paring these key parameters with a normal population, has advantages in focusing rehabilitation programmes. Such work is not restricted to any particular category of patient, but can be applied in most situations.

The advantages offered by this new system are considerable. Subjects are no longer restricted to movement in a straight line but can freely move to any section of the walk mats. The system dimension are 9 × 0.8 m, although this can be varied to suit a particular situation. The subject footwear is not restricted or adapted for the system. The subject may walk in normal footwear, bare foot, or with prosthetic or orthotic devices. The walking surface is totally unobtrusive.

Detailed design and construction of the such a walk mat system are in progress. The first section of the system is nearing completion and will be tested in a clinical environment.

Reference

Crouse J, Wall J C, Marble A E (1987). Measurement of temporal and spatial parameters of gait using a microcomputer-based system, *J Biomed Eng* 1987; 9; 64–8

Estimation of three-dimensional joint angles using QUALYSIS position sensors

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The QUALYSIS position sensor identifies the x-y position of an object and transforms it to coordinates that can be read by a computer. The sensor has two components: the camera equipped with an infra-red (IR) strobe flash, an electronic shutter (open during 1/1250s during each exposure) and a variable gain function which enables the object with the highest intensity to become normal and all other objects to be dark; and the video processor which receives the signal from the camera and incorporates electronic logic and mathematical algorithms which increase the resolution of the sensor above that of the camera itself (1/30 000 of the field of view of the camera across the diagonal) at a sampling rate of 50 Hz. The sensors can be used to detect light spots produced either directly by a light source or indirectly by reflecting light.

In 2-D mode the sensor can detect, at a distance of 2 m between the camera and the centre of 25 mm marker (COD = 2 m), a movement of a distance of 1 mm across the plane of view and can follow the oscillation (15 Hz) of a 5 mm marker at distance of 750 mm peak to peak 50 mm. Coupling two sensors together it is possible to sample at 100 Hz or generate three-dimensional coordinates for any given object.

We have used an Apple™ Macintosh® SE/30 to control, collate and display the data, which could be analysed off-line from generated SYLK files and by employing a data spread sheet analysis package. Visualization and sorting of markers can be significantly enhanced using larger screen monitors with colour facilities.

Placing markers on the corners of a 3/4/5 triangle we have sought to determine the reproducibility of angle estimation using two sensors synchronized to record simultaneously. Angles were calculated using the trigonometric formulation of the cosine rule.

The system shows a high degree of reproducibility in both static and a dynamic phases.

Plegic limb classification using cluster analysis

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Walking abnormalities in cerebral palsy can be precisely defined using sophisticated gait analysis techniques. However, utilization of this data currently requires interpretation of complex gait analysis data. We describe a technique that uses highly accurate motion analysis to assess abnormal gait in cerebral palsy and automatically classifies the abnormal limb into clinically recognizable groups.

Fifty-five hemiplegics and ninety-one diplegics were analysed using an optoelectronic scanner (CODA 3). The sagittal kinematics of the affected limb in hemiplegics correlated with those of both affected limbs in diplegics. We introduce the concept of the 'plegic limbs'. The saggital kinematics of 237 affected limbs were studied using cluster statistical analysis. Eight clear groups emerged. Each group demonstrates consistent clinically recognizable features, e.g. stiff leg gait, genu recurvatum, crouch gait, etc. This system can analyse the gait of an abnormal limb and automatically place the limb into a clinically recognizable group.

A nomenclature for normal and pathological gait

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Our objective was to identify events common to normal and pathological gait which could be used to define the phases of the gait cycle. A total of 103 children who had pathological gait and 70 children who were neurologically normal underwent kinetic gait analysis. Two events common to all gaits studied – pelvic high point in stance and hip high point in swing – allow the subdivision of the gait cycle into biomechanically relevant phases rather than temporally by percentages. The events of foot contact, opposite foot off, pelvic high point, opposite foot contact, foot off, and hip high point allow division of the gait cycle into first double support, pelvic lift, pelvic fall, second double support leg lift, and leg reach.

Intra-subject variability of ground reaction force data in children

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Little is known about the variability of gait in children. Gait analysis techniques may provide objective measures