TASK: S-3 NON-INVASIVE MONITORING OF SPINAL/PELVIC ALIGNMENT

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Rationale

Spinal deformity of individuals with spinal cord injury, and other disabilities such as cerebral palsy, muscular dystrophy or brain injury, can lead to loss of sitting stability, loss of upper body function, decrease in respiratory capacity, increased risk of pressure ulcers, and increased pain and discomfort [Hobson, et al. 1992], [Hobson, 1992]. Increasing numbers of prescribers and suppliers of seating and mobility devices are attempting to address these problems. Unsupported claims are often made that specialized seating inserts and cushions can reduce or inhibit the onset of spinal and/or pelvic deformity of individuals using wheeled mobility devices (WMD). More importantly, service providers and WMD users do not have a quantitative method of assessing either the current status or the past history of spinal/pelvic alignment while seated in their WMD. Serial x-rays taken at 3-6 month intervals are thought to expose clients to unacceptably high levels of radiation exposure, especially if follow-up is extended over a number of years. Determination of pelvic/spinal alignment is recognized as one of the most important variables in special seating. It is important to be able to take the measurements while the client is in the WMD, as the contribution of the seating support to the spinal/pelvic alignment is often the desired determinant.

Many non-invasive techniques have been applied to detect and measure scoliosis and kyphosis of the spine. Most of these techniques were developed to detect idiopathic scoliosis through screening of school age children. Among the more qualitative methods developed are the Scoliometer [Amendt et al, 1990] Back Contour Device Moir [Burwell et al 1983], topography [Daruwall, 1985] and thermography [Cooke, 1980]. The more quantitative techniques have been surface topography [Pekelsky et al], light beam scanning (ISIS) [Turner-Smith, et al 1986], and ultrasonic digitization [Letts et al 1988]. All of these techniques have been compared to the "gold standard" of orthopedic radiographic spinal measurement, the Cobb method. Some techniques correlate better than others with the conclusion by several investigators that the frequency of radiographs can be reduced, but not eliminated from spinal monitoring, especially for scoliotic curves that have progressed beyond a 30^0 Cobb angle. Good correlation between spinous process mapping and the Cobb measurements was demonstrated by [Letts et al. 1988], for curves over 30^0. Furthermore, they were able to demonstrate that an acceptable correction factor can be achieved for curves under a 30^0 Cobb angle.

The major limitation of these techniques is that they require direct exposure of the spine to the measurement instrumentation, preferably in the erect standing position. Radiographs require medical approval, are costly, and run the risk of excessive exposure. A literature review was unable to identify any technique or instrument that could measure and record spinal/pelvic alignment of a person seated in their WMD.

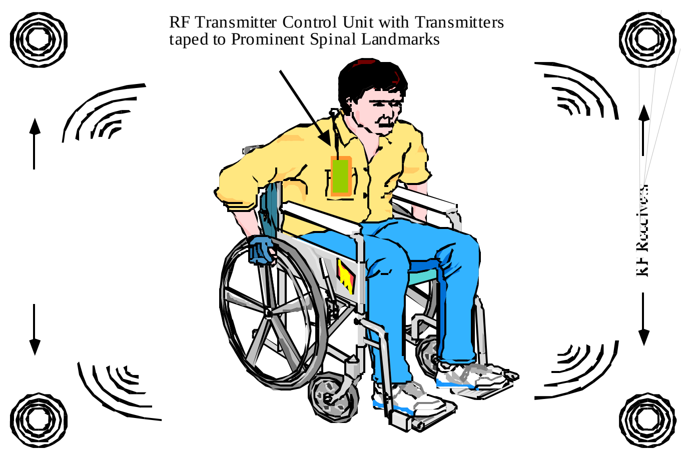

Figure 41. Schematic of radio frequency method of determining spinal pelvic position of a subject seated in his/her personal wheelchair.

Goals

To research and develop a quantitative method, including reasonably priced instrumentation, to monitor changes in spinal/pelvic alignment of a wheelchair seated person at risk of increased deformity.

Outcome Summary

This task was transitioned into the technology transfer phase at the end of Year II (7/31/95). No further RERC funds were expended on this task. A partnership was formed with ARTSCO, Inc. (Pittsburgh, PA) to continue the prototype development of the measurement tools. An NIH/NCMRR SBIR technology transfer grant was awarded to ARTSCO to further the development this technology. In addition, a technical report entitled, Spinal/Pelvic Alignment Monitoring of Wheelchair Users, which details the research findings, has been prepared and is available from the RERC upon request.

Phase I research began in October 1997. Under the support of the NIH/SBIR, ARTSCO collaborated with the Antenna Lab at the Virginia Tech University to design small flexible patch antennas that could be placed on landmarks of the spine. Prototype antennas were completed in February 1998. While Virginia Tech was developing the antennas, ARTSCO developed the supporting electronics system to test the feasibility of measuring spinal alignment through radio frequency signals. A signal generator capable of producing a 900MHz sine wave and a vector voltmeter capable of measuring small phase differences were purchased. The laboratory was set up with three receiving antennas, and one transmitting antenna. A special calibration jig was developed by ARTSCO to move the transmitting antenna in 1mm increments in each dimension (X, Y, Z). Electronic switches and a computer software program were written to measure the phase difference between each pair of receiving antennas. Upon acquiring the prototype antennas from Virginia Tech, testing of the system began at the ARTSCO facility.

To date, testing conducted at the ARTSCO laboratory has not succeeded in demonstrating the ability to calibrate the actual movement of the transmitting antenna to the movement measured through the RF phase difference technique. The most likely cause of the error is unwanted signal reflections from objects, walls, ceilings and floors in the laboratory. Research is continuing at the ARTSCO lab to determine the cause of errors and remedy the situation.

Recommended Future Research

At this time research should focus on determining the cause of the inability to calibrate. Testing the system in a chamber that absorbs all RF signals would eliminate unwanted reflections, and therefore test the theory postulated above. At this time ARTSCO is attempting to arrange a test with a center that has this type of chamber. Once calibration is achieved, human tests should be initiated. An X-ray should first be taken with the antennas in place on the spine to determine if the antennas are indeed over the bony landmarks of interest. Secondly tests should be undertaken to determine whether the measurements made of the antenna locations match the actual locations of the antennas on the spine.

Publications

Malagodi, M.D., "Technical Identification of a Non-Invasive Spinal/Pelvic Monitoring System for Individuals Seated in Personal Wheeled Mobility Devices". Poster Presentation. 17th Annual RESNA Conference, Nashville, TN. June 1994.

References

Hobson DA. & Tooms RE. (1992) Seated Lumbar/Pelvic Alignment A Comparison between Spinal-cord Injured and Non-injured Groups. *Spine*; 17:293-298.

Hobson DA. (1992) Comparative effects of Posture on Pressure and Shear at the Body-Seat Interface. *J Rehabil Res Dev* ; 29(4).

Amendt LE, Ause-Ellias KL, Eybers JL, et al. (1990) Validity and Reliability of the Scoliometer. *Phys Ther*;70:108-117.

Burwell RG, James NJ, Johnson F, et al. (1983) Standardized Trunk Asymmetry Scores: A Study of Back Contour in Healthy School Children. *J Bone Joint Surgery* (Br); 58:64-71.

Daruwalla US, Balasubramaniam P. (1985) MoirÈ topography in scoliosis - Its accuracy in detecting the site and size of the curve. *J Bone Joint Surg*; 67B:211-213.

Cooke ED, Carter LN, Pilcher MF. (1980) Identifying scoliosis in the adolescent with thermography. *Clin Ortho*; 148:172-176.

Neugebauer H, Windischbauer G. (1987) School screening: A New Pilot Study. Stokes IAF, Pekelsky JR, Moreland MS, eds. Surface Topography and Spinal Deformity. Stuttgart, Federal Republic of Germany: Gustave Fischer Verlag GmbH & Co KG; pp. 177-186.

Turner-Smith AR, Harris JD. ISIS (1986) An automated shape measurement and analysis system. In: Harris JD, Turner-Smith AR, eds. Surface Tomography and Spinal Deformity. Stuttgart, Federal Republic of Germany: Gustave Fischer Verlag GmbH & Co KG; pp. 31-38.

Letts M, Quanbury A, Gouw G, Kolsun W, Letts E (1988) Computerized Ultrasonic Digitization in the Measurement of Spinal Curvature. *Spine*; 13: 1106-1110.