Activity Positioning and Ischial Tuberosity Pressure: A Pilot Study

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Ipsilateral ischial tuberosity pressure of 12 subjects seated in wheelchairs was measured during reach to an activity positioned on both an upright and a flat plane. Ischial tuberosity pressure during cross-body, forward, and lateral reach was measured with a static pressure measurement device. Differences between flat-plane readings and upright-plane readings were analyzed with a t test; no significant difference was obtained. A repeated-measures analysis of variance revealed significant differences in ischial tuberosity pressure between cross-body, forward, and lateral reach in the flat plane activity. However, no significant difference was found between cross-body, forward, and lateral reach in the upright-plane activity. Results of this study support the theory that forward and lateral positioning of activity can supplement standard techniques for relieving pressure.

Pressure sores, the most common iatrogenic condition, are costly but preventable for persons who remain seated or in bed for extended periods of time. The bed has been called the “most dangerous splint yet devised by mankind” (Roaf, 1976, p. 5). The incidence of pressure sores among persons with spinal cord injury has been estimated at 21.6% for persons with paraplegia and 23.1% for persons with quadriplegia. In addition, pressure sores account for 4% of all deaths among persons with spinal cord injury. The average cost of treatment in 1982 was $20,000 to $30,000 for a single sore; the current estimated cost is as high as $70,000, depending on severity and type of treatment (Heilig, 1991; Krouskop, Noble, Garber, & Spencer, 1983). Two billion dollars per year is spent to heal pressure sores (Zacharkow, 1984).

Although numerous causes of pressure sore development have been cited, unrelieved pressure is considered to be the primary cause (Exton-Smith & Sherwin, 1961). Pressure sores develop as a result of sustained pressure on the skin. The excessive gravitational force of continuous pressure decreases blood flow to the area, thus tissues do not receive oxygen and nutrients. The body’s failure to dispose of tissue waste eventually results in cell necrosis. Pressure is more likely to develop under bony prominences and during inactivity (Garber, Krouskop, & Carter, 1978).

An activity that promotes movement is likely to relieve pressure and redistribute weight. However, this hypothesis has not been tested in the literature. The prevalence of decubiti among persons with spinal cord injury and the lack of empirical evidence supporting occupational therapy intervention necessitate the examination of the effect of purposeful activity on lowering ischial tuberosity pressure.

Literature Review

Occupational therapy intervention in pressure sore prevention and treatment is not discussed much in the literature. When occupational therapy is cited, precautionary treatment consists of aiding and educating the patient in identifying self-care deficits and employing self-inspection techniques (Briddle, Yasenchak, & Nidiffer, 1992; Trombly, 1989). The literature does not recommend activity for the prevention of sores, despite the documented premise that the less active the patient is, the greater the risk is for decubiti (Levine, Simpson, & McDonald, 1989).

Persons without functional sensory systems are especially susceptible to pressure sore formation. Persons with spinal cord injury lack the informative sensory input that reveals pressure buildup and the need for active relief, thus, formation of sores is common, and pressure releases along with wheelchair cushions have been the standard tools for prevention. The primary site for pres-
sure sore formation is the ischial tuberosity; other sites are the greater trochanter of the femur and the sacrum (Zacharkow, 1984). Research has indicated that low pressures for long periods are more harmful than high pressures for short periods (Exton-Smith & Sherwin, 1961). The person with spinal cord injury who is seated in a wheelchair with unrelieved pressure is therefore highly susceptible to ischial tuberosity pressure sore formation.

Research with elderly subjects has demonstrated that the occurrence of pressure sores is directly related to the number of spontaneous movements made during sleep. Subjects who obtained a low motility score were classified as “liable for pressure sore formation and required special nursing” (Exton-Smith & Sherwin, 1961, p. 1126). In contrast, subjects who obtained a high motility score required no special care (Exton-Smith & Sherwin, 1961). Mobility has been identified as the most controllable factor related to the development of decubiti (Pronsati, 1991).

Zacharkow (1984) contended that poor sitting posture is one of the major factors, perhaps the most ignored factor, in pressure sore formation. More pressure sore occurrences are attributed to the sitting position than to the supine or recumbent positions. Rogers (1973) determined 30 mmHg as the maximum safe subischial tuberosity pressure, whereas Ferguson-Pell considered pressure as high as 60 mmHg to be safe (Ferguson-Pell, Wilkie, Reswick, & Barbenel, 1980).

Research within a vocational setting for persons with spinal cord injuries revealed that a cross-body reach provided relief under the ischium corresponding to the arm used for the reach (Swans, Krouskop, & Smith, 1988), whereas reach to the same body side caused an increase in pressure to that side. Pressure was also found to increase on the posterior thigh during forward reach (Swans et al., 1988). However, the influence of purposeful activity on ischial pressure and the positioning of activity on pressure distribution has not been documented in the literature.

Purpose

Hypotheses guiding this research were that (a) ischial pressure would be less when a person engaged in an upright-plane activity that required forward reach, cross-body reach, and lateral reach than when the person engaged in the same activity at a flat plane that required little or no extended forward reach and (b) cross-body reach would provide greater ischial pressure relief than would forward and lateral reaches, regardless of how the activity is positioned.

Method

Subjects

Persons with spinal cord injuries of T-1 or below qualified for this study. Subjects were recruited from a local support group for persons with spinal cord injuries and were screened on their ability to reach forward and move a game piece. Eight subjects with paraplegia resulting from a traumatic spinal cord injury participated in the study. Data were collected on 3 additional subjects whose paraplegia was not the result of traumatic spinal cord injury, but of transverse myelitis, spina bifida, or cerebral palsy. One additional subject with a gunshot wound to the spinal cord was considered paraparetic. All 12 subjects had adequate muscle function of the upper extremities to engage in the chosen activity, a checkers game. All 8 of the subjects with traumatic spinal cord injuries and the subjects with transverse myelitis and spina bifida had sensory impairment of the buttocks.

Instrument

The Lotus Pressure Meter (PR 38) was used to measure seated ischial tuberosity pressure. It consists of one pressure-sensing bubble 1 1/2 in. in diameter, a hand-held gauge with a red light for indicating pressure and squeezing air into the bubble, and a tube connecting the sensing bubble to the gauge (see Figure 1). The pressure-sensing bubble is placed under the ischial tuberosity and the subject is seated. The hand-held gauge is then depressed to allow air into the pressure-sensing bubble through the connecting tube. When the air pressure in the bubble reaches the level that is present under the body, the gold-plated contacts within the sensing bubble separate and

Figure 1. The Lotus Pressure Meter (PR 38). Note: Available from Lotus Health Care Products, 31 Sheriden Drive, Naugatuck, CT 06770.
the red indicator light goes off. By recording the pressure reading on the dial at which the red light goes off, the researcher can determine seated ischial tuberosity pressure. During pretest, this instrument was demonstrated to work consistently when measuring seated pressure between the ischial tuberosity and a wheelchair cushion. Other seated pressure measurement devices exist but were not available for use in this study.

**Procedure**

For this study, an upright plane was defined as a plane parallel to the subject in a wheelchair that requires neutral head centering through visual engagement in activity and that promotes forward, cross-body, and lateral reaches. A flat plane was defined as a plane perpendicular to the subject in a wheelchair that requires little head centering and does not promote forward, cross-body, and lateral reaches. Extended active reach was defined as full elbow extension combined with shoulder flexion or adduction approximating 90°, with the intent of grasping an object located 2 in. further from the body than the subject’s arm length. Three types of extended reach were used. Forward reach was defined as extended reach in the sagittal plane that approximated but did not exceed 90° shoulder flexion. Cross-body reach was defined as extended reach across the midline of the body that did not exceed 90° shoulder flexion with 45° shoulder horizontal adduction. Lateral reach was defined as extended reach lateral to the body midline that did not exceed 90° shoulder flexion with 45° shoulder horizontal abduction.

A flat table was used for pressure analysis in the flat plane and an easel for analysis in the upright plane. The act of forward, cross-body, and lateral reach in an upright plane encourages elevation of the buttocks from the seat and alleviates pressure briefly and naturally. Each subject participated in both the upright-plane activity and the flat-plane activity. In this manner, data from all 12 subjects were gathered during reach in the two activity planes and the three reach positions.

Subjects were seated in their own wheelchairs with the activity positioned 2 in. beyond their extended arm length to encourage active reach for both flat and upright activity planes. To control for order of presentation, half of the subjects began with the checkers activity in the flat plane, whereas the other half began with the checkers activity in the upright plane. The checkers activity was placed on a flat table of appropriate height for the subject. The exact activity positioning was within 20° of midline for direct front placement, greater than 20° to the right of midline for placement to the right, and greater than 20° to the left of midline for placement to the left. These positions allowed for measurement of forward, cross-body, and lateral reach on a flat surface. The appropriate table height required the shoulder girdles to remain in a neutral, anatomical position (neither elevated nor depressed) with the subject’s elbows flexed to 90° and forearms placed comfortably flat. The upright checkers activity was positioned at an elbow with the same criteria to allow for measurement of forward, cross-body, and lateral reach (see Figure 2).

The pressure-sensing bubble of the pressure meter was positioned directly under the ischial tuberosity that corresponded to hand preference. Ten subjects were right-handed; 2 were left-handed. Palpation determined the exact location of the appropriate tuberosity, and the pressure-sensing bubble was taped to the outside of the subject’s clothing for repeated readings. Subjects had previously been instructed to wear loose-fitting clothing such as sweatpants.

Each subject reached four times to each of the six activity positions (three positions on the flat surface and three positions on the upright surface) and maintained these positions while I took pressure readings. Four pressure readings were taken for each of the six positions, and an additional four readings were taken with no reach (arms in lap), for a total of 28 readings per subject.

**Results**

The obtained pressure readings were averaged for each activity position and compared. First, differences in pressure readings for each of the three upright positions were compared with differences in pressure readings for each of the three flat surface reach positions with a dependent t test. Results indicated an increase in pressure during cross-body, forward, and lateral reach in the upright plane when compared with the same reach in a flat plane, but the differences were not statistically significant (see Table 1).

The obtained results were not consistent with the hypothesis that ischial pressure would be lower in activities positioned at an upright surface. Despite the lack of significant difference between upright-plane and flat-plane ischial pressure, each plane was analyzed separately for differences between cross-body, forward, and lateral reach. A repeated-measures analysis of variance exam-

**Table 1**

| Ischial Tuberosity Pressure in Upright-Plane and Flat-Plane Activity Positions (N = 12) |
|---------------------------------|-----------------|----------------|---|---|---|---|
| Reach Position                  | Upright         | Flat           | D  | t  | P  |
|--------------------------------|-----------------|----------------|---|---|---|---|
| Cross-body reach                | 50.667          | 20.42          | 25.792 | 16.04 | 5.875 | 1.010 | .35 |
| Lateral reach                   | 44.917          | 21.82          | 34.125 | 12.65 | 10.792 | 1.850 | .09 |
| Forward reach                   | 36.167          | 17.75          | 33.896 | 14.81 | 2.271 | 0.803 | ns  |

Note: For no reach (sitting with arms in lap), M = 35.79, SD = 16.55; ns = not significant.
Figure 2. Reaching positions during activity for right-handed subject: (a) forward reach, flat plane; (b) forward reach, upright plane; (c) lateral reach, flat plane; (d) lateral reach, upright plane; (e) cross-body reach, flat plane; (f) cross-body reach, upright plane.
ined differences among the three reaching behaviors on a flat plane and resulted in a significant difference ($F = 6.637, p = .005$). Post hoc analysis with the Scheffé multiple comparison revealed differences between cross-body reach ($M = 26.79$) and lateral reach ($M = 34.13, D = 7.34, \text{Scheffé} = .05$) and between cross-body reach and forward reach ($M = 33.90, D = 7.11, \text{Scheffé} = .05$), but not between lateral reach and forward reach ($D = .23$).

Analysis of variance in the upright plane indicated no significant difference in ischial pressure among the three reaching behaviors ($F = 3.133, p = .054$). Cross-body reach produced lower pressure ($M = 30 \text{ mmHg}$) than did forward reach ($M = 36 \text{ mmHg}$) and lateral reach ($M = 44 \text{ mmHg}$), but the difference was not statistically significant.

**Discussion**

The hypotheses guiding this project were that ischial pressure would be lower during the upright-plane activity than during the flat-plane activity and that pressure would be lowest during cross-body reach. Compared with the flat-plane position, however, the upright-plane position did not lower pressure; it actually increased pressure during cross-body, forward, and lateral reach. These results do not support the hypothesis that upright-plane positioning will lower ischial tuberosity pressure.

The second research hypothesis was partially supported. A cross-body reach did relieve some pressure and was the most effective reach for reducing ipsilateral ischial tuberosity pressure. These results are consistent with the findings of Swarts et al. (1988) and further demonstrate that lateral reach increases pressure to the ischial tuberosity on the ipsilateral side in which the subject reaches. In addition, a cross-body reach provides pressure relief to the ipsilateral tuberosity of hand preference. Although Swarts et al. (1988) also determined that lateral reach relieves pressure on the contralateral ischial tuberosity, whereas cross-body reach increases pressure on the contralateral tuberosity, that result was not found in the present study. Positioning the activity lateral to the body, thereby promoting cross-body reach, may relieve pressure more effectively than positioning the activity in an upright plane. The upright plane may actually increase pressure on the posterior portion of the ischial tuberosities, whereas a cross-body reach provides greater weight shift and postural adjustments and thus relieves ischial pressure to the ipsilateral ischial tuberosity.

Lateral reach and forward reach in an upright plane actually increased pressure to the ipsilateral ischial tuberosity. Because a single-arm reach requires a very subtle weight shift and lowers pressure in one spot while increasing it in another, engagement and participation in an activity that requires a variety of reaching behaviors will appropriately relieve pressure for those seated in wheelchairs. Cross-body reach will be only partially successful in providing a lowered pressure because, as Swarts et al. (1988) have determined, pressure increases to the contralateral tuberosity. Therefore, reach during activity should not replace use of pressure relief mechanisms, such as wheelchair pushups. Reaching behavior should be used in conjunction with standard pressure relief techniques.

Prousnai (1991) has identified that mobility is the most controllable factor in the development of pressure sores. Occupational therapists may therefore assume the vital role in prevention by prescribing purposeful activity that requires a variety of cross-body reaches to relieve pressure. Furthermore, therapists are responsible for educating patients and families about various preventive techniques. Therapists need not be concerned with creating activities that can be used as pressure relief mechanisms in an upright plane; instead, therapists should incorporate activities that require cross-body movement. Like the findings of Levine et al. (1989), the findings of the present study indicate that the more active the patient is (in this case, in performing cross-body reaches), the lower the risk is for developing decubiti.

The unsophisticated technology characteristic of the Lotus Pressure Meter (PR 38) is a limitation of this study. Although a reliable and valid measurement tool, it is perhaps the least sophisticated seated pressure indicator available. This meter is a static measurement device that measures pressure in an area of 1½ in². Overall seated wheelchair pressure more accurately indicates true seated buttock pressure. Nevertheless, when the meter was placed directly under the ischial tuberosity, consistent results were obtained before and during this project. A more sophisticated pressure measurement device that measures dynamic overall pressure would yield interesting data regarding reach, pressure, and differences among various activity positions.

Further research could examine the effect of various activities on relieving pressure, in hopes of determining specific behaviors and activities that are the most successful. Studies that determine the frequency of reach in activity to prevent decubiti would yield valuable information. Two essential questions regarding frequency remain unanswered; specifically, what frequency of reach in activity will prevent decubiti and how many times per day this frequency is necessary.

**Summary**

Ipsilateral ischial tuberosity pressure was found to be significantly lower for 12 subjects in wheelchairs when they engaged in cross-body reach during the flat-plane activity. In addition, positioning an activity in the upright plane did not lower ischial tuberosity pressure significantly more than positioning the same activity in the flat plane. Although one can conclude that positioning activity lateral to the body and incorporating a variety of reach-
ing behavior provides some degree of pressure relief, additional research with bilateral ischial tuberosity measures and the recording of reach time is needed to establish the degree to which activity setup may effectively replace standard pressure relief techniques.

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References
Rogers, J. E. (1973). Tissue trauma group. Annual report of progress: Rehabilitation Center at Rancho Los Amigos Hospital, Downey, CA.