Clinical Evaluation of the Hemi Wheelchair Cushion

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A foam cushion was designed for wheelchair users who propel their wheelchairs with the assistance of one lower extremity. It allows users to extend one hip to reach the ground without having to slide forward on the seat, thus maintaining a more erect posture. The cushion was evaluated to identify contraindications for its use. Eleven subjects (10 stroke patients and 1 patient with an above-the-knee amputation) were tested on the Hemi Wheelchair Cushion and on a second cushion chosen by their primary occupational therapists. Seat interface pressures, both before and after dynamic movement, sitting balance, and wheelchair mobility were measured for each cushion.

An analysis of mean pressure values revealed no significant difference between the cushions (p = .80). Average pressures after dynamic movement showed a statistically significant difference from pressures before activity (p < .05). Subjective evaluation revealed that the Hemi Wheelchair Cushion did not adversely affect sitting balance or wheelchair mobility, and no contraindications for its use were identified. The results of this clinical evaluation indicate that the Hemi Wheelchair Cushion is an economical and appropriate option for wheelchair users who propel themselves with the assistance of one leg.

Proper positioning of a person in a wheelchair is critical for obtaining rehabilitative goals and addressing long-term postural concerns. The goal of a good seating system is to provide sufficient support to enable the person to maintain a stable posture, thereby minimizing the static contraction of postural muscles (Zacharkow, 1988). An improved posture enhances a person's functional abilities. When proper seating is neglected, it affects posture and may result in discomfort, fatigue, work inefficiency, pressure ulcers, or any combination of these.

For protection from pressure ulcers in the seated position, a wheelchair cushion and a properly fitted wheelchair are equally important. Wheelchairs are selected to fit the height, width, and strength of the person. Proper alignment of the footrests and armrests helps distribute body weight over the ischial tuberosities. To enhance portability, a sling seat and back are standard features on most wheelchairs. A sling seat, however, provides inadequate support, which may cause persons to sit at a slight angle, thereby creating a pelvic obliquity that increases the tendency for the hips to adduct and rotate internally (Zacharkow, 1988). Sitting with a pelvic obliquity will result in an increased potential for pressure ulcers over the ischial tuberosities and greater trochanter (Winter & Pinto, 1986). To minimize the effects caused by the sling seat and backrest, wheelchair cushions and back supports are used.

Durability, care, effectiveness, maintenance, and cost are factors considered in choosing a cushion (Torrance, 1983). Cushion selection for persons with hemiplegia depends on the person's sitting balance and ambulation abilities. Studies have shown that sitting balance, bladder control, and walking correlate significantly to predict the motor and functional outcomes of stroke patients (Loewen & Anderson, 1990; Sandin & Smith, 1990). In persons with hemiplegia, the paralysis of unilateral trunk muscles creates a pelvic obliquity, thus more weight is borne on the paralyzed side. This posture leads to asymmetrical pressure distribution (Nicol & Koerner, 1985).

This obliquity can be heightened when the person uses his or her foot to propel a wheelchair. The person tends to slide the buttocks forward in the chair to make better contact with the floor, resulting in a slumped, kyphotic posture (Zacharkow, 1988). To solve this problem, a low-seat wheelchair with an appropriate seat depth may be used; these chairs, however, are costly and cannot always be obtained by rehabilitation facilities and nursing homes for their clients who use wheelchairs. Another solution often employed is to lower the sitting height by removing the seat cushion or substituting a thin cushion. This option does not provide adequate support for the buttocks and may lessen comfort and increase the risk of pressure ulcers.

The Hemi Wheelchair Cushion1 was designed to pro-

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1Manufactured by Span America Medical Systems, Inc., Greenville, South Carolina 29606.
mote easier wheelchair propulsion with the use of the lower extremity without compromising posture, pelvic alignment, or pressure relief (Sprigle, 1991). The cushion was made from a 3-in. HR45 foam with a 2.8 lb density. One side of the cushion was tapered down half of the width to allow the limb to contact the floor (see Figure 1). The slope begins approximately halfway on the cushion to provide adequate support for the buttocks and to allow the hip to extend slightly. This enables the person to reach the ground without having to slide forward on the seat and into a posterior pelvic tilt.

The purpose of this study was to determine the effectiveness of the Hemi Wheelchair Cushion with respect to pressure, sitting balance, and wheelchair propulsion while identifying any contraindications for its use. Additionally, we compared the Hemi Wheelchair Cushion with other marketed cushions used by persons with hemiplegia, although we did not intend to assess its effectiveness over other cushions. Rather, the study was designed to determine whether the Hemi Wheelchair Cushion design improves wheelchair propulsion, making it a viable option for persons who propel a wheelchair with the assistance of one leg.

Method

Subjects
Subjects who used one of their lower extremities to assist with wheelchair propulsion were selected from four regional facilities: two rehabilitation hospitals and two long-term-care facilities. They were selected by their respective occupational therapists overseeing their care. Five men and six women participated in this study. Ten of these subjects had suffered a cerebral vascular accident, and one had an above-the-knee amputation.

Instrument

Interface pressures were measured with a pressure monitor that incorporated two 6-in. by 4-in. (15 cm x 10 cm) pneumatic transducers centrally placed under the ischial tuberosities. Calibration of the pressure monitor indicated accuracy to ± 5 mm Hg at the 100 mm Hg calibration level. Each transducer had 12 pressure sensors arranged in a 4 by 3 array, thus pressures were measured at 24 locations.

Two 6-point grading scales were developed for the study, one to evaluate sitting posture and the other to evaluate wheelchair mobility. The sitting posture scale was used to evaluate the subject's ability to be placed in and maintain an erect, symmetric posture. Criteria for good sitting posture were an erect trunk in slight anterior pelvic tilt, arms in relaxed position at the side or in the lap, hips at 90° flexion, and knees flexed to position the feet properly on the footrests. The scale ranged from cannot be placed in normal posture (0) to can assume and sustain test posture (5).

The wheelchair propulsion scale was used to judge each subject's ability to independently propel and turn the wheelchair while maintaining good sitting posture. This scale was scored from cannot move wheelchair (0) to propels wheelchair independently with good posture (5). Both grading scales were scored collaboratively by the first researcher and the subject's occupational therapist. The first researcher assisted in scoring to maintain consistency in the scoring across subjects and in different clinic settings. The occupational therapists, however, were most familiar with the individual subjects and thus were necessary to the evaluation process.

Procedure

Subjects completed an informed consent form prior to participation. Each subject's wheelchair was adjusted for proper fit, and additional equipment, such as a solid back, solid seat, or arm trough, was added, if necessary. Any additional equipment remained consistent throughout the evaluation.

Each subject was evaluated first on his or her regular foam or foam and gel cushion, as selected by that person's occupational therapist, and second on the Hemi Wheelchair Cushion. A trial period of 4 days preceded the clinical evaluation of cushions to allow subjects time to become acquainted with the cushions and any added equipment and to practice wheelchair propulsion.

For the evaluation of each cushion, the subject was positioned on the cushion and balance and posture were scored by his or her occupational therapist. Seven therapists were involved in scoring. After placing the pressure transducers centrally under the ischial tuberosities of the subject, we measured pressures at each of the 24 locations. Consecutive measurements were recorded to ensure repeatable pressure values. With the transducers in place, the subject then propelled the wheelchair throughout the clinic for 3 minutes, after which interface pres-
ures were again measured, and the propulsion scale was scored.

**Data Analysis**

Mean pressures and standard deviations were calculated for each side. Interface pressures were analyzed with a three-factor multivariate repeated-measures analysis of variance on the mean pressure measurements. The independent variables were cushion type (i.e., hemi vs. subject's regular cushion), predynamic versus postdynamic postures, and impaired versus unimpaired side seat interface pressures. All statistical comparisons were evaluated for significance at a probability level of .05.

The results for both sitting balance-posture and wheelchair propulsion were tabulated for both the Hemi Wheelchair Cushion and the subject's regular cushion to determine the respective levels of performance. The performance of the Hemi Wheelchair Cushion was categorized as follows: (a) diminished performance, (b) unchanged performance; or (c) improved performance.

**Results**

Analysis of the mean pressure measurements indicated no significant difference between the Hemi Wheelchair Cushion and the second cushion tested \((p = .80)\) nor between the impaired versus unimpaired limb distribution pressures \((p = .80)\). A significant difference was found when we compared predynamic versus postdynamic mean pressures for both cushions \((p < .01)\). The predynamic pressure for the Hemi Wheelchair Cushion was 45.2; for the other cushion, 43.5. The postdynamic pressure for the Hemi Wheelchair Cushion was 50.9; for the other cushion, 51.6. On the Hemi Wheelchair Cushion, the mean pressure difference between the impaired (supported) and unimpaired (cutout) sides was only 1.5 mm Hg. The cutout (unimpaired) side exhibited a higher peak pressure in only 2 of 11 cases. A bilateral peak pressure difference of greater than 10 mm Hg was found in 5 subjects. In 4 of these cases, the supported (impaired) side experienced the higher pressure.

Results of the balance–posture evaluations indicated that 5 of the subjects could assume an unaided test posture and 4 subjects could independently assume the test posture and maintain a normal posture with the Hemi Wheelchair Cushion. In comparison with each subject's regular cushion, 9 of the 11 subjects exhibited no postural difference while using the Hemi Wheelchair Cushion. One subject's posture was noted to have diminished while sitting on the Hemi Wheelchair Cushion, and 1 subject's posture improved (see Figure 2).

Nine subjects could propel their wheelchair with fair to good sitting posture while seated on the Hemi Wheelchair Cushion (see Figure 3). While using the Hemi Wheelchair Cushion, 8 subjects had no change in propulsion performance as compared with the other cushion, whereas 3 subjects showed improvement in their propulsion.

**Discussion**

The clinical evaluation of the Hemi Wheelchair Cushion indicated that it performed as well as the subjects' regular cushions in distributing pressure under the ischial tuberosities. Cushions regularly used by the subjects were of several types and were the choice of the subjects' therapists. Comparisons of the Hemi Wheelchair Cushion to the subjects' other cushions represented a comparison to a support deemed appropriate for that person in regard to pressure and balance.

One of the concerns about the Hemi Wheelchair Cushion was that it would induce a pelvic obliquity due to the difference in leg support and angle of the hips created by the design of the cushion. The finding that the mean pressures under the cutout (unimpaired) side were not statistically different from the pressures under the supported (impaired) side dispelled this concern. In fact, for most subjects, the pressures on the support side tended to be higher than those measured on the cutout side.

The presence of a pressure discrepancy between the impaired and unimpaired sides for both cushions could be explained by the critical role of the footrest. When a wheelchair user propels with the aid of one foot, the contralateral leg is supported by a footrest. In the seated posture, a small portion of the weight from the trunk is...
transferred from the pelvis to the lower extremity. The thigh then transmits this weight and the weight of the thigh itself to the cushion. If the footrest is adjusted too high, the thigh is not adequately supported by the cushion and the upper body weight is instead transferred to the cushion through the pelvis. This may explain the higher, although not significant, interface pressures measured under the ischial tuberosities on the supported side in two cases. A second reason for this discrepancy could be associated with the trunk imbalance of tone and strength commonly seen in persons with hemiplegia. This muscular imbalance can lead to a pelvic obliquity and asymmetric pressure distribution.

Wheelchairs and cushions must be selected to suit the patient’s needs and to provide support to prevent pressure ulcers. Persons who appear to have a pelvic obliquity when seated in their wheelchairs should be tested through the use of pelvic palpation and pressure measurements. In addition, persons should be encouraged to reposition themselves after working on equalizing weight distribution through trunk strengthening.

The only statistically significant result of the pressure analysis was the increase in readings following dynamic movement of self-propelling a wheelchair with one of the lower extremities for both the Hemi Wheelchair Cushion and the subject’s regular cushion. This finding raises the question of mobility versus pressure, as the clinical specialist will need to determine whether a person is causing damage to his or her skin by self-propelling with the lower extremity. The act of propelling a wheelchair with a lower extremity induces a forward sliding force on the body that can pull the pelvis forward into a posterior tilt and increase shear forces on the tissue. Persons who propel in this manner should be educated about the possible effect that propelling has on their posture, and they should be encouraged to reposition themselves after movement. Shear loading has been identified as a contributor to increased pressure over bony prominences (Bennett, Kavner, Lee, & Trainor, 1979). Further research to investigate the factors of friction and shear forces resulting from dynamic wheelchair activity is needed to determine how they affect the skin integrity of persons who propel themselves with a lower extremity.

The clinical evaluations of posture and propulsion indicated no difference in the performances of the two cushions for the majority of subjects. It appears that both the Hemi Wheelchair Cushion and the subjects’ personal cushions performed well and did not have a detrimental effect on posture or propulsion ability. Furthermore, 3 subjects showed improvement in their ability to propel the wheelchair while seated on the Hemi Wheelchair Cushion. The performance scales used in this study appeared to be limited in detecting subtle differences. Future research should use expanded scales that might determine if differences truly exist.

After the experiment, when asked to select which cushion they would prefer, 10 of the 11 subjects selected the Hemi Wheelchair Cushion. They reported that it allows easier management of the wheelchair with less exertion of energy as well as increased comfort.

The Hemi Wheelchair Cushion is a relatively low-cost foam cushion with performance ratings comparable to other cushions used with this population. Its low cost may make it accessible to persons who might otherwise not be able to afford a cushion, such as persons in nursing homes, who do not always have therapeutic services available or budgets to accommodate such expenditures.

Summary

The Hemi Wheelchair Cushion was devised for persons who use one of their legs to propel a wheelchair. In the three areas studied (pressure, balance, and propulsion), this cushion’s performance was comparable to that of other commercially available cushions. With other factors being equal, one must look at such qualities as comfort, durability, and cost. The Hemi Wheelchair Cushion is a low-cost foam cushion that provided adequate comfort and support for the majority of subjects with hemiplegia in this study. The results of this study lead us to conclude that the Hemi Wheelchair Cushion is a viable alternative to more costly wheelchair cushions.