IS GAIT ANALYSIS USEFUL IN REHABILITATION ?

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INTRODUCTION: In current clinical practice, physical examinations, X-rays and requesting reports of subjective impressions are the most frequent methods for the evaluation of an individual's orthopedic condition. These familiar methods cannot predict the biomechanical function (i.e., forces, structural integrity) of joints, a complete leg or the locomotor apparatus. In addition to clinical evaluation, more specific functional measurements of the movement apparatus, particularly during gait, seem to be desirable. This presentation illustrates our experiences with instrumented gait analysis and its efficiency as a scientific and clinical tool. The main problem was to find sensitive parameters (indicators) which characterize the functional state of a patient's locomotor apparatus.

METHODS: Our gait analysis is based on measurements of kinematic and kinetic data during level walking on a 12 m walkway, while EMG data is also used in special cases. The measurement systems are one opto-electronic device (PRIMAS, Delft, NL) and two force plates (KISTLER, Winterthur, CH).

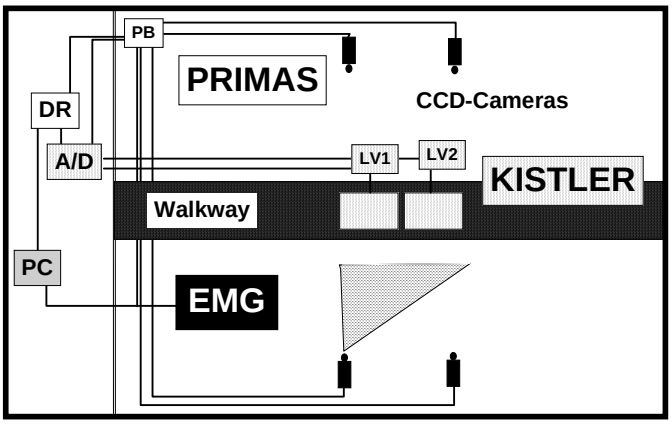

Figure 1: Scheme Gait lab

Since 1992, 650 individuals (including amputees n=155, orthopedic patients n=350 and normal subjects n=110) have been measured in our gait lab. Selected systematic tests were performed with amputees, whereby different prosthetic components and prosthetic alignments were used. Also, individual cases without positive clinical or X-ray findings who complained of functional pain received gait analysis.

RESULTS: Joint moments are the single best indicators of the manner in which amputees adapt their motor activity to changes in the prosthesis.
Evaluating a prosthetic suitable for stance phase safety in weight bearing is the most important factor. Stance phase safety is determined by an amputee's stump activity and prosthesis characteristics, including prosthetic alignment as well as design of prosthetic components.
In the case of single axis knee joints, the ground reaction force must act in front of knee joint, as otherwise the prosthesis will not be stable (Fig. 2).

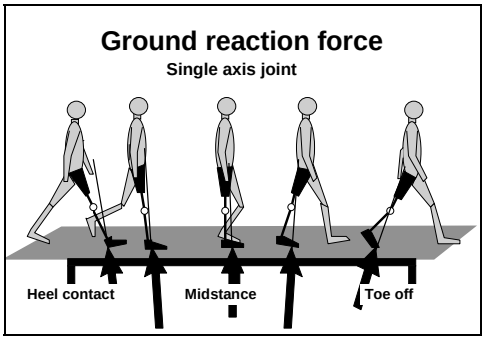

Figure 2: Ground reaction force during prosthetic stance phase in case of single axis knee joints

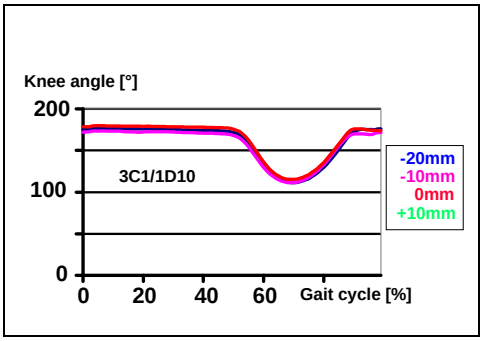

Figure 3: Knee angle depending on prosthetic alignment (see Fig. 4)

In Figures 3 and 4 typical knee angle and external moments are shown for a trans-femoral amputee walking on a prosthetic single axis knee joint with different prosthetic alignments. Thus, external knee and hip moments clearly describe the important aspects of the amputee's effort and prosthetic safety during single support. Parameters such as knee angle are not sensitive.

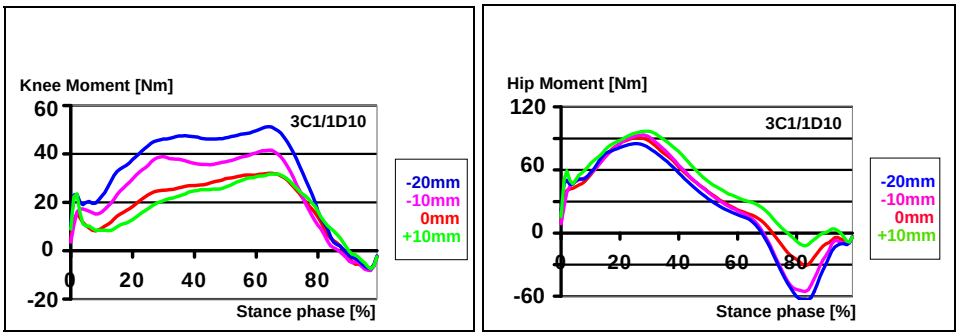

Figure 4: External moment of prosthetic knee joint and hip joint depending on prosthetic knee joint position (-20 to +10 mm in relation to normal fitting alignment)

Patients complaining of pain despite negative clinical findings walk with asymmetrical muscle joint moments. Such joint moments often objectively document the patient's rehabilitation state and his or her progress.
The next figures present the measurement results for a 38-year-old man (M.S.) who complains of low back pain. X-rays and physical examinations were negative.

Fifteen years previously he had suffered a skiing accident, which was treated by an ACL reconstruction of the left knee. At the time of examination he did not complain of lower extremity pain.
Visual observation during gait did not reveal any gait deficiencies. At least the stance phase knee angle and ground reaction force of both legs do not show any abnormalities (Fig. 5 and 6).

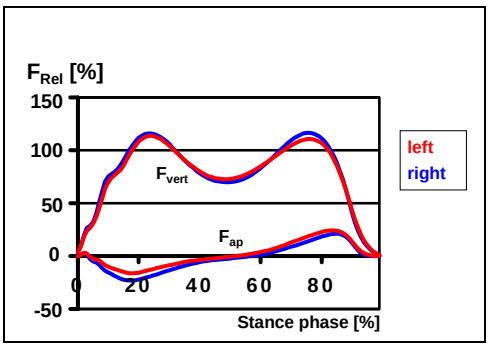

Figure 5: Ground reaction force during stance phase (in case of M.S.)

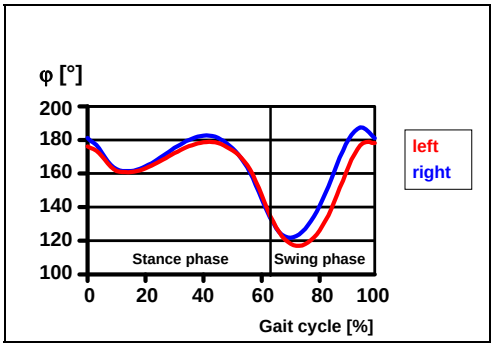

Figure 6: Knee angle (in case of M.S.)

External moments reveal really sufficient information. The enormous asymmetry between the hip moment of the right and left hip joints lead to asymmetrical hip muscle innervations. Thus, the left knee joint is relieved by changed motor activity resulting from functional strain on the hip and pelvic muscles.

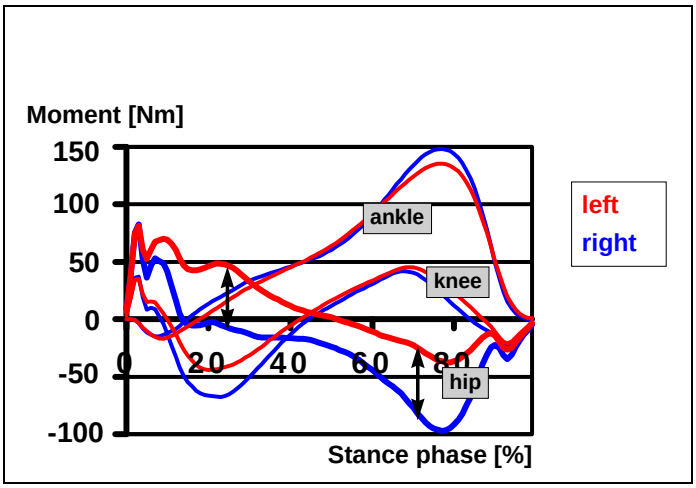

Figure 7: External moment of ankle joint, knee joint and hip joint of both legs (in case of M.S., see text)

CONCLUSIONS: The human gait cycle is a consistently and precisely repeatable complex of movements performed one million times annually. Therefore, gait analysis can only be clinically useful if measurement systems can very sensitively

and quickly determine external joint moments, and sometimes EMG data. For orthopedic and prosthetic tasks, such measurement equipment is now available.
In addition to instrumented gait analysis, biomechanical knowledge is absolutely necessary so that orthopedic patients can benefit from the valuable data provided by gait and motion analysis.

REFERENCES:

Blumentritt, S. (1990). Die Beziehung zwischen dem Gang des Menschen und dem Hüftgelenkaufbau in der Frontalebene. *Gegenbaurs morphol. Jahrb*. **136**, 677-693.
Blumentritt, S., Scherer, H. W., Schmalz, T. (1998). Ganganalyse von Oberschenkelamputierten mit einem Kniegelenk mit Rotationshydraulik. *Med.Orth.Tech*. **118**, 51-61
Condie, D. N. (Ed.) (1994). *International Conference on Clinical Gait Analysis. Book of Abstracts.* Dundee: University of Dundee.
Gage, J. R. (1991). Gait Analysis in Cerebral Palsy. London: Mac Keith Press.
Perry, J. (1992). Gait Analysis. Thorofare, N.J.: Slack Incorporated.
Schmalz, T., Blumentritt, S., Wagner, R., Gokeler, A. (1998). Ganganalytische Verlaufsuntersuchung patellasehnenversorgter Rupturen des vorderen Kreuzbandes. *Phys. Rehab. Kur. Med*. **8**, 1-8
Stüssi, E. (Ed.). (1992). European Symposium on Clinical Gait *Analysis. Proceedings*. Zürich: Hans Beusch print-service.
Wolff, J. (1892). Das Gesetz der Transformation der Knochen. Berlin: Hirschwald.