The spatial relationship between the angle of inclination of a seating system's backrest from the seat and the hip flexion angle has not been established for children with cerebral palsy. Therefore, the child's hip flexion angle should not be described as the angle between the seat and the backrest unless the relationship between the hip flexion angle and the backrest's angle of inclination is established. The purpose of this article is to describe the components, operation, and uses of an electric goniometer designed to monitor and measure changes in hip flexion angle while positioning children with cerebral palsy.

The position of the hip joint during sitting is crucial to the overall effectiveness of the seating system for children with cerebral palsy. Clinical observations and research results suggest that the position of the hip joint contributes to controlling hyperactive muscle activity. Because the pelvis serves as the base of support for the proximal segments of the body in the sitting position, the hip flexion angle also affects the functions of the trunk, head and neck, and upper extremities. Several studies have been conducted to determine the effect of hip flexion angle on specific variables in children and young adults with cerebral palsy. The seats and backrests of specially constructed positioning devices were angled specifically to alter the hip flexion angle. Although hip flexion angle was not measured directly, the results obtained in these studies were attributed to changes in hip flexion angle. Changes in the angle between the seat and the backrest may affect not only the hip flexion angle but also the lumbar spine. Changes in hip flexion angle, therefore, may be attributed partly to lumbar lordosis.

**COMPONENTS AND OPERATION**

The goniometer shown in the Figure is designed for use while the child is seated. It consists of three main parts: a proximal arm, a potentiometer, and a distal arm. The proximal arm is made of Orthoplast® and is preshaped to fit the general contour of the lateral aspect of the pelvis. The anterior and posterior aspects of the proximal arm extend to the anterior and posterior aspects of the pelvis, respectively. Each aspect contains a rubber cup that is positioned on the skin over the anterior-superior iliac spine and the posterior-superior iliac spine.

The center of the goniometer contains a potentiometer, or variable resistor. A constant-voltage electrical current is supplied to the potentiometer through a cable. The resistance to this current depends on the relative position of each arm of the goniometer and, consequently, on the range of motion at the hip. The output voltage from the potentiometer varies linearly with the ROM at the hip, and voltage level is converted by computer software into degrees of movement. The ROM is displayed on a video monitor every second. The goniometer has an operational ROM of 40 to 285 degrees.

The distal arm is made of low-density polyethylene. It also contains two rubber cups—a proximal cup, positioned on the skin over the greater trochanter, and a distal cup, positioned on the skin over the lateral epicondyle.

The medial surface of the rubber cups contains double-sided adhesive tape that secures the arms of the goniometer to their respective bony prominences. A pair of Velcro straps further secure the arms to the patient's body (Figure, inset). The use of cups and straps ensures that movements of the pelvis or thigh in the sagittal plane are accompanied by a corresponding movement of the arms of the goniometer. Because the proximal arm is located on the pelvis, only true hip flexion angle is recorded; all trunk movements are excluded.

The materials with which both arms are made allow them to be twisted and bent laterally (but not anteriorly or posteriorly). This property of the goniometer ensures that lateral or medial rotation and adduction or abduction of the hip are accommodated but do not affect the measurement of hip flexion. This construction also ensures that the goniometer is not displaced from the hip during testing and that the axis of rotation of the goniometer is in the axis of rotation of the hip joint. The length of both arms of the goniometer and the position of the cups on the arms are adjustable for different body sizes. The cost of the goniometer is about $300.

**CURRENT USES**

Positioning the hip is a purely subjective process for many clinicians providing adaptive seating to children with cerebral palsy. The electric goniometer, however, can be used to provide continuous information on the position of the hip, and it is a potentially useful evaluative tool for determining an appropriate, individualized, adaptive seating position.

Research currently is being conducted to determine the relationship between the angle of the seat and the backrest (the mechanical hip flexion angle) and the true hip flexion angle.
angle (the anatomical hip flexion angle). The results of the studies may allow clinicians to obtain reliable and valid quantitative values for the amount of true hip movement produced by a specified amount of change in the mechanical hip angle.

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REFERENCES