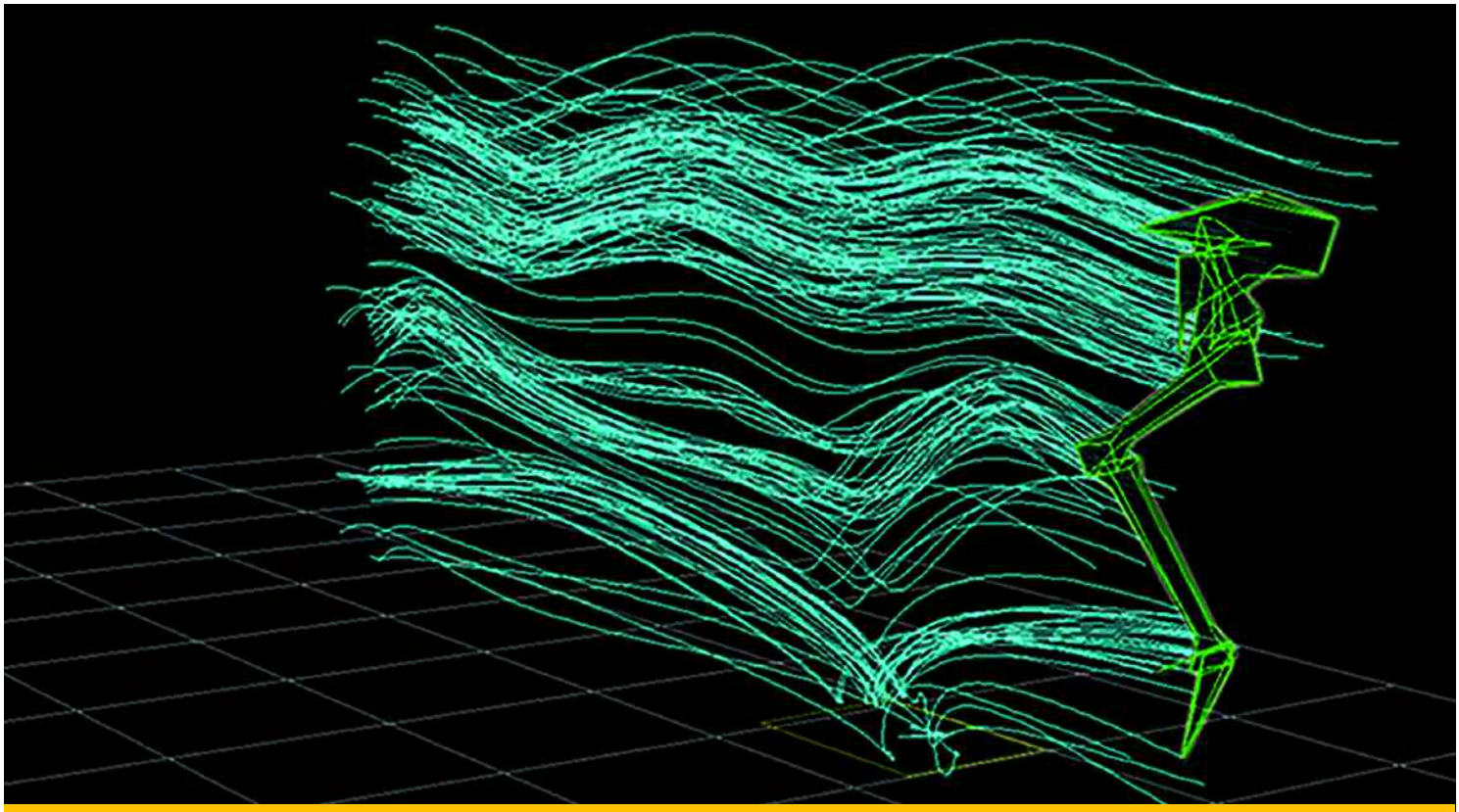
UWA INVESTIGATING THE LOCOMOTION OF BIRDS TO UNDERSTAND THE PRINCIPLES OF HUMAN BIPEDAL LOCOMOTION

Ostriches, ligaments and chucking: Research at the University of Western Australia

BY DR. DAVID LLOYD AND DR. JONAS RUBENSON

The School of Sport Science, Exercise and Health (SSEH) at the University of Western Australia (UWA) currently run two motion analysis laboratories, a 12 camera Vicon MX system for sports research, and a 7 camera Vicon MX motion analysis system for clinical research. The UWA group has always been heavily involved in sports and clinical biomechanics research, but now a team of researchers (Drs. Jonas Rubenson, David Lloyd and Paul Fournier) have also branched into investigating the locomotion of birds to understand the principles of human bipedal locomotion. To study the mechanics and energetics of gait in the largest bird species, the ostrich (Struthio camelus), they implemented a range of techniques normally used in clinical gait analysis.

Initially, the team trained birds to walk and run on a treadmill, while collecting both metabolic (oxygen consumption) data and 2D kinematic data using high-speed video cameras. Subsequently, an outdoor gait laboratory was built (in collaboration with Denham Heliams and Fauna Technologies) that integrated kinematic data from high-speed cameras and force-plate data using Vicon's BodyBuilder software to analyze 3D joint biomechanics.



AN EXCELLENT COMPARATIVE MODEL FOR UNDERSTANDING THE MECHANICAL DETERMINANTS OF HUMAN LOCOMOTOR ENERGY USE

Their findings are providing insight into musculoskeletal form and function, as well as long-standing questions of bipedal gait. The team's work has contributed to a shift in the way we interpret walking and running. Traditionally, running is distinguished from walking on the basis of having an aerial phase, i.e. when both feet are off the ground. However, they have shown that this definition of walking and running may be misleading [1]. An alternate definition of walking and running is based on mechanical energetics, walking being defined as a pendulum-like exchange between gravitational potential energy and horizontal kinetic energy, while running defined as a bouncing-like exchange of both gravitational and kinetic energy with the elastic energy stored in the legs. Their findings showed that bouncing running can occur without an aerial phase in ostriches, which the authors have called "grounded running". It has now been speculated that humans may use grounded running when moving on very compliant surfaces or in altered gravity environments (such as those on other planets), and that some children with cerebral palsy are using a grounded running gait rather than a walking gait.

The study also found that the selection between walking and grounded running is associated with a reduction of the metabolic cost of locomotion in ostriches. This finding solidifies the view that energy use is a key factor dictating gait selection in animals, including humans. Importantly, the study shows that the shift in dynamics of the body probably explains the reduction in energy use when humans choose to switch to a run.

The researchers are further exploring the relationship between locomotor mechanics and energetics. Ostriches possess a strikingly different limb morphology compared to humans, yet share a similar body mass. Because of this, ostriches are an excellent comparative model for understanding the mechanical determinants of human locomotor energy use.

The first step in this research was the development of a 3D kinetic model of the ostrich limb. The model was constructed from both static anatomical data and joint motion data using the school's Vicon motion capture system. The model has been used to explore whether mechanical and/or muscular work can explain the differences in the energy cost of locomotion between ostriches and humans. The investigators have also used their 3D model to explore the control of 3D joint and limb motions of running ostriches [2].

Ostriches may prove to be useful models for other areas of biomechanics. For example, these animals are capable of running and maneuvering at incredible speeds and, as the researchers have discovered, with remarkably high loads at their joints. Ostriches may yet reveal a few secrets of knee joint stabilization and injury prevention.

Preventing Sports Injury

Understanding knee joint loading and stabilization during running and sidestepping is a key to preventing anterior cruciate ligament (ACL) injuries in sport. These costly injuries occur all too often in many sports around the world, which is the reason for the large ACL injury research programme at UWA (Drs David Lloyd, Tim Doyle, Jacque Alderson, Profs Bruce Elliott and Tim Ackland, and PhD students Alasdair Dempsey, Jon Donnelly, James Dunne and Marcus Lee). The reason why the ACL ruptures is very simple: it breaks when the load applied to the ligament exceeds its' current strength. However, this raises two much more difficult questions to answer. The first, why does the strength of the ligament get too low? The second, why does the load applied to ligament get too big? This latter question is the focus of the UWA research.

ACL ruptures most commonly occur just after initial foot contact during non-contact sidestepping [3-5]. The UWA group has shown that in this period of the sidestep the knee is loaded with large valgus and internal rotation moments, while the quadriceps are extending the knee [6-8]. However, there were no broken ACL's in their laboratory studies. Reviewing videos of ACL injuries actually occurring has shown that when the ACL breaks the knee gives way into valgus and internal rotation [3-5]. So valgus and internal rotation moments, combined with the quadriceps extending the knee, all which highly loaded the ACL in cadaveric studies [9], are the probably loads causing ACL injury during sidesteps.

To prevent ACL injuries from occurring external valgus and internal rotation moments need to be reduced. But there is another way to prevent injury. It appears the knee loads recorded during laboratory sidestepping were on many occasions larger than those required to completely break all the knee ligaments [10], not just the ACL. But people did not break their knee ligaments in the laboratory! This suggested to the UWA group that muscles stabilize the knee preventing ACL rupture [11, 12]. So to reduce the incidence of ACL injuries one must lower loading and/or improve the muscular stabilization of the knee in sidestepping [13].

The UWA group has engaged in two laboratory based training studies funded by the Australian Football League Research and Development Board. The findings revealed that while sidestepping, certain facets of the player's technique can be changed to decrease knee loading. and that specially designed balance training will improve muscular stabilization of the knee. But does such training actually work to reduce injury ACL injury?

Some very good research from other groups has shown the promise of balance training [14, 15], but no work has addressed technique training. By teaming up with sports epidemiologist Professor Caroline Finch at University of Ballarat, the UWA group has received over $1,000,000 from the Australian National Health and Medical Foundation to see if their technique and balance training can reduce the incidence of ACL in community level Australian Football. This four year study is half completed and has shown some exciting data regarding this scientifically developed training.

▶ CONTINUED OVERLEAF

↑ **Side stepping in UWA sports motion analysis laboratory**
Photo - Alasdair Dempsey

New Support Engineer For Australia

Vicon is very pleased to have Aaron Chin on board as the new Support Engineer for Australia. Aaron has worked with the International Cricket council in assessing bowling action legality and helped develop spin bowling models with Cricket Australia. Aaron completed his Bachelor of Science at the University of Western Australia and is close to completing his PhD on developing a 2 degree of freedom model of the elbow for use with Vicon systems. ■

↑ **Markers for new upper motion analysis model**
Photo - Amity Campbell

Upper Limb Modelling and International Cricket Council

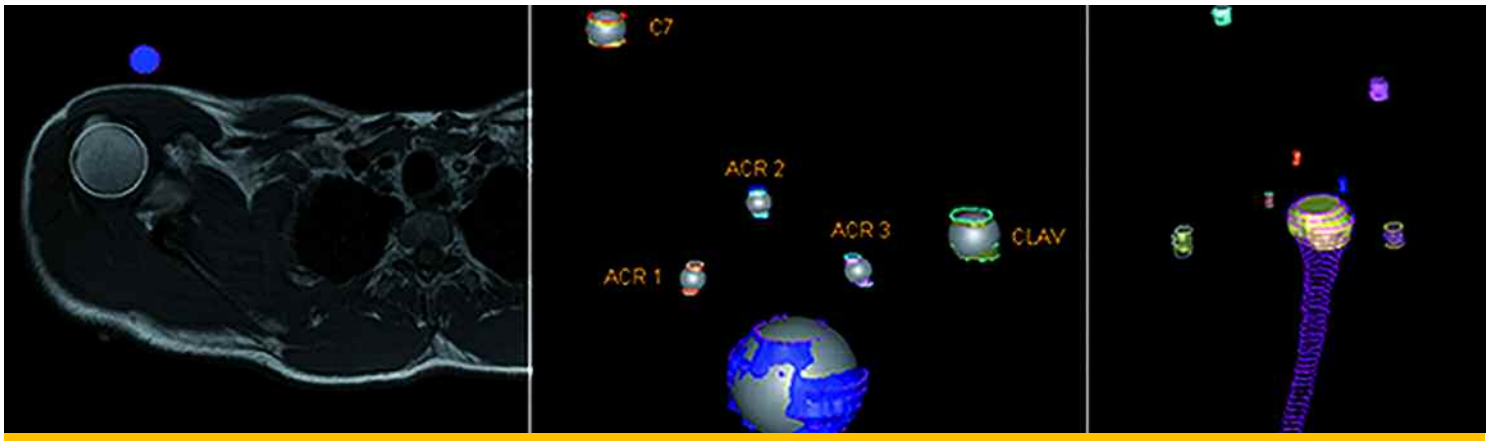
While this lower limb ACL injury research continues, the UWA group (Drs Yanxin Zhang, David Lloyd, Si Reid and Jacque Alderson, with PhD candidates Aaron Chin, Amity Campbell, and Kane Middleton) has been continually developing and testing new upper body motion analysis models.

The first upper limb model developed by the group was applied to "chucking in cricket bowling" [16]. The International Cricket Council is currently using the model in Biomechanics of Bowling testing unit [17].

Based on the experience gained from this work and the development of their lower body model [18], UWA is finishing the development of their "new" upper body model.

This new model uses multiple marker triads per segment, functional calibration methods and MRI imaging to best represent and measure torso, shoulder, elbow and wrist motion in many and varied upper limb tasks.

This very active group continues to develop innovative motion analysis modeling methods and apply them to movement research in sports performance, sports injury, comparative animal work, and clinical musculo-skeletal conditions. ■



↑ **MRI images of shoulder and markers for new upper motion analysis model** Images – Amity Campbell

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International Foot and Ankle Biomechanics Community

THE I-FAB INITIATIVE (INTERNATIONAL FOOT AND ANKLE BIOMECHANICS COMMUNITY) HAS BEEN LAUNCHED TO SUPPORT THE INTERNATIONAL COMMUNITY OF RESEARCHERS AND RESEARCH USERS RELATED TO FOOT AND ANKLE BIOMECHANICS.

Dr Chris Nester from University of Salford UK explains, "i-FAB aims to develop a co-ordinated approach to address the challenges of foot and ankle biomechanics research and connect a wide range of stakeholders in common research activities. i-FAB is being created by people with a passion for research on the foot and ankle and we hope it can support the activities of like minded researchers and research users internationally."

Visit **www.i-FAB.org** for information on how to join, to download the i-FAB launch presentation and for details of the September 2008 Congress in Bologna. ■

First Gait Analysis Lab To Open In Pakistan

The Biomedical Engineering Department of NED University of Engineering & Technology, Karachi has opened the first clinical gait analysis laboratory in Pakistan.

The lab is equipped with 8 Vicon MX3+ cameras, Vicon Nexus and Polygon, three AMTI OR6-7 force plates and Noraxon wireless EMG system.

The lab will be used for diagnostic and treatment purposes for cerebral palsy, spina bifida, clubfoot and flat feet in children; stroke, traumatic brain and spinal cord injury, osteoarthritis, sports injuries and mechanical mal-alignments for adults.

The team consists of Dr.S.M.Wasim Raza, Orthopedic Surgeon, Ms. Tajwar Sultana and Ms. S.Kanwal Zaidi, Computer Engineers, Abu Zeeshan Bari, Mechanical Engineer and Mr. Abdul Ghaffar Qureshi, Lab Technician.

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We value your opinion on the service you've received from Vicon and would appreciate it if you would complete our customer satisfaction survey. All completed surveys will be entered in to a prize draw to win a digital camera. To complete the survey you'll need to login to your Vicon Online Support account **www.vicon.com/support**. Terms and conditions apply. ■

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Check out the Vicon Standard website for archived articles, clinical paper summaries, the image library as well as the current issue of The Standard. If you have a colleague who would like to register for The Standard visit **www.vicon.com/standard**

We welcome your feedback and encourage you to contact us if you'd like to contribute or be featured in our upcoming edition. Contact **editorial@viconstandard.org**

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Vicon Profiles

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The University of Dundee's Orthopedic and Trauma Surgery Department has been at the forefront of the use of motion capture, by clinicians and researchers, for more than 30 years.

The current Director of the Institute of Motion Analysis and Research (IMAR), Professor Rami Abboud, has worked in the field of motion analysis, in Dundee, since 1988 and has overseen a number of ground-breaking developments starting with the establishment of the Foot Pressure Analysis Clinic and Laboratory in 1993 and subsequently IMAR in 2003.

One of the most recent developments was the addition of the sports biomechanics lab in January 2007. This brings IMAR to five motion labs with facilities used for both clinical and research work. "This new lab was added to IMAR to compliment our other facilities and to focus specifically on sports-related biomechanics research and assessment, using the excellence from our clinical service to benefit the sports arena," explains Professor Abboud. The lab is 32 metres long with twelve Vicon® MX13 cameras, eight Vicon® F40 cameras, two 100 Hz digital cameras, two AMTI force platforms and other pressure related systems (e.g. Emed-X platform). One of the force platforms is sited on rails such that the different stride lengths of various athletes during running or walking can be accommodated. The Vicon® F40 cameras are ideal for the work being done at the Institute as they are able to capture up to 370 Hz at 4 million pixels, significantly faster and more accurate than previous generations of Vicon® cameras. "We have recently invested in dedicated high-tech treadmills, rowing machines, exercise cycles and a golf simulator that will be synchronised with our existing equipment and the Vicon® systems".

All of these elements have enabled Professor Abboud and his team to undertake studies based on a degree of detail beyond the reach of other facilities, as the professor himself explains: "We now have an extremely flexible Institute which we use for a wide variety of research studies and clinical work. The ability to use the smaller 3mm Vicon markers (rather than the traditional 25mm markers) have allowed

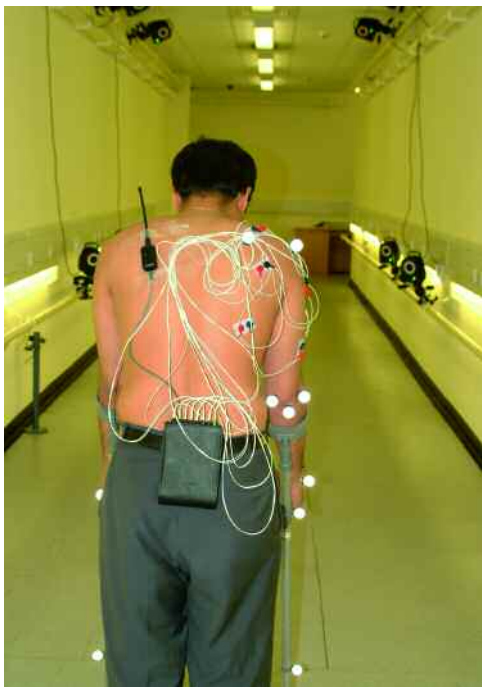
us to evaluate aspects of movement such as the joints of the spine, hands and feet. We have several studies of this nature

WE HAVE BEEN INVESTIGATING IT NOW FOR ALMOST 10 YEARS AND IT HAS BEEN OUR FIRM BELIEF, FOR SOME TIME, THAT FOOTWEAR IS THE MAIN CAUSE OF ANKLE INJURIES

underway and more in the pipeline."
An example of the wide reaching aspects of the work of IMAR is from a large study of footwear. One such study was the evaluation of the support offered by running shoes. This study was originally started around six years ago. The proposal was to take a sample of running shoes from three brands and three price categories – inexpensive, medium and expensive. It is quite likely that most people would assume that the more expensive the running shoe the better its design and structure, and also that they would offer the runner a superior level of comfort and support. Not so, says Professor Abboud. "We compared comfort, pressure attenuation and shock absorption within each of these categories of sports shoes, and the results showed that the inexpensive and medium shoes were as good as the most expensive, if not better in some instances. In other words, paying more for your sports shoes does not guarantee a better quality. The first phase of this study, published in the British Journal of Sports Medicine, formed a small part of a bigger project which evaluated many aspects of running shoes, and in fact, we have now studied over 100 pairs of running shoes of different designs." IMAR is engaged in a series of projects concerning footwear and biomechanics, which could ultimately help shoe manufacturers design better footwear.

"Proprioception is another element of biomechanics that we strongly believe needs to be examined," says Professor Abboud. "We have been investigating it now for almost 10 years and it has been our firm belief, for some time, that footwear is the main cause of ankle injuries. Recent studies have confirmed this by showing a direct link. "Here is an example that most people should be able to relate to. Imagine yourself walking. If you are walking barefoot you will never twist or invert your feet/ankles. However, if you are wearing shoes or sandals, the possibility of twisting them would be higher."

An area of research that is a particular focus for Professor Abboud is the issue of footwear support, proprioception and the diabetic foot. "When I was doing my own PhD, almost 18 years ago, I found that some diabetic patients suffered from muscle dysfunction. The Tibialis Anterior muscle, which decelerates the foot following heel strike, during normal walking, shows an abnormal firing pattern in diabetic patients and results in a forefoot slap as they walk.



This increases the pressure under the forefoot; the contact time of the foot on the ground; the duration of that contact, and so forth. Together, these factors facilitate the development of ulcers of the foot, which may ultimately result in amputation" says Professor Abboud.

Another major element of the work at IMAR is the Clinical Gait Analysis Service, run by Mrs Sheila Gibbs, Senior Clinical Scientist. This service has grown over the past 17 years and has seen through the various developments of the Vicon® hardware and software and continues to contribute to current developments.

Looking ahead, Professor Abboud and his IMAR team are working to further their research into the diabetic foot, by quantifying and modelling both motion and pressure data. The aim is to provide clinicians with a clinical service whose aim is to facilitate more effective treatment regimes. There are also studies underway evaluating the same group of patients using Vicon technology to examine endothelial (circulatory) dysfunction during gait.

Dundee is committed to using motion capture for the benefit of patients and sports enthusiasts, now and well into the future, by taking the research carried out in the Institute into the clinical and sporting arenas. ■

Conferences

North America

April

GAIT AND CLINICAL MOVEMENT ANALYSIS SOCIETY - 13TH ANNUAL MEETING
*VICON EXHIBITING
02-05 April 2008
Richmond, Virginia
www.amrms.com/ssl/gcmas/

AMERICAN ALLIANCE FOR HEALTH, PHYSICAL EDUCATION, RECREATION & DANCE
08-12 April 2008
Fort Worth, Texas
http://iweb.aahperd.org/Memberweb/convention/

SOUTHERN CALIFORNIA CONFERENCE ON BIOMECHANICS
11-12 April 2008
California Lutheran University,
Thousand Oaks, California
http://public.clunet.edu/~mleblanc/SCCB/

SOUTHEASTERN MEETING OF THE AMERICAN SOCIETY OF BIOMECHANICS
27-29 April 2008
Birmingham, Alabama
www.seasb.org/schedule.htm

May

NORTHWEST BIOMECHANICS SYMPOSIUM
09-10 May 2008
Boise State University
http://coen.boisestate.edu/NBSymposium/index.asp

INJURY BIOMECHANICS SYMPOSIUM
19 May 2008
Columbus, Ohio
http://medicine.osu.edu/ibrl/

AMERICAN COLLEGE OF SPORTS MEDICINE - 55TH ANNUAL MEETING
28-31 May 2008
Indianapolis, Indiana
http://www.acsm.org/Content/NavigationMenu/Education/Conferences/AnnualMeeting1/Annual_Meeting_Wrap_.htm

18TH ANNUAL CLINICAL GAIT ANALYSIS GAIT COURSE
28-31 May 2008
Hosted by Connecticut Children's Medical Center
Hartford, CT
wvasque@ccmkids.org

June

4TH INTERNATIONAL SYMPOSIUM ON ADAPTIVE MOTION OF ANIMALS & MACHINES
01-06 June 2008
Cleveland, Ohio
http://amam.case.edu/

SOCIETY FOR EXPERIMENTAL MECHANICS - SEM XI INTERNATIONAL CONGRESS & EXPOSITION
02-05 June 2008
Orlando, Florida
http://www.sem.org/CONF-AC-TOP.asp

2008 SUMMER BIOENGINEERING CONFERENCE
25-29 June 2008
Marco Island, Florida
http://divisions.asme.org/bed/events/summer08.html

July

AMERICAN COLLEGE OF SPORTS MEDICINE - REGIONAL MEETINGS *VICON EXHIBITING
16-19 July 2008
Sitka, Alaska
http://www.acsm.org/AM/Template.cfm?Section=Regional_Chapter_Meetings&Template=/CM/HTMLDisplay.cfm&ContentID=3535

August

AMERICAN SOCIETY OF BIOMECHANICS - 2008 ANNUAL MEETING
05-09 August 2008
University of Michigan
http://www.asbweb.org/

NORTH AMERICAN CONGRESS ON BIOMECHANICS
*VICON EXHIBITING
05-09 August 2008
Ann Arbor, MI
www.nacob2008.org

October

AMERICAN COLLEGE OF SPORTS MEDICINE - REGIONAL MEETINGS
16-17 October 2008
Springfield, MO
http://www.acsm.org/AM/Template.cfm?Section=Regional_Chapter_Meetings&Template=/CM/HTMLDisplay.cfm&ContentID=3535

SOCIETY FOR EXPERIMENTAL MECHANICS - 2008 SEM FALL CONFERENCE
27-29 October 2008
Springfield, Massachusetts
http://www.sem.org/CONF-FALL-TOP.asp

AMERICAN COLLEGE OF SPORTS MEDICINE - REGIONAL MEETINGS
October 2008
St Cloud, MN
http://www.acsm.org/AM/Template.cfm?Section=Regional_Chapter_Meetings&Template=/CM/HTMLDisplay.cfm&ContentID=3535

AMERICAN COLLEGE OF SPORTS MEDICINE - REGIONAL MEETINGS
October 2008
Mid West
http://www.acsm.org/AM/Template.cfm?Section=Regional_Chapter_Meetings&Template=/CM/HTMLDisplay.cfm&ContentID=3535

November

AMERICAN COLLEGE OF SPORTS MEDICINE - REGIONAL MEETINGS
November 2008
Southwest USA
http://www.acsm.org/AM/Template.cfm?Section=Regional_Chapter_Meetings&Template=/CM/HTMLDisplay.cfm&ContentID=3535

AMERICAN COLLEGE OF SPORTS MEDICINE - REGIONAL MEETINGS
November 2008
Mid Atlantic
http://www.acsm.org/AM/Template.cfm?Section=Regional_Chapter_Meetings&Template=/CM/HTMLDisplay.cfm&ContentID=3535

AMERICAN COLLEGE OF SPORTS MEDICINE - REGIONAL MEETINGS
13-14 November 2008
Boston, MA
http://www.acsm.org/AM/Template.cfm?Section=Regional_Chapter_Meetings&Template=/CM/HTMLDisplay.cfm&ContentID=3535

December

AMERICAN COLLEGE OF SPORTS MEDICINE - ADVANCED TEAM PHYSICIAN COURSE
11-14 December 2008
Austin, Texas
http://www.acsm.org/AM/Template.cfm?Section=Advanced_Team_Physician_Course

Vicon Setting the standard for Life Sciences

Rest of the World

April

THE BRITISH ASSOCIATION OF SPORT & EXERCISE SCIENCES - 2008 ANNUAL STUDENT CONFERENCE
*VICON EXHIBITING
03-04 April 2008
Bedfordshire University, UK
http://www.bases.org.uk/newsite/studentconf.asp

ENDOCORONARY BIOMECHANICS RESEARCH SYMPOSIUM
10-11 April 2008
Marseilles, France
http://www.congres-ebr.com/

5TH WORLD CONGRESS OF SPORTS TRAUMA & 6TH ASIA PACIFIC SOCIETY FOR SPORTS MEDICINE MEETING
11-13 April 2008
Hong Kong, China
http://www.cuhk.edu.hk/whoctr/wcst2008/

6TH STAFFORDSHIRE CONFERENCE ON CLINICAL BIOMECHANICS *VICON EXHIBITING
25-26 April 2008
Staffordshire University, UK
http://www.staffs.ac.uk/sccb/

NSCA EUROPEAN CONFERENCE 2008 FOR SCIENTIFIC STRENGTH & CONDITIONING
28-29 April 2008
Amsterdam, Netherlands
http://www.associationhq.com/nsca/2008/

May

4TH INTERNATIONAL SYMPOSIUM ON SWIMMING & SCIENCE
15-16 May 2008
Warsaw, Poland
http://www.awf.wroc.pl/awfnew/english/site.php?ID=K21

June

INTERNATIONAL SPORTS ENGINEERING ASSOCIATION - 7TH INTERNATIONAL CONFERENCE
02-06 June 2008
Biarritz, France
http://www.isea2008.estia.fr/

INTERNATIONAL SOCIETY OF BIOMECHANCIS IN SPORTS ANNUAL MEETING
14-18 June 2008
Seoul, Korea
http://www.isbs2008.org/

INTERNATIONAL SOCIETY OF ELECTROPHYSIOLOGY & KINESIOLOGY - XVII ANNUAL CONGREE
18-21 June 2008
Ontario, Canada
https://www.isek2008.ca/default.asp

July

INTERNATIONAL SOCIETY OF BIOMECHANICS IN SPORTS
*VICON EXHIBITING
14-18 July 2008
Seoul, Korea
http://http://www.isbs2007.com

10TH INTERNATIONAL SYMPOSIUM OF 3D ANALYSIS OF HUMAN MOVEMENT
02-04 July 2008
Amsterdam, Netherlands
http://www.3dma-08.org/

EUROPEAN SOCIETY OF BIOMECHANICS - 16TH CONGRESS
*VICON EXHIBITING
06-09 July 2008
Lucerne, Switzerland
http://www.esb2008.org/

EUROPEAN COLLEGE OF SPORT SCIENCE - 13TH ANNUAL CONGRESS
*VICON EXHIBITING
09-12 July 2008
Estoril, Portugal
http://www.ecss-congress.eu/index.php

ESM2008: INTERNATIONAL CONFERENCE ON DYNAMIC LOAD DISTRIBUTION IN BIOMECHANICS
28-31 July 2008
Dundee, Scotland
http://www.ESM2008.com/

August

JOINT PRE-OLYMPIC CONGRESS ON SPORTS SCEINCE & SPORTS ENGINEERING
05-07 August 2008
Nanjing, China
http://olympiccongress.org

IEEE 30TH ANNUAL INTERNATIONAL CONFERENCE OF ENGINEERING IN MEDICINE & BIOLOGY SOCIETY
20-24 August 2008
Vancouver, Canada
http://www.embc2008.com/

INTERNATIONAL CONGRESS OF THE POLISH SOCIETY OF BIOMECHANICS 2008
31 August-03 September 2008
Warsaw, Poland
http://www.biomechanics2008.awf.wroc.pl/index_en.php

September

THE BRITISH ASSOCIATION OF SPORT & EXERCISE SCIENCES - 2008 ANNUAL CONFERENCE
*VICON EXHIBITING
02-04 September 2008
Brunel University, UK
http://www.bases.org.uk/newsite/annualconf.asp

1ST CONGRESS FOR THE INTERNATIONAL FOOT & ANKLE BIOMECHANICS COMMUNITY
04-06 September 2008
Bologna, Italy
http://www.i-fab.org/

EUROPEAN SOCIETY OF MOVEMENT ANALYSIS FOR ADULTS & CHILDREN - XVII ANNUAL MEETING
*VICON EXHIBITING
11-13 September 2008
Antalya, Turkey
http://www.esmac.org/

3RD WORKSHOP ON BIOMECHANIAL EXPERIMENTATION
16 September 2008
Bern, Switzerland
http://www.ircobi.org/

October

ASICS CONFERENCE OF SCIENCE & MEDICINE IN SPORT
16-18 October 2008
Hamilton Island, Australia
http://www.sma.org.au/ACSMS/2008/

Literature Update: The Standard

DR. ED BIDEN

THE MOST ENJOYABLE ASPECT OF WRITING A BRIEF COLUMN SUCH AS THIS IS THAT IT PROVIDES THE OPPORTUNITY, PERHAPS "EXCUSE", TO REVIEW A MUCH WIDER RANGE OF MATERIAL THAN WOULD BE THE CASE IN ONES DAY TO DAY ACTIVITIES.

Sports Movement

We begin with Bartlett, R., Wheat, J., Robins, M.,"Is movement variability important for sports biomechanists?" Sports Biomechanics, Vol 6, # 2 2007, pp 224-243. This paper surveys a wide range of work on movement variations in sport. They examine the variability reported in three different sports, javelin throwing, basketball shooting and running. For the two throwing activities they find that the patterns of motion for different athletes are quite different and they speculate that there is not actually such a thing as an optimal pattern which would work for everyone. They find that among high level athletes in the javelin throw, variability is reduced during competitions when compared to training. This suggests to them that the observed variations in movement patterns may not be "noise", but rather be the end result of mechanisms which adjust so that excessive repetitions of identical loads are avoided to protect the body.

Their discussion of locomotion, particularly running, was of most interest to me. They draw on various sources and conclude that there is evidence that risk of injury is related, in an inverse fashion, to variability. Their thesis, which they admit is not demonstrated conclusively at this point, is that variability in movement patterns protect the athlete from overuse syndromes. Their conclusion is that in analysis of sports there should be considerably more attention paid to measurement of multiple cycles to allow assessment of variation within the individual as well as comparisons to group averages. If this is the case in sports, then is it also something which should be considered in clinical settings.

Milwaukee Foot Model

It is interesting to speculate whether being able to separate intra and inter subject variations would have affected the results reported in: Canseco, K., Long, J., Marks, R., Khazzam, M., Harris, G., "Quantitative characterization of gait kinematics in patients with hallux rigidus using the milwaukee foot model", Journal of Orthopedic Research, EPub Ahead of Print, Oct 30, 2007. These authors use a 15 camera VICON and the Milwaukee Foot Model (MFM) to compare a group of 22 people with Hallux Rigidus to a group of 25 normals. This should be recognized as a substantial series. The biomechanics is of interest because the foot model which they use approximates the foot as four interacting segments and allows measurements of quite subtle motions. Using the MFM they are able to measure and report that the primary differences seen in this population were consistent reduction in hallux dorsiflexion and metatarsal plantarflexion. Both these motions would be difficult to observe using a less flexible model.

They approach the comparison between the two groups from the standpoint of population comparisons and produce a set of results which identifies statistically significant differences in motion ranges. Their results have quite high variability and it would be very interesting to know whether the variation within an individual is as high as the variation of the group and how much impact this has on the comparisons.

THEIR CONCLUSION IS THAT IN ANALYSIS OF SPORTS THERE SHOULD BE CONSIDERABLY MORE ATTENTION PAID TO MEASUREMENT OF MULTIPLE CYCLES TO ALLOW ASSESSMENT OF VARIATION WITHIN THE INDIVIDUAL AS WELL AS COMPARISONS TO GROUP AVERAGES.

Increasingly, motion analysis is being applied to analysis of the arm. Also, the use of motion analysis is being taken up by more and more disciplines in order to

provide quantitative assessment. The next three papers look at an application in whole body motion in sports; one in brain research; and a very nice presentation of the development of a model for assessment in primates.

Arm Biomechanics in Throwing

Sachlikidis, A., Salter, C., "A biomechanical comparison of dominant and non-dominant arm throws for speed and accuracy", Sports Biomechanics, Vol 6, #= 3 2007 , pp 334-344 develop an argument that high level athletes may benefit from becoming as ambidextrous as possible. The argument is that the ability to use both hands, or both feet, increases performance capacity in general and in some sports is critical. They then proceed to conduct an experiment with high level cricket players performing overhand throws. Using a combination of a 250 Hz 8 camera VICON 612 and other high speed video they measure whole body movement using a previously defined model which divides the throw into 6 phases. They then compare timing and postures within each phase. The paper provides an example of good use of multiple technology. The VICON system is used to track the throwing motion but the actual ball motion tracked separately using high speed video. They demonstrate that the throws with the dominant and non-dominant arms are quantitatively different and the results could be used to create training regimes to achieve the objective of making the thrower more "ambi-lateral". An interesting aspect, in light of the paper by Bartlett et al, is that the variability as measured by standard deviation was consistently higher on the dominant side than was the case on the non-dominant side. One might speculate whether these athletes were consciously or unconsciously introducing variation in their strong throws to protect themselves from injury.

Neural Control

Assessment of motion as way of demonstrating various neural control strategies is the subject of Lee, G., Fradet, L., Ketcham, C., Dounskaia, N., "Efficient control of arm movements in advanced age", Journal Experimental Brain Research, Volume 177, #1, 2007, pp 78-94. Drawing straight lines is a task that has been used widely to assess coordination and how well people can regulate motions. This paper looks at the ability to draw straight lines on a flat surface and compares young adults, in roughly their third and fourth decades, with older adults in their seventh and eighth decades. The line drawing task was done seated with the trunk restrained and a sling used to support the arm so as to minimize the effect of gravity. The participants drew a sequence of straight lines following a pattern while their arm motions were captured using a 3D motion tracking system. Their movements were assessed for the frequency content, accuracy, and relative inertial and muscular moments. It is interesting to me that the only consistently significant differences were in the frequency content of the motions, with the older population being generally slower. One wonders if the extreme simplification of the tasks and the constraints placed on the subjects contributes to this result. At some level this approach of reducing the task to an extremely simple one which can be analysed with planar models is the opposite of Canseco et al where they try to take an actual activity and approach it with a measurement model of sufficient complexity to measure the subtleties.

Primate Reaching

The final paper in this review is Chan, S., Moran, D., "Computational model of a primate arm: from hand position to joint angles, joint torques and muscle forces", Journal of Neural Engineering, Vol 3, 2006, pp 327-337. This paper applies motion analysis and modeling techniques which have been used in human movement analysis to a primate model. They use a 3D motion tracking system and the SIMM muscle modeling system to assess reaching in small primates. In some ways there is nothing particularly new in this paper other than it seems they are addressing an audience who are unfamiliar with such techniques. As a result, this would make an excellent teaching paper because it provides a very high level of detail as to how they approached the problem of defining the limb, and particularly muscle, geometry and how they then used this in combination with movement tracking to model the kinematics and kinetics of the arm. They even provide a supplemental link to Matlab software to implement their solution.

WITH THE SYSTEMS WE HAVE TODAY THIS IS MUCH LESS OF A LIMITATION AND THESE PAPERS SUGGEST EXPLICITLY OR BY IMPLICATION THAT THERE MAY BE ELEMENTS IN WITHIN-SUBJECT VARIATIONS WHICH ARE IMPORTANT.

These papers have made me curious about whether we should be more focused on intra-subject variation. When quantitative movement analysis began 50 years ago the focus had to be on measuring "typical" examples because the effort involved in film digitization made multiple measures for single individuals impractical. With the systems we have today this is much less of a limitation and these papers suggest explicitly or by implication that there may be elements in within-subject variations which are important. ■

Nuffield Orthopedic Centre Raises £10,000.00 For Action Medical Research

Vicon would like to congratulate the Nuffield Orthopedic Center in Oxford, UK for participating in the challenge of a lifetime and cycling 300 miles from London to Paris. The team raised a staggering £10,000.00 for Action Medical Research www.action.org.uk as well as challenging their fitness levels and willpower.

From left to right: Andy Wainwright, Rob Buckingham, Vince Webb (front row), Rachel Buckingham (back row), Jo Bates (middle), Jennifer McCahill (middle), Hilary Bridge (back row), Jon Warwick, Mark Selfridge, Tim Theologis

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