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IMAR: an Overview of Activity

The University of Dundee's Orthopaedic and Trauma Surgery Department has been at the forefront in 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, 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 by acquiring the Gait Analysis Laboratory from the NHS. IMAR is ideally situated to collaborate with both NHS and University clinical departments to promote excellence in teaching and research and to provide a comprehensive service in the fields of biomechanics, gait and motion analysis.

In January 2012, Professor Abboud was awarded an Honorary Fellowship (FRCS) from the Royal College of Surgeons (RCS) of England in recognition of his dedication towards teaching, training and research in Orthopaedics and Biomechanics. The Fellowship is the highest recognition that the RCS can award and can only be awarded to a maximum of up to 30 living non-medically qualified individuals at any one time.

IMAR is privileged to have one of the leading Gait Analysts in Europe, Mrs Sheila Gibbs, leading our Clinical Gait Analysis Services. In March 2012, Sheila was elected Chair of the Clinical Movement Analysis Society (CMAS) for two years. We are also fortunate in having an extremely gifted Technical Manager in Dr Graham Arnold who completed his PhD in 2011 developing a unique three-dimensional force system for 3D foot pressure measurement (patent 1109423.2).

IMAR boasts five state of the art five laboratory facilities which include:

- Foot Pressure Analysis Laboratory
- Gait Analysis Laboratory
- Sports Biomechanics Laboratory
- Materials Testing Laboratory
- Disability Research and Assessment Laboratory

One of the most recent developments was the addition of a 32 metre long sports biomechanics laboratory (pictured below) in January 2007. This superb new lab was added 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. This has now led to a close working relationship between various professional Football Clubs and IMAR.

Clockwise left to right: marker placement; running research; football shoes study; investigation of cricket bowling action; Pedar in-shoe analysis – running shoes study; wheelchair/seating propulsion technique research.

Since 2002, a plethora of high-tech equipment has been acquired for biomechanical research and translation into clinical applications, a full list of which can be seen on page 8.

One of the force platforms in the Sports Biomechanics Laboratory is sited on rails such that the different stride lengths of various athletes during running or walking can be accommodated. There are 26 Vicon® MX13, F40 and T20 cameras, which are ideal for the work being carried out at IMAR as they are able to capture up to 400Hz and up to 4million pixels, significantly

faster and more accurate than previous generations of Vicon® cameras. We have recently invested in dedicated high-tech equipment, such as golf and racing cycle simulators, which are synchronised with our existing pressure equipment and the Vicon® systems.

Clockwise left to right: golf swing analysis; bicycle saddle development; research into tennis elbow symptoms; RTA rapid extrication procedures; three-dimensional CAD of the Foot; gait analysis of cerebral palsy children.

All of these elements have enabled Professor Abboud and his team, which is supported by approximately 35 research students every year, to undertake research studies based on a degree of detail beyond the reach of other facilities:

> "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 underway and more in the pipeline."

An example of the wide reaching aspects of the work of IMAR can be seen from a large study of commonly available footwear. One such study evaluated the support offered by different brands of running shoe. This study originally began twelve 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.

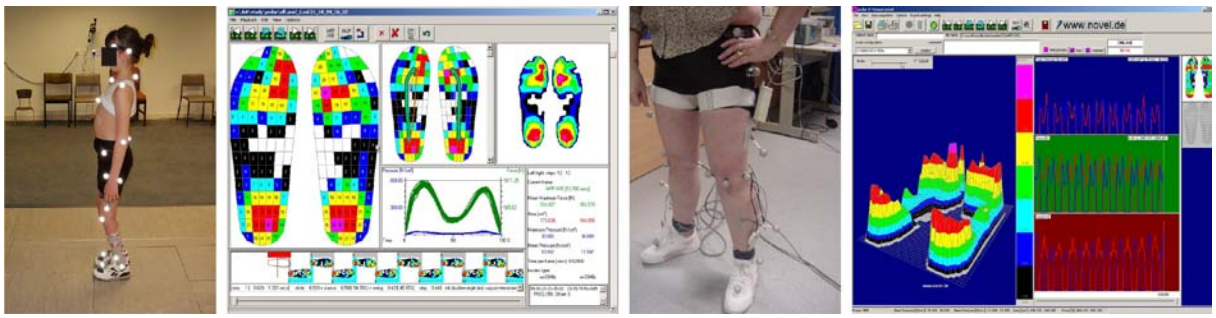
> "We compared comfort, pressure attenuation and shock absorption within each of these categories of sports shoes, and the results showed that the inexpensive and medium priced shoes were as good as the most expensive, if not better in some instances. In other words, paying more for your sports shoes does not guarantee a better shoe. The first phase of this study, published in the British Journal of Sports Medicine (Clinghan *et al.* 2008), formed a small part of a larger 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.

Clockwise left to right: laser marker placement; barefoot lower limb gait and pressure analysis; football boot research study; the One Show, BBC Television at IMAR; ankle proprioception stability using hydraulic platforms.

Proprioception is another element of biomechanics that we strongly believe needs to be examined. We have been investigating it now for almost 16 years and it has been our firm belief, for some time, that footwear is the main cause of most types of ankle injuries. Recent studies have confirmed this by showing a direct link.

An area of research that is a particular focus for IMAR is the diabetic foot. Almost 19 years ago, we found that diabetic patients suffered from muscle dysfunction. The tibialis anterior muscle, which decelerates the foot following heel strike during normal walking, showed an abnormal firing pattern in diabetic patients resulting in a forefoot slap. This increased the pressure under the forefoot; the instant of contact time of the forefoot on the ground; the duration of that contact, and so forth. Together, these factors facilitate the development of foot ulcers, which may ultimately result in amputation when combined with proprioceptive deficiency and/or ill-fitting footwear.



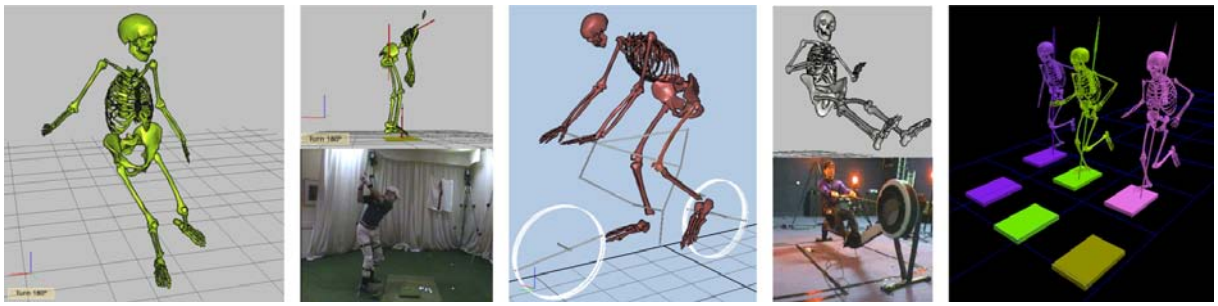
Clockwise left to right: gait analysis in cerebral palsy children; software data for foot pressure measurement; lower limb motion research; peaks of foot pressure and graphical data.

A further area of major interest is clubfoot. We have recently introduced a new scoring system, the IMAR-Scoring System, as well as a novel IMAR-Clubfoot pictorial scale. Both aim to predict relapse and assist surgeons in the evaluation of clinical and surgical outcomes.

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

Looking to the future, the IMAR team is 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.



Clockwise left to right: 3D model studying football techniques; golf swing analysis; research into cycling saddle pressures and groin blood flow; research into energy expenditure during rowing; 3D models of running styles in athletes.

Staff at IMAR

Professor Rami J Abboud ~ Director and Head of Department
Dr Graham Arnold ~ Technical Manager
Mr Ian Christie ~ Postgraduate Skills Tutor and Graphic Design
Dr Tim Drew ~ Senior Lecturer
Mr Arpit Jariwala ~ Clinical Lecturer (Orthopaedic Surgeon)
Mr Ian Gibbs ~ Rehabilitation Technician
Mrs Sheila Gibbs ~ Principal Clinical Gait Analyst
Mrs Sheila MacDonald ~ PA to Professor Abboud
Mr Sadiq Nasir ~ IT Developer and Project Support
Mr Arun Ramanathan ~ Clinical Research Fellow (Orthopaedic Surgeon)
Dr Weijie Wang ~ Senior Lecturer

Current IMAR Equipment

The Institute of Motion Analysis at Dundee University is dedicated in providing the best clinical and research facilities regarding motion capture that we possibly can. In order to achieve this it is paramount that we have the latest high-specification equipment available to researchers, clinicians and teachers. Below is a detailed alphabetical inventory of available equipment:

- 2D CAD system for insole manufacturing
- 3D CAD system for insole manufacturing
- 3D flat screen television
- ADC11. High-resolution two-channel analogue data capture
- ADCV-55. Video to digital converter and mixer
- Balance board with wii
- Barefoot Emed-m pressure system with portable runway
- Barefoot Emed-St4 pressure system
- Barefoot Emed-X pressure system with portable runway (sports)
- Bicycle simulator setup
- Biometrics myometer, pinchmeter, goniometer and data logger
- CareFusion Oxycon Pro™ fully-featured cardiopulmonary exercise testing unit
- CrazyFit massage and exercise vibration platform
- Cricket simulator setup
- Dual high-speed digital video capture
- Dynamic robot for proprioception assessment
- Eight-channel wireless electrodes bipolar Delsys Trigno EMG system
- Fastrak 3D goniometry system
- Foot and ankle hydraulic platforms
- Force plate calibration unit
- Formula 1 driving simulator cockpit
- GAITRite Gold gait measurement system
- Golf simulator setup
- Inshoe Pedar-m pressure system
- Inshoe Pedar-X pressure system (sports)
- Inshoe pressure calibration trublu system
- Isotrak 3D goniometry system
- LDS 2kHz vibration controller and shaker motors (e.g. simulating the effect of vibration in Formula 1 racing cars)
- Motor car with removable sections for road traffic accident extraction trials

- Muscle stimulator
- One wired two channels Delsys EMG system
- Oxycon ECG recorder
- Oxycon mobile wireless ergospiratory system
- Oxycon professional ergospiratory system
- Pedcad CAD/CAM automated orthopaedic design manufacturing system
- Pico Scope 3425. USB data capture unit
- PicoScope. Single-channel analogue signal recorder
- Pliance bicycle pressure map
- Pliance equestrian pressure map
- Pliance pen pressure system
- Pliance pressure calibration trublu system
- Pliance wheelchair/seating pressure map
- Portable 3D laser scanner
- Quad video capture system
- Scientific foot pressure analysis software
- Segway. Two wheeled self-balancing personal transport system
- Smartwheel wheelchair movement analyser
- Treadmill, exercycle and rowing machine
- Two 50" plasma televisions
- Two blood pressure and heart rate monitor mobile units
- Two wireless eight channels bipolar EMG TMSI systems
- Two wireless four-channel EMG TMSI systems
- Vicon 612 motion capture system with eight JAI cameras (50Hz) and two Kistler force plates plus four movie cameras
- Vicon F40 high-speed motion capture system (370Hz) with eight high-resolution (4megapixel) cameras and on board data processing of 136,000 markers per second
- Vicon MX13 high-speed motion capture system (up to 400Hz) with 12 high-resolution (1.3megapixel) cameras with 3D CMOS sensors and four AMTI high-frequency platforms (for sports) and two 100HZ colour digital cameras
- Vicon T20 high-speed motion capture system (400Hz) with six high-resolution (2megapixel) cameras, on board data processing of 136,000 markers per second and two AMTI high-frequency platforms
- Xbox with Kinect
- Zoewik Roell Universal Testing Machine