VICONPEAK

THE STANDARD

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EXPLORING COMPLEX MOVEMENT DISORDERS THROUGH SHARED ASESSMENT – new challenges through shared assessment

by Diane Damiano, PhD PT

The Shared Movement Assessment Center (SMAC) in the Department of Neurology at Washington University specializes in the analysis of individuals with complex movement disorders for both clinical and research purposes. As an integral part of the Cerebral Palsy Center at St Louis Children's Hospital, the primary goal of our research efforts is to improve the lives of persons with cerebral palsy by enhancing their motor capabilities.

Dr. Brunstrom reviewing a clinical study with Julie Weber, the research physical therapist. Looking on is our administrator, Freda Branch.

While the mission of the center as stated is hardly unique, the fact that it is housed within the Department of Neurology is somewhat atypical as most similar clinical and/or research facilities have tended for the most part to be housed within orthopaedic departments. Applications for motion analysis technologies within the medical field alone have been expanding rapidly in recent years not only across clinical disciplines, but across different diagnoses and with respect to other types of movement difficulties beyond level gait at a self-selected speed (see Figure 1). Our facility is consistent with the above trends and in addition, we also exemplify the growing interest in relating biomechanical changes to the underlying neurophysiology of central nervous system disorders.

The SMAC houses a Vicon 612 Motion System with eight M2 cameras and workstation, Polygon and BodyBuilder software, all provided by a grant from the National Center for Research Resources which requires that the system be requested and utilized by a team of at least three NIH-funded investigators. These individuals include Janice Brunstrom MD, a pediatric neurologist who is the Medical Director of the facility, Diane Damiano PhD, a physical therapist and researcher who primarily evaluates and studies individuals with cerebral palsy in collaboration with Dr. Brunstrom and others, Joel Perlmutter MD, a neurologist and senior scientist renowned for his work in adult movement disorders particularly Parkinson Disease, and John McDonald MD PhD, a well-recognized spinal cord researcher/physician who now heads the International Center for Spinal Cord Injury at Kennedy-Krieger Institute in Baltimore. In addition to the Vicon Motion capture system, the SMAC also has two Kistler force plates, a Noraxon 16 channel EMG system with MyoResearch software, a Biodex System 3, and a touch screen computer for patient questionnaires, among other quantitative assessment instruments and tools.

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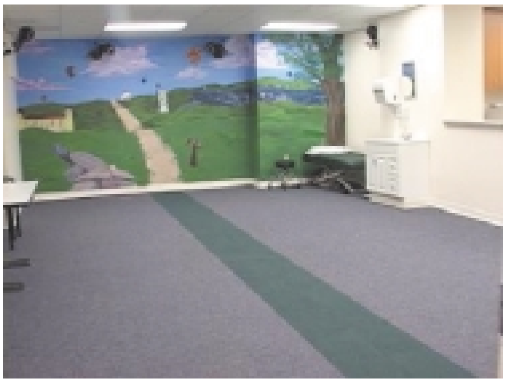

Figure 1.
A view of a patient in the laboratory who is being assessed on ramp ascent and descent.

This movement assessment center was the vision of Diane Damiano, who was previously the Research Director of the Motion Analysis and Motor Performance Laboratory in the Department of Orthopaedics at the University of Virginia before coming to Washington University in St Louis in 2000. Her research focus has been almost exclusively on characterizing motor impairments in children with cerebral palsy and on evaluating the effects of existing or novel interventions on gait and gross motor function. Several years ago, she and her colleagues challenged the conventional wisdom that strengthening was contraindicated for those with spasticity and they have since shown that direct muscle strengthening has a clinically important effect on motor performance in these individuals with no evidence of worsening spasticity. In fact, intense physical activity may actually decrease spasticity, an intriguing hypothesis that was proposed and recently tested by Dr. McDonald in collaboration with Dr. Sadowsky and Dr. Damiano in a project funded by the Christopher Reeve Paralysis Foundation. Using resistance torque and EMG measurements, these investigators demonstrated that, in addition to many other positive effects on health and function, subjects with spinal cord injuries who regularly used an FES-cycle had significantly lower spasticity and less of a need for spasticity reducing medication compared to age and injury matched non-exercising controls.

The clinical population we serve at the Shared Movement Assessment Center is very diverse and includes not only children with cerebral palsy, but has also included children and adults with other relatively common, rare, or as yet undiagnosed neurological deficits. Our interest also extends beyond (above) the lower extremity and we regularly employ the full body gait model in combination with EMG to evaluate dystonic posturing in the trunk and upper extremities. However, as initially intended, we are predominantly a research facility even though our clinical and research interests are inextricably linked.

One of the first novel intervention studies we conducted in our now two-year old center was an investigation lead by Dr. Janice Brunstrom on the use of levodopa for children with hypertonic cerebral palsy (CP). This project, funded by a Young Investigator Award from the Child Neurology Society, tested the hypothesis that many of the movement abnormalities in CP which are classically attributed to spasticity may actually be due to dystonia and would therefore respond positively to a medication that only addresses the latter symptom. Dr. Brunstrom believes that dystonia is far more common in CP than the 20% previously reported. We have conducted an open label trial of a short term course of levodopa on nine children with a diagnosis of spastic cerebral palsy who also demonstrated abnormal postures or movement patterns at rest or when attempting to perform various motor tasks that resemble those seen in persons with primary dystonia. Our two main outcome measures were upper extremity kinematics and lower extremity balance measures. Since no single ‘standard’ upper extremity 3-D kinematic model yet exists, we sought permission to use the one developed by Drs. George Rab and Anita Bagley from the Sacramento Shriners Hospital and adapted to Vicon motion capture systems by Ms. Robin Devorak from the Portland Shriners Hospital. We chose two upper extremity reaching to target tasks, one which emphasized accuracy and one which

Picture of Lab Staff including (left to right) Julie Weber, Julie Anderson and Cole, Jason Wingert and Diane Damiano. Far wall is a mural of Forest Park in St Louis by two young local artists.

emphasized speed of movement, and a rapid repetitive elbow flexion-extension task utilized previously by Dr. Amy Bastian, now of Kennedy-Krieger, as described in a published case study on the use of levodopa in an individual with CP with Dr. Brunstrom and colleagues, and which were adapted from Optitrak to our Vicon system. Figure 2 shows a stick figure for the dominant upper extremity 'reach to target' task in the sagittal plane with the target position shown in blue. The main output parameters we evaluated were peak wrist velocity (see Figure 3), 3-D wrist path and endpoint error as the person attempted to hold the finger position on the target. Consistent and statistically significant improvements were noted in these parameters as a result of the medication at both freely chosen and fast reaching speeds; however, these were not associated with functional gains on the Melbourne Assessment of Unilateral Upper Limb Function. We also evaluated tandem gait performance before and after medication on those subjects who were independently ambulatory. Based on the results from our pilot study, a larger, longer duration controlled trial is being planned.

We are also nearing completion of a pilot study funded by the United Cerebral Palsy Research and Education Foundation testing the hypothesis suggested by Allison Arnold, Scott Delp and their colleagues at Stanford University that lower extremity extensor strength training alone will improve the 3-D kinematics of crouch gait. Specifically, they proposed that as a result of intense strengthening, mid stance knee and hip position will be in greater extension with a concurrent reduction of stance phase hip internal rotation and adduction, and ankle dorsiflexion, if excessive. Future goals are to extend this investigation and perform dynamic simulations in collaboration with Arnold and Delp to model and predict which patients are more likely to respond positively to strength training and which may be more successfully treated through surgical or other interventions.

Two new investigations funded primarily though the NIH (NINDS and NCMRR) are just now underway in our center and involve close collaboration with neurologists and neuroscientists, specifically Dr. Brunstrom, Dr. McDonald, and Dr. Harold Burton who is an expert on somatosensory function and functional brain imaging. The first project involves the characterization of sensorimotor function in cerebral palsy and its relationship to sensory processing in the brain. Jason Wingert, a doctoral candidate in the Movement Science Program at Washington University who has been in the center since its opening, has received fellowship awards from the NIH and the Foundation of Physical Therapy to help support this project in addition to support from UCP. The sensory testing includes precise quantification of tactile discrimination and proprioception in both the upper and lower extremities which will be correlated to temporal-spatial and kinematic gait performance during free and fast speed walking with and without vision of one's lower extremities using 'dribble' glasses which allow one to look forward but not down (See Figure 4 for: a) photo of the dribble glasses and b) the proprioception testing device). Using the full body COM model and dual force plates, we will also evaluate standing balance with and without

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Figure 2.
Sagittal view of upper extremity 'reach to target' task in person with cerebral palsy. The red dots indicate the pointing finger and wrist markers, and the blue dot indicates the target.

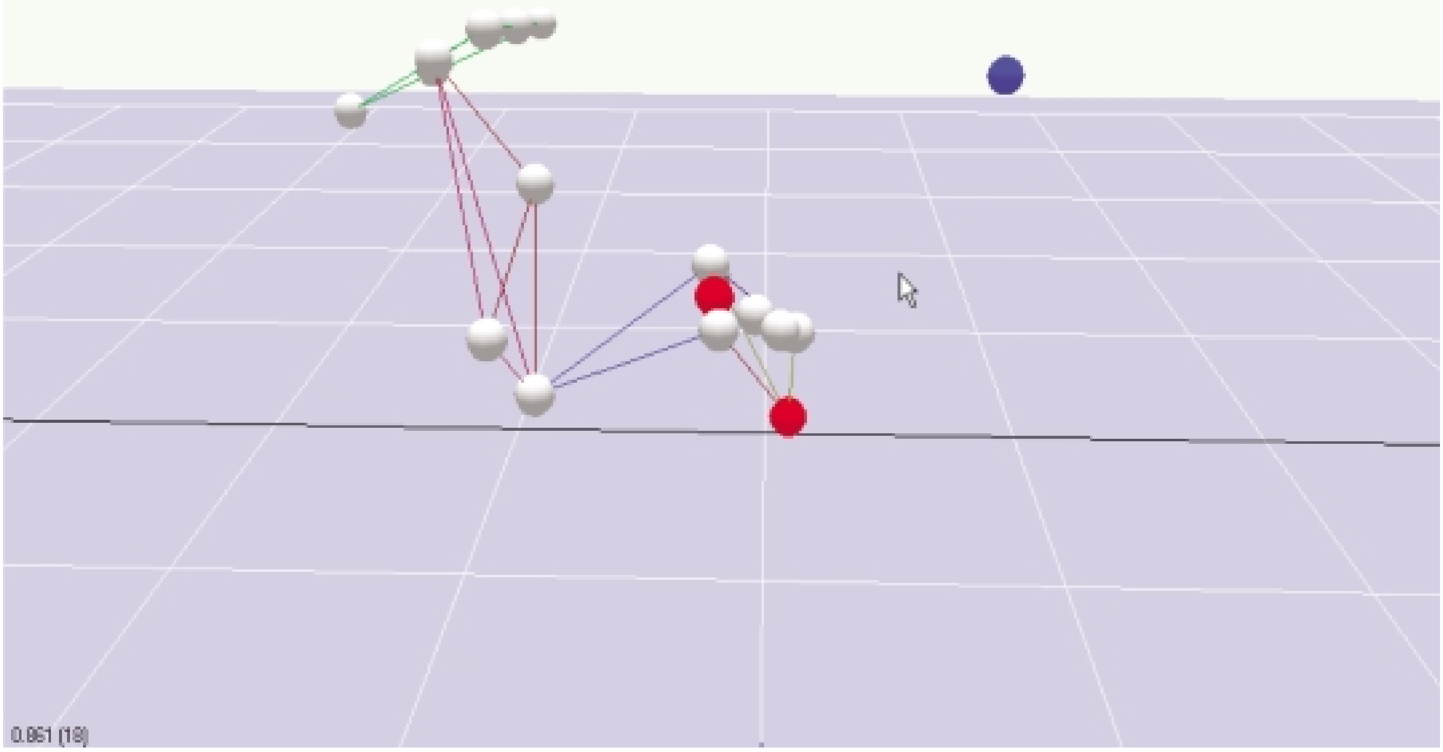
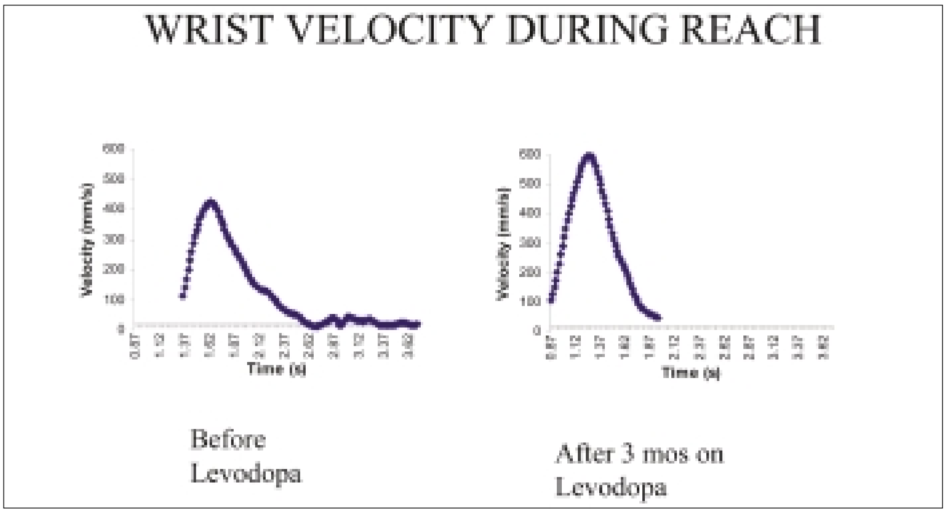


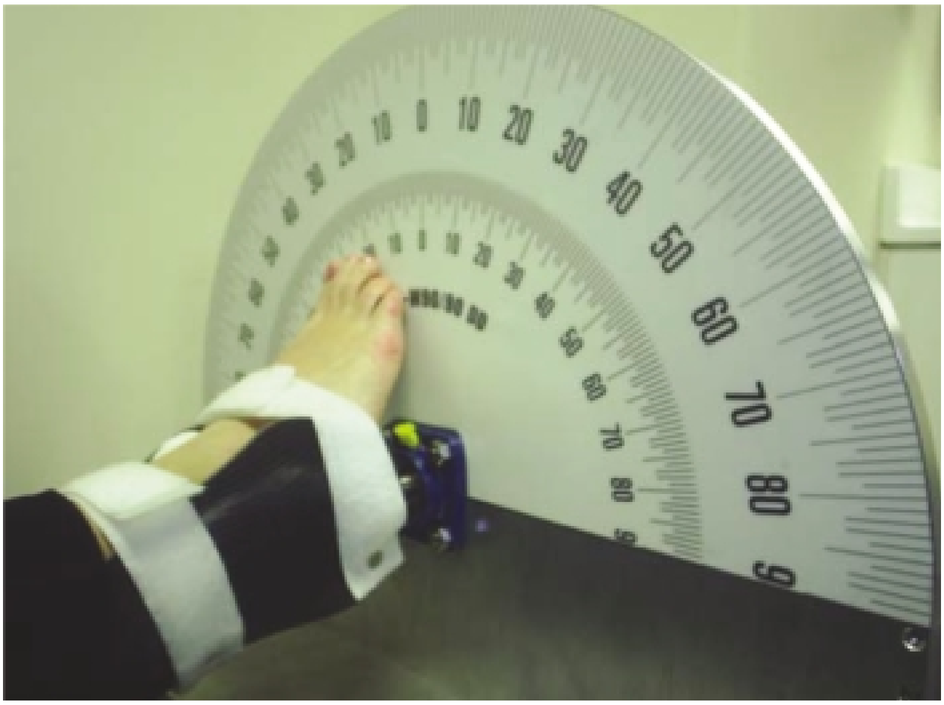
Figure 3.
Data from a single subject with cerebral palsy showing faster reaction time, greater peak velocity and less endpoint fluctuation after the course of medication



(a)

Figure 4.
A picture of (a) the 'dribble glasses used to test how much the loss of vision disrupts the gait kinematics and temporal spatial features. These data will be correlated with those obtained on (b) our quantitative device made in house that measures lower extremity proprioception.

(b)



vision – in essence, a quantitative Romberg Test. We hypothesize that sensory performance and processing will be deficient in CP compared to normal and that sensory function will be related to motor performance. The second investigation is focused on quantifying the effects of a novel intervention in CP, motor-assisted cycling, on lower extremity coordination during reciprocal lower extremity activities such as active cycling and overground walking, modeled after the investigations by Drs. McDonald and Sadowsky on the use of FES-cycles in patients with spinal cord injuries. As a secondary goal, Dr. Burton will lead the fMRI investigation of potential changes in cortical activation in response to a standardized lower extremity sensory stimulus before and after the intense training. We are testing the hypotheses of whether imposed fast reciprocal movements alone, in the absence of electrical stimulation, can alter spinal circuitry and drive changes in the spatial extent and magnitude of activation in the motor cortex.

Other important members of our team include Julie Anderson (Witka) who is now our part time engineer in addition to being a full-time new mom to Cole (See lab photos – Figures 5 & 6); Julie Weber is a research physical therapist who plays an integral role in the assessment of both clinical and research subjects and Freda Branch who heads the administrative aspects of the cerebral palsy center in general as well as for our facility. Our program is obviously very dependent on strong collaboration among our center's team and 'outside' clinical and basic scientists at Washington University and at other hospitals and universities across the country. In addition to projects we have initiated in our center, other investigators are encouraged to perform studies here with our assistance, for example, another doctoral student in the Movement Science Program mentored by Dr. Joel Perlmutter, recently completed a project evaluating arm swing in relation lower extremity step length and cadence across gait velocities in patients with mild Parkinson Disease compared to age-matched healthy controls. Examples of nearly completed or newly initiated projects that involve multi-center collaborations include the Functional Assessment Research Group (FARG) investigations led by Drs. Chet Tylkowski and Donna Oeffinger at Lexington Shriners Hospital, and a newly funded randomized placebo controlled trial on hamstring botulinum toxin injections led by Dr. Phil Gates of the Shreveport Shriners Hospital with Dr. Brad Racette, a neurologist here at Wash U, as the site PI. We are committed to the idea that advances in our understanding of movement abnormalities and the effects that treatments have on these abnormalities involve precise quantification, creative exploration and extensive collaboration. We feel that the motion capture community, in particular, has served as an excellent model of the pursuit of excellence in measurement and evaluation and of the willingness to share information and expertise to move our respective fields forward.

We appreciate this opportunity to introduce our center to the Vicon community and would like to thank Gerald Bishop and the STANDARD staff for this interest and assistance. If anyone would like to share information or to learn more about our center's clinical and research efforts, please do not hesitate to contact us at (314) 286-1581 or at *damianod@neuro.wustl.edu*

This is an image of the first brochure from Vicon. It will shortly take its place, along with a remarkable and interesting selection of equipment and accessories tracking the history of movement analysis and its development over the years, in the new Vicon Museum. This venture is gradually taking shape under the expert eye of Vicon's Engineering Director Tom Shannon who will act as the Museum's curator.

The oldest item currently ready for the museum catalogue is a 1982 First Generation Interface Unit. Vicon is currently shipping the sixth in the series to be improved and upgraded over the years as movement science has advanced and demands increased.

If any STANDARD readers are able to locate an example of a COTRON silicon tube camera (circa early 1980s) and its strobe unit (both painted an 'unusual' shade of brown!), Tom would be interested to hear from you. These were the first cameras sold after those shown in the brochure. So, if anyone can throw any light on this, just let us know.

Tom Shannon told THE STANDARD "In a future issue I hope to offer a personal acount of not only the significant but also the many minor decisions that were taken by a small team of dedicated people developing the future of movement analysis through more than two decades".

Editor's Note

Check out the STANDARD website: *www.viconstandard.org* for archived articles, a library of clinical paper summaries, news and the Image Library, as well as the current content of THE STANDARD. If you have a colleague who would like to register for THE STANDARD it can be accomplished easily online at *www.viconstandard.org*

We are always pleased to mention the presentation or publication of Vicon Users' papers, accompanied by the appropriate website connection if applicable and/or the publisher's details. Please send title, author and publication information with a short summary by e-mail to *gbishop441@aol.com* or post a copy of the paper itself to Gerald Bishop, Editor, The Standard, Gerald Bishop Associates, Hillview House, New Street, Charfield, Wotton-under-Edge, Gloucestershire GL12 8ES, England.

Incidentally, anyone searching for published papers can not only go to the "Papers" section of *www.viconstandard.org* but, for a wider search, to an extremely comprehensive collection of academic and professional publications at *www.ingenta.com* A recent check showed that over 17 million papers were online there from almost 30,000 publications. A search for "gait analysis" for example, produced a list of 905 and "Vicon" located 105. It is worth checking out.

Finally, check out the NASA website *www.nasa.gov* which is packed with interesting information. If you go to the Home page and type "ABF" into the Search box you will arrive at "Anthropometry and Biomechanics Facility (ABF)". A click on this line takes you to three choices – Equipment, Facilities and Projects. Click on "Projects" to see a list of various interesting aspects of NASA's work. Among these is a project entitled "Evaluation of a full body scanning technique for the purpose of extracting anthropometrical measurements" (numbered 12 in the list). Click on to see the Vicon 612 10-camera system in action. A click on "Equipment" in the three choices includes a description of the Vicon system.

IMAGING

3-D IMAGING OF MUSCLES AND BONES

by Nicola Fry, Adam Shortland.

One Small Step Gait Laboratory,
Guy's Hospital, London, England.

Adam and Nicky with the 3D probe

Researchers at the One Small Step Gait Laboratory in Guy's Hospi been developing a 3D ultrasound system for the measurement of r morphology using a Vicon 612, a primitive ultrasound scanner anc

Progressive muscular and bony deformities are features of cerebral palsy and other childhood disorders. It is during adolescence that the functional mobility of children with these conditions decline, with many losing their ability to walk in their late teens and early twenties. It is likely that deterioration in muscle properties and the compromise of the skeletal levers leads to this loss of mobility. If we had a good way of quantifying deformity at different stages in the development of the child we may be able to:

- Understand more of the natural history of deformity development.
- Intervene at an earlier stage to maintain function.
- Assess the effects of our interventions on local musculoskeletal deformity.

Medical ultrasound imaging has been around since the late 1960s, and is the most common imaging modality in the hospital environment. It has wide range of applications from assessing blood flow in the carotid artery to imaging tumours in the liver. 2D ultrasound is a useful but largely qualitative technique and in some areas it has been superseded by tomographic CT scanning and MRI. 3D ultrasound is a recent development but has great potential in quantitative imaging. 3D ultrasound is used routinely to assess the growing foetus or to inspect internal abdominal organs. These systems have exceptional accuracy but in general have a small scanning window. 3D scanning of limb segments requires that the position and the orientation of the probe can be registered over large distances. There are such freehand 3D systems available using magnetic tracking technology, but if you have a motion laboratory, a video frame grabber, a friend who is an ultrasonographer, and a bit of time on your hands, you could make one yourself!

Ultrasound probe with 3D localiser

The following step-by-step instructions are targeted at those in the laboratory with an engineering bent:

STEP 1: Find or buy an analogue 2D B-mode ultrasound machine with a 5 or 7.5 MHz linear array probe. Perfectly adequate, new examples can be bought for as little as $15000, but you may be able to "borrow" one from your local radiology department. Often, these analogue machines are being thrown away in favour of their hi-resolution digital counterparts. Make sure your ultrasound machine has a composite video output. It is wise to include your new purchase in a hospital-wide quality assurance scheme.

STEP 2: Construct a 3D localiser from the Vicon marker kit. We attach 4x 14 cm marker stems to a small Perspex™ block. It's best to keep the markers a good distance apart (at least 20 cm) to reduce errors. The Perspex™ block should be machined so that it locks to the surface of your ultrasound probe.

STEP 3: Fix the Perspex™ block to the probe and secure it (we use tie-wrap) (see Figure). Connect the video output of the ultrasound scanner to your analogue video framegrabber (or to your firewire card using a DV bridge).

STEP 4: Before you can image in 3D, you'll have to find the equation of the

tal, London, have musculoskeletal d video frame grabber.

plane of the ultrasound image with respect to a local co-ordinate system defined by the probe-mounted marker set (3D localiser). This is a bit of a challenge, but you should find the paper of Fry et al. most helpful. Once you've worked the calibration out, you will be able to find the global co-ordinates of any pixel within the ultrasound image as you move the probe through space.

STEP 5: You need to write a computer program to construct a 3D image block of voxels from the ultrasound video images and the co-ordinates of your 3D localiser using an interpolation algorithm. There are a number of algorithms you could choose from (for review see Rohling et al. 1998); we use a nearest pixel algorithm and it seems to work well. If you were very clever you could write a plug-in for Vicon Workstation!

STEP 6: To investigate and display sections through your 3D volume you will need to write a suite of programs, or you can buy a program such as Analyse or IDL. In principle, you could write the code in MATLaB but the memory management of the very large matrices involved may be a limitation.

STEP 7: If you are not well-acquainted with ultrasound machines then ask a radiographer to help you out and go on a course to familiarise yourself with the physics of ultrasound and its safe usage. Get yourself a musculoskeletal ultrasound atlas and a good anatomy book with lots of pictures. Now play with your new toy, making sure you have all the necessary ethical and institutional approvals.

Applications

There are a number of ways in which you can use your system to inform treatment decision-making and even get better motion analysis results!

Muscle morphology

The need for an alternative to the passive range of motion examination to measure muscle deformity is clear. Passive ROM is the primary tool used for treatment selection across the world yet the examination has poor intra- and inter-rater reliability and cannot distinguish without ambiguity the muscles or muscular components responsible for a limitation in joint range.

There is poor correlation between the static measurements of the clinical examination and the dynamic measurements from analysis of the child's movement, possibly because the factors that govern active and passive movements are not equivalent. Unambiguous statements describing the dimensions of muscles would help us to separate the contributions of deformity, weakness and neurological deficit to the patient's motor problems, directly informing treatment recommendations.

The Figure illustrates a 3D ultrasound scan of the calf musculature of a normally-developing child and a child with spastic diplegic cerebral palsy of similar age. The hope is that by measuring the response of muscles to different treatments (eg strengthening, Botulinum toxin and surgery) in research studies, we will be able to determine the optimum treatment for those attending our gait laboratory for clinical and ultrasonic assessment.

Anatomical modelling

The surface of bone can be identified under ultrasound scanning easily because it reflects so much of the incident acoustic power. This means that reconstructions of the bone surface can be made with 3D ultrasound. We have used this technique to estimate the centre of the femoral head with respect to a pelvic reference frame formed from the anterior and posterior iliac spines, and compared the results to those from MRI. In the medio-lateral and anterior-posterior directions there is exceptional agreement between the two methods (within a few millimetres), but work needs to be done to improve the accuracy

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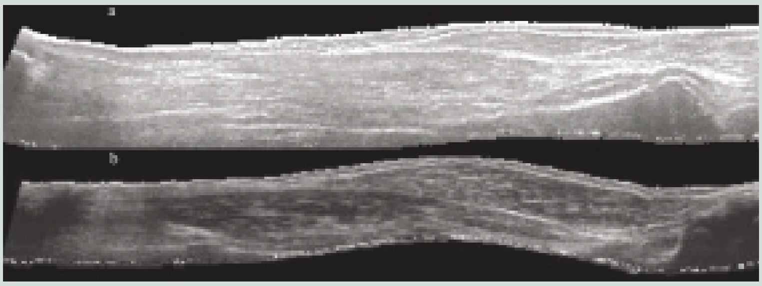
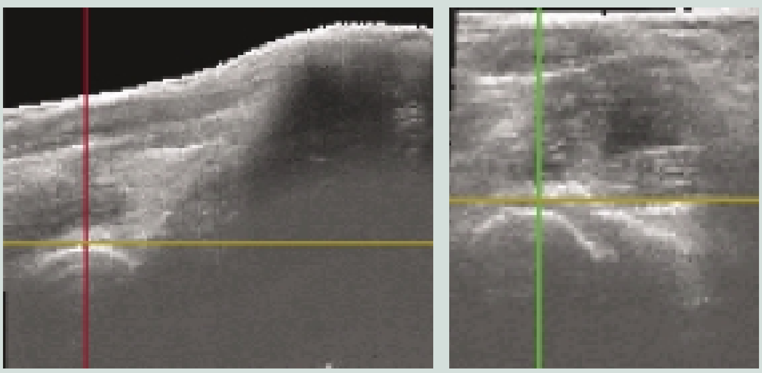


Longitudinal slices through the calf muscles of (a) child with spastic diplegic cerebral palsy and (b) a normally developing child. Skin surface is at the top of the images, knee at the right and ankle on the left.



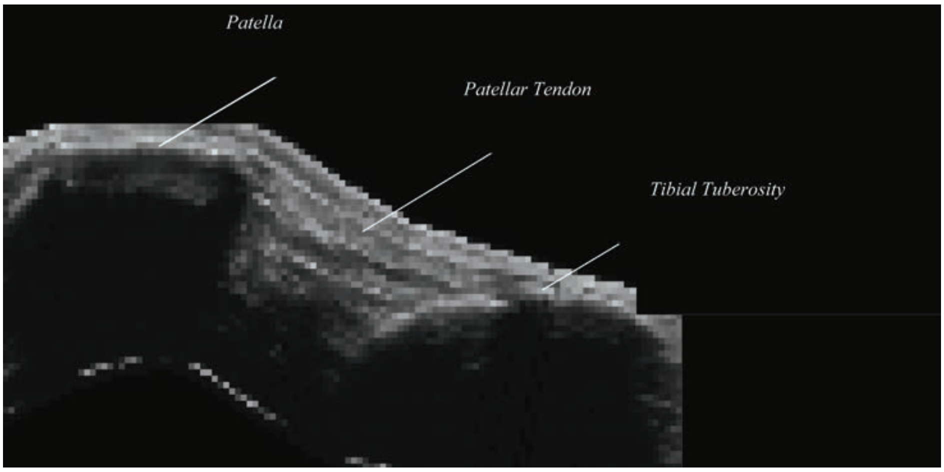
Longitudinal and transverse sections of a 3D volume containing the femoral head.

needs to be done to improve the accuracy of the method in the inferior-superior direction.

Our intention is to extend the technique to create partial surface reconstructions of the skeleton to enable a precise relationship between anatomical and technical reference frames to be found for individual subjects.

Bony morphology

In the clinical environment, tibial torsion, femoral anteversion and patella alta are measured by palpation of bony landmarks. Certainly, the lack of reliability of these measures may encourage a conservative approach to intervention being adopted. We have conducted 3D ultrasound studies in vitro and in vivo which indicate that 3D ultrasound can measure femoral anteversion and tibial torsion reliably, and in good agreement with the standard 3D CT method or MRI methods. Routine, serial measurements of bony torsion made possible with ultrasound will enable us to evaluate the natural history of skeletal deformity and its adaptation after surgical intervention.



Longitudinal section through a 3D ultrasound volume containing the patella and the proximal tibia.

In summary, 3D ultrasound is a safe imaging method that can be used to estimate the morphology of the musculoskeletal system. It is a useful adjunct to 3D gait analysis for the assessment of patients with muscle and bony deformities.

References

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VIDEOCONFERENCING

a new way of presenting reports

by Bjorn Lofterod
Chief Consultant,
Section for Child Neurology
Rikshospitalet University Hospital,
Oslo, Norway

The first clinical motion lab in Norway was established at our hospital as late as January 2002. Since then we have had an increasing demand for gait analysis from all over Norway. In the first year we performed 60 analyses and this year we will carry out approximately 150 analyses. Our staff is expanding and we have a multidisciplinary approach. The team consists of physiotherapists, orthotists and physicians (a child specialist neurologist and an orthopaedic surgeon). They all work part-time in the laboratory. We use a six-camera Vicon 612 system and two AMTI force plates. So far we have been very satisfied with the system and support. In the near future we hope to supplement our resources with a video vector system and equipment for evaluating oxygen consumption.

From the start we have focused on a close co-operation with the referring clinicians. We believe this is vital in order to give the patient the best advice. Hence it makes the physicians generally more as part of their treatment plan.

Our ideology is that the result will not be better than the weakest link in the chain. The team in the laboratory therefore tries to take responsibility for the whole chain and to secure any weak part. To achieve this aim good communication between the professionals that take part in the treatment is necessary

We make team conclusions. However final conclusions are always made in cooperation with the referring specialists, as they know the patient best and have good knowledge of the rehabilitation resources in the county. All the patients have a follow up post-treatment analysis. In order to evaluate our recommendations and results we are very much concerned that the patient follows the treatment plan outlined, including appropriate training and use of orthosis. Among patients receiving surgery we now know (through our own study of this subject) that the surgeons follow the preoperative gait analysis recommendations in more than 90 % of the cases.

Our ambition to play a major role in the patient's treatment plans has many challenges, such as the effective communication of our recommendations. So far we have communicated these recommendations to the referring specialists at regular meetings, which we call conclusion seminars. During these meetings the team presents the patient and analysis as displayed in a Polygon report. In the first two years we always had the seminars at our hospital. During that period we experienced inconsistency in attendance, and sometimes we found that the most important persons of the local rehabilitation team could not find time to meet. There may be many reasons for inconsistency in attendance, but for Norway high travelling expenses and unstable weather conditions mean a lot. The country has only 4.8 million people, but is very long and narrow and it takes about three hours to travel by air from the north to the south.

In order to achieve our goal concerning a close cooperation with the referring specialists we had to look for another way of organising some of the conclusion seminars. It turned out that all the cooperating hospitals had a videoconference system, but like us they hardly ever made use of it. Now, two years later, we have good experience in organising gait analysis conclusion seminars by videoconferencing with hospitals all over Norway. One definite advantage is that it allows more people to take part, as there are no travelling expenses to fund. The referring specialist can involve colleagues and local members of the multidisplinary team in the discussion. No travelling time means that all involved can make their day more efficient, and it is also easier to find time to suit everyone when you are not depending on public transport. All these facts ensure a better attendance, and hopefully a better final result for the patient. When the attendance improves more professionals learn about the possibilities and restrictions of gait analysis. This may in future lead to a better selection of high priority patients.

Before each meeting we send our Polygon report as a Word document by e-mail so all participants are prepared for the subsequent discussion. We and our colleagues at the other end have two screens. On one screen we can see the team from the other hospital (and vice versa), and on the other screen we present the patient by using an ordinary Polygon report. Details and future treatment are discussed before a joint conclusion is drawn. We use about 30 minutes for each patient presented and usually have two to three patients presented at each meeting. We use a Tandberg Videoconferencing System, but we believe there are also other high quality products on the market.

‘ all involved can make their day more efficient ’

One disadvantage is that the screen is smaller than the screen we use when we present the reports at our hospital. This may blur the text in the report. The picture may also sometimes appear a bit unclear, but this is usually a question of adjusting the system. Sound is rarely a problem. Videoconferencing will of course never be the same as having your colleagues in the same room, but it is close to it and the organisation is very convenient as a means of connecting specialist services.

There is a good cooperation between the motion labs in the Nordic countries (Denmark, Finland, Sweden and Norway). Three years ago we formed the Nordic Vicon User Group. The group meets twice a year for professional and social networking. A result from this teamwork is a Nordic normal reference database. As far as I know we are the only team in the group up to now that use videoconferencing in our clinical work. But future multicenter studies between the four countries may be a perfect challenge for more active use of videoconferencing with less attendant less travel expenses. We may also be able to establish joint discussions and consult each other concerning difficult cases using this useful method.

The movement analysis team. From left: Terje Terjesen (orthopaedic surgeon); Ann-Britt Huse (cpo); Bjorn Lofterod (child neurologist); Reidun Jahnsen (physiotherapist); Monica Johannessen (physiotherapist); Ingrid Skaaret (cpo).

A view of the movement analysis laboratory with a subject under test.

MEETING POINTS ...

American Academy of Cerebral Palsy & Developmental Medicine (AACPDM) – International Cerebral Palsy Conference at the Faculty of Medicine, University of Oulu, Finland from February 2 to 5, 2006; the 6th International Congress on Cerebral Palsy in Bled, Slovenia, entitled "New Advances in Treatment of Cerebral Palsy" from April 20 to 22, 2006 and the 10th International Child Neurology Conference at the Bonaventure Hilton, Montreal, Canada from June 11 to 16, 2006. See *www.aacpdm.org*

American Academy of Orthotists & Prosthetists The 2006 Annual Meeting in Chicago, USA will be held from March 1 to 14 at the Hyatt Regency Riverside Center. Details on *www.oandp.org*

American Academy of Physical Medicine and Rehabilitation (AAPMR) The 67th Annual Assembly will be at the at the Hilton Hawaiian Village Convention Center, Honolulu, from November 9 to 12, 2006. In 2007 it will be in Boston Massachusetts, USA at the Sheraton Marriott Hilton Hynes Convention Center from September 27 to 30, and in 2008 at the Marriott Convention Center, San Diego, California, USA from November 20 to 23. Information on *www.aapmr.org*

American Academy of Podiatric Sports Medicine The Annual Meeting in August 2006 is to be held in Las Vegas, Nevada, USA. Information, as it becomes available, on *www.aapsm.org*

American College of Sports Medicine – The 53rd Annual Meeting in 2006 is in Denver, Colorado, USA from May 31 to June 3. Details shortly on *www.acsm.org/meetings* The 54th Annual Meeting is currently planned for New Orleans, USA from May 30 to June 2, 2007.

American Alliance for Health, Physical Medicine & Rehabilitation National Convention in 2006 is from April 25 to 29 at the Salt Palace Convention Center, Salt Lake City, Utah, USA. ~ Details on *www.aahperd.org*

American Physical Therapy Association (APTA) The APTA Annual Conference 2006 will be held from June 21 to 24 in Orlasndo, Florida, USA. APTA website *www.apta.org*

American Podiatric Medical Association The Annual Scientific Meeting in 2006 will be from August 7 to 10 at MGM Grand, Las Vegas, Nevada USA. Poster submissions by February 1, 2006. Main site *www.apma.org*

American Society of Biomechanics The next Annual Meeting will be from September 6 to 9, 2006 at the Virginia tech – Wake Forest School of Biomedical Engineering & Sciences, Blacksburg, Virginia, USA. Meeting website is *www.asb2006.org* or e-mail for information to *aliceb@vt.edu* The Society website is *www.asb-biomech.org*

American Spinal Injury Association – the 32nd Annual Scientific Meeting is at the Westin Copley Place Hotel, Boston, Massachusetts, USA from June 24 to 28, 2006. Abstract submissions by Novewmber 25, 2005. More details from *www.asia-spinalinjury.org/annualmeeting*

Association of Academic Physiatrists (AAP) 42nd Annual Educational Conference will be from March 1 to 4, 2006 at the Hilton Daytona Beach Oceanfront Resort, Daytona Beach, Florida, USA. Details from Lynn Lawson e-mail *lylawson@physiatry.org* Telephone (317) 431 3368; Fax (317) 823 9950. Main website *www.physiatry.org*

Association of Children's Prosthetic and Orthotic Clinics The 2006 Annual Meeting, from May 17 to 20, will be at the Hyatt Regency in Sacramento, California, USA. The Shriners Hospital for Children will be the host clinic. Information by e-mail from *raymond@aaos.org* Telephone (847) 698 1637; Fax (847) 823 0536. The main website is *www.acpoc.org*

Australian Physiotherapy Association 14th Biennial Conference on Musculoskeletal Physiotherapy is at Brisbane Convention Center, Brisbane, Queensland, Australia from November 24 to 28, 2005. Conference details: *www.mpa2005.com.au* or e-mail *mpa2005@meetingplanners.com.au* The Association website is *www.physiotherapy.asn.au* The Animal Physiotherapy Group Conference is being held December 3 & 4 2005 at the School of Veterinary Science, University of Melbourne, Victoria, Australia, Details are available by e-mail from *rose.kraljak@physiotherapy.asn.au* or by telephoning Rose Kraljak, APA on (03) 9536 9335; Fax (03) 9534 9199.

British Association of Prosthetists and Orthotists The BAPO Annual Conference 12, to be held at SEEC, Glasgow, Scotland, UK, is from March 24 to 26, 2006. Details on website *www.bapo.com* or Secretariat telephone +44 (0)845 166 8490

Canadian Physiotherapy Association The 2006 Congress will be held from June 30 to July 2 at the Delta St John Hotel & Conference Centre in St John, New Brunswick, Canada. Information from *www.physiotherapy.ca/congress2006*

Clinical Movement Analysis Society The CMAS 5th Annual Conference will be held on 23 & 24 March 2006 in Newcastle upon Tyne, England. Information available shortly on *www.cmasuki.org*

European Medical and Biological Engineering Conference (EMBEC) The 3rd Conference is from November 20 to 25, 2005 at the Congress Centre in Prague, Czech Republic. *www.embec05.org*

European Orthopaedic Research Society The next EORS Congress will be June 7 & 8, 2006 at the Istituti Ortopedici Rizzoli, Bologna, Italy. Abstract submissions by January 15, 2006; early registration by March 31, 2006. Information by e-mail from *fisiopat@ior.it* and the website *www.ior.it/eors06*

European Paediatric Orthopaedic Society is holding the 25th Meeting in Dresden, Germany from April 5 to 8, 2006 (year of Dresden's 800th anniversary). The Meeting will take place in the Congress Center, Hotel Westin Bellevue in Dresden www.westin-bellevue.de The main Society website is. *www.epos.efort.org* and directly for information on the congress, submission of papers online etc *www.epos.efort.org/Dresden2006/index.asp*

European Society for Movement Analysis in Adults & Children (ESMAC) The 15th Annual Meeting is also the First Joint ESMAC/GCMAS meeting (GCMAS 11th Annual Congress) and will be in Amsterdam, Netherlands from September 25 to 30, 2006. Online abstract submission from January 10, 2006 and abstract submission deadline March 15, 2006. Early registration date is June 1, 2006. More information from *j.harlaar@vumc.nl* The 2007 Meeting is planned for Athens, Greece. The main ESMAC website is *www.esmac.org*

Human Factors and Ergonomics Society of Australia The 2005 National Conference is in Canberra from November 21 to 23. Website *www.ergonomics.org/au* International Ergonomics Association information by email from *info@iea2006.org* including the IEA 2006 16th Congress from July 10 to 14 in Maastricht, Netherlands.

International Federation of Foot & Ankle Societies (IFFAS) The Seventh Biennial Canadian Orthopaedic Foot & Ankle Symposium will be April 8 & 9, 2006 at the Medical Sciences Building, Kings College Circle, Toronto, Canada. Information e-mail *iffas@globalfoot.org* The main website is *www.globalfoot.org*

International Federation of Sports Medicine (FIMS) The 4th European Sports Medicine Congress from October 13 to 15, 2005 will be at the Hawaii Grand Hotel, Lemesos, Cyprus. Contact Pyrgos Congress Ltd, Nicosia, Cyprus – telephone 09357 2277 4157; fax 09357 2278 1031. The FIMS World Congress of Sports Medicine in 2006 will be at the International Convention Center, Beijing, China from June 12 to 16. Information from the National Research Institute of Sports Medicine in Beijing – telephone +86 (10) 6719 2750; fax +86 (10) 6719 2755; e-mail *ligp@263.net* The FIMS website is *www.fims.org*

International Society of Biomechanics XXIst Congress will be from July 1 to 5 at the International Convention Center, Taipei, Taiwan. Information being compiled on *www.isb2007.org*
The ISB website is at *www.isbweb.org*

International Society for Biomechanics in Sport The next International Symposium will be from July 14 to 16, 2006 at the University of Salzburg, Austria.Telephone +43 662 8044 4884; fax +43 662 6389 4884. Information from *isbs2006@sbg.ac.at*
Main ISBS website *www.isbs.org*

International Society of Electrophysiology & Kinesiology The XVI Congress will be held at the Lingotto Congress Center, Torino, Italy from June 28 to July 1, 2006. There will be a pre-Congress Workshop on June 28 and a post-Congress Course on Movement Analysis in Sport and Exercise on July 3 & 4 at the University Institute for Movement Sciences in Rome. Information from *www.isek2006.it*
The main website is *www.isek-online.org*

International Society of Physical & Rehabilitation Medicine (ISPRM) The 4th International Congress from June 10 to 14, 2007 is to be in Seoul, Korea and the 5th will be held in Istanbul, Turkey. More information will become available at the Society's website *www.isprm.org*

International Society of Postural & Gait Research The 2007 Conference is planned for Baltimore, USA. Information, as it becomes available, on *www.ispgr.org*

International Society for Prosthetics & Orthotics The 12th ISPO World Congress is to be held from July 29 to August 3, 2007 at the Vancouver Convention Centre in Vancouver, Canada. Information from the ISPO Congress website *www.ispo.ca/congress* or from the president ISPO Canada, Edward Lemaire, PhD, Institute for Rehabilitation Research and Development 505 Smyth Road, Ottawa ON, Canada KIH 8M2, Telephone (813) 737 7350 Ext 5592. Meanwhile the UK National Member Society for Prosthetics & Orthotics is holding the next Annual Scientific Meeting in the UK on November 4 and 5, 2005 at the Hilton Swindon, Great Western Way, Swindon, England. Details on *www.ispo.org.uk* or e-mail *info@ispo.org.uk*
Telephone/Fax +44 (o) 141 560 4092

Japanese Orthopaedic Association The 79th Congress will be at the Pacifico Yokohama from May 18 to 121, 2006. Information e-mail *office@joa.or.jp*
The Association's 21st Annual Orthopaedic Research Meeting from October 19 to 20, 2006 will be at Brick Hall, Nagasaki.
The Association website is *www.joa.or.jp*

National Athletic Trainers Association (USA) The 57th Annual Meeting & Clinical Symposia is planned for New Orleans from June 27 to July 1, 2006 and in 2007 from June 26 to 30 in Anaheim, California, USA. Information, as it becomes available. from *www.nata.org*

Orthopaedic Research Society (ORS) – The 52nd Annual Meeting will be from March 5 to 8, 2006 in New Orleans, Louisiana, USA. Abstacts online June 20 to August 22, 2005. In 2007 the Meeting will be in San Diego, California, USA.
See *www.ors.org* or e-mail *ors@aaos.org*

Scoliosis Research Society (SRS) – The 40th Annual Meeting is from October 28 to 30, 2005 with pre-meeting courses on October 27, at the Loews Miami Beach Hotel, Miami, Florida, USA, and the 41st is planned for September 13 to 16, 2006 in Monterey, California, USA.
Information on SRS website *www.srs.org*

Society for Neuroscience The 36th Annual Meeting – is planned for New Orleans, USA in 2006 from October 21 to 25, and the 37th in 2007 from November 3 to 7 in San Diego, California, USA.
www.sfn.org

World Confederation for Physical Therapy The 2007 International Congress on World Physiotherapy will be from June 2 to 6, at the Vancouver Convention and Exhibition Centre, Vancouver, Canada. Proposal submissions by January 31, 2006; call for abstracts available from January 1, 2006 for submission by September 15, 2006. Information on
www.wcpt.org/congress/index.php
The main website is *www.wcpt.org*

Additional sites of interest

American Academy of Kinesiology & Physical Education *www.aakpe.org*
American Academy of Pediatrics *www.aap.org*
American Orthopaedic Society for Sports Medicine (AOSSM)
Society website: *www.aossm.org*
American Society of Exercise Physiologists *www.asep.org*
Australian Association of Exercise & Sports Science *www.aaess.com.au*
Bone & Joint Decade (2000-2010) *www.boneandjointdecade.org*
Canadian Association of Prosthetists & Orthotists *www.pando.ca*
Canadian Society for Biomechanics *www.health.uottawa.ca/biomech/csb/*
Gait & Clinical Movement Analysis Society *www.gcmas.org*
International Federation for Medical & Biological Engineering
www.ifmbe.org (Click on *"Calendar"*)
International Organization of Physical Therapists in Women's Health
www.ioptwh.org
North American Society for Pediatric Exercise Medicine *www.naspem.org*
Ontario Kinesiology Association *www.oka.on.ca*
For Physical Therapy links through the University of Sydney
www.library.usyd.edu.au
Biomechanics World Wide (Useful links)
www.per.ualberta.ca/biomechanics
For world wide orthopaedic links
www.freeortho.com/associations
For other events refer also to
www.gcmas.org/societies.html

LITERATURE UPDATE

by Dr. Ed Biden,
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Recently there has been renewed interest in some long standing challenges in motion analysis and the first papers in this review look at a selection from how-to-estimate muscle forces during walking based on EMG to how-to- measure foot to floor forces during treadmill walking.

To begin, **Bogey, R., Perry, J., Gitter, A., "An EMG to Force Processing Approach for Determining Ankle Muscle Forces During Normal Gait", IEEE Transactions on Neural Systems and Rehabilitation, Vol 13, #3 Sep 2005 pp 302-310**, describe experiments with a group of ten normal adult males who had data collected to track movements, forces and EMG. The motion capture system was a Vicon 512. The moments around the ankle were computed using conventional Newtonian methods. The EMG portion was done by collecting data, with fine wire electrodes, for ten muscles crossing the ankle. The signals were used as input to a complex model which includes the geometry of the joint, and muscles surrounding it, and a Hill-based model to estimate forces based on EMG. The results of the EMG estimates were then collapsed to estimate the net moments at the joint and these values were compared favorably to the motion analysis results. This paper represents one more step on the path to being able to compute individual muscle forces on a routine basis.

Cerveri, P., Pedottu, A., Ferigno, G., "Kinematical models to reduce the effect of skin artifacts on marker-based human motion estimation", J. Biomech, Vol 38, 2005 pp 2228-2236 take us back to the ongoing problem of how to account for skin movement when what is wanted are the underlying motions of the skeleton. They use an approach which they described originally in 2003 that uses Kalman Filters to estimate kinematic variables. A Kalman Filter is essentially a model of how the system is expected, in this case the person moving, to perform. The actual measured data are then compared to the model and the differences are reconciled. Their tests suggest that the method can be used with 2D data without explicit reconstruction of marker positions, and that the locations of markers can be generated from the filter models. The challenges of the technique are that the Kalman Filter needs either an explicit mathematical model for the motion to be measured or a statistical model which provides empirical data about motions of the type. This would seem to limit the applicability, particularly when 2D data are used, to movements in conditions which have been studied extensively in order to provide these data.

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continued overleaf

LITERATURE UPDATE *continued*

It is interesting that **Hlavorsen, K., Soderstrom, T., Stokes, V., Lanshammar, H.,"Using an Expanded Kalman Filter for Rigid Body Pose Estimation", J. Biomechanical Engg, Vol 127, June 2005, pp475-483** also use a Kalman Filter approach to modeling rigid body motion. Their approach assumes 3D coordinates are known and develops a model of the underlying motion and its parameters. The particular strength the authors see in their method is that it is particularly robust in estimating the motion of a segment when there are gaps in the marker record, a common problem in patient measurement situations where motions do not follow typical patterns. Their method is linked to the motion of individual segments and seems quite able to be generalized.

More conventionally, **Rivest, L., "A Correction for axis misalignment in the joint angle curves representing knee movement in gait analysis", J. Biomech, Vol 38, 2005, pp 1604-1611** describes an elegant technique by which the smaller motions of varus-valgus angulation and ab-adduction at the knee can be decoupled from knee flexion in order to minimize cross talk. Developed based on Vicon captured data, the method proposed is able to reduce "noise" in the measured angles, resulting in tighter boundaries on the angle measurements.

Verkerke, G., Hof, A., Zijlstra, W., Ament, W., Rakhorst, G., "Determining the centre of pressure during walking and running using an instrumented treadmill", J Biomech Vol 38, 2005, 1881-1885 tackle the problem of how to make force measurements when using a treadmill. They provide a brief history of the development of treadmill force measuring systems and identify a key problem as being how to separate left and right during double support. To address this, they support the treadmill belt using two independent force plates, one on the left and one on the right. These force plates measure vertical load and are used to estimate center of pressure each time a sample is taken. Estimates of center of pressure are accurate to about 6mm laterally and 20mm in the fore aft direction which is sufficient to give reasonable measures of step width and length. They also found that they could extract timing information accurately from the instrumented treadmill. This method is a nice addition to the tools of movement analysis because it allows assessment of multiple steps within a laboratory setting.

Movement analysis produces a huge amount of data and many techniques are used to reduce the amount of data which must be presented. In many cases "scores" of various sorts are calculated. **Flanagan, S., Salem, G., "The Validity of Summing Lower Extremity Individual Joint Kinetic Measures", J. Applied Biomechanics, Vol 21, pp 181-188 2005**, look at how well summed measurements across joints correlate with various sorts of task. They chose a simple barbell lifting task and investigated how well sums of various common kinetic measurements explain the variability seen in their test subjects. The important findings are not the details of what works for a barbell task, but rather the observation that, depending of what is used as the output measure, different kinetic measures had very different levels of success in predicting them. The strong implication is that before using any particular method when generating a "score" it is critical to do an assessment of whether the "score" is actually correlated with the outcome measure for the specific task being measured. They cite the example of a widely used score which turned out to be a very poor predictor when used in their simple lifting task.

The paper by **Weber, D., Stein, R., Chan, K., Loeb, G., Richmond, F., Rolf, R., James, K., Chong, S., "BIONic WalkAide for Correcting Foot Drop", IEEE Transactions on Neural Systems and Rehabilitation Engineering, Vol 13, #2, June 2005, pp 242-246** provides a very interesting case study of the use of motion analysis to assess novel technology. The person featured in this work has a foot drop secondary to a motor vehicle accident. To address his foot drop he has used a surface stimulation system for several years. For this study he also had "BION" stimulators implanted so that a comparison could be made. "BION"s are very small stimulators which can be injected using a large needle and are activated by radio frequency signals external to the body.

The experiment consisted of a comparison of his walking ability without any aids, with ankle foot orthoses, with surface stimulation and with the BIONs. A Peak Motus system was used to track his gait under all conditions. The individual walked markedly better using the stimulation systems, and the BION implantable system worked comparably to the surface simulation but without the need for daily positioning of the stimulating electrodes.

On a completely different track, the paper by **Kobayashi, Y., Takashima, T., Hayashi, M., Fujimoto, H., "Gait Analysis of People Walking on Tactile Ground Surface Indicators", IEEE Transactions on neural Systems and Rehabilitation, Vol 13, #1, Mar 2005 pp 53-59** is an indicator of how sophisticated and sensitive motion analysis techniques have become. The authors used a Vicon 512 system to investigate changes in gait when people walk over the sort of pebbled surfaces which are used to warn visually impaired individuals of the proximity of curbs, steps and so forth. I am sure that it's not very long ago that detecting such subtle changes would have been viewed as impossible for motion capture systems. That said, these investigators were able to show subtle but significant differences in toe height during swing as well as changes in joint angles and moments as a response to the changes in surface.

I will conclude these reviews with **Blemker, S., Delp, S., "Three Dimensional Representation of Complex Muscle Architectures and Geometries", Annals of Biomedical Engg. Vol 33, #5, 2005 pp 661-673**. This group is well known for development of complex models of muscles around joints. This paper describes the next step in development. Previously muscles were built up of many line elements. In the new model a finite element approach is used which can account for changes in moment arm along the fibers. Modeling the fibers as 3D elements allows prediction of interactions between fibers that has not been possible before. The authors describe various "templates" which correspond to different fiber geometries and allow the building up of very complex models. Full implementation of these sorts of models into all the areas where they can potentially be used will require extensive verification over many subjects, a challenge which the authors acknowledge. This type of model, combined with data from experimental studies such as Bogey et al discussed at the beginning of this review, have the potential to allow motion studies and joint mechanics studies to merge, resulting in measures and models which reflect the actual function of individual muscles.

VICONPEAK

OMG
3D from the moving image

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