FINITE ELEMENT CALCULATION OF SEAT-INTERFACE PRESSURES FOR VARIOUS WHEELCHAIR CUSHION THICKNESSES.

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Seat interface pressures in wheelchairs are of interest to both researchers and clinicians since many patients with spinal cord injuries develop pressure ulcers. Pressure ulcers unquestionably result from a very complex set of risk factors, but the primary mechanism is sustained high pressure and the associated loss of circulation. The highest pressure occurs beneath the ischial tuberosities due to the concentration of localized forces. The relatively recent advent of pressure-sensitive nets have made it possible to measure seat interface pressures. However, it is not clear whether the interface pressure provides enough information, since there is evidence that the highest pressures are interior and that pressure ulcers develop internally and spread toward the surface. The goal of the current study is to investigate the effect of the cushion thickness on these interior pressures with a finite element model of the buttock and lower pelvis. It was found that urethane cushions did in fact reduce the maximum stress below the ischial tuberosity but that increasing the thickness beyond 8cm was ineffective in further reducing stress. It was also found that seat-interface pressures were a good but not a complete measure of internal stress reduction.

Background

Seat interface pressures are of interest to both researchers and clinicians since many patients with spinal cord injuries who use wheelchairs develop pressure ulcers. Pressure ulcers unquestionably result from a very complex set of risk factors, but the primary mechanism is sustained high pressure and the associated loss of circulation. The highest pressure occurs beneath the ischial tuberosities (IT) due to the concentration of localized forces. Wheelchair cushions reduce the pressure underneath these bony prominences by redistributing the forces over a larger area. The relatively recent advent of pressure sensitive mats with multiple sensors in a matrix has made it possible to measure seat interface pressures. Producers of cushions use seat interface pressures to assess the effectiveness of cushions in relieving high pressure. However, it is not clear whether the interface pressure provides enough information, since there is evidence that the highest pressures are interior (Reddy *et al.*, 1982) and that pressure ulcers develop internally and spread toward the surface.

Previous studies have used finite-element models of the buttocks and lower pelvis to investigate the interior pressures that occur in a seated human. Previous studies usually focused on isolated seating scenarios (Dabnichki *et al.*, 1994). The goal of the current study was to investigate, in a systematic fashion, the effect of the cushion thickness on these interior pressures.

Methods

In order to study the interior pressures, a three-dimensional model of the buttocks and lower pelvis was developed using ANSYS® finite-element software. To reduce the computational requirements of the problem, an axisymmetric model was used. Each

buttock was taken to be a horizontal circular slab of radius 16 cm and width 8 cm. The buttocks were considered to consist of nearly incompressible "soft" human tissue with a Young's modulus of 47 kPa and a Poisson's ratio of 0.49 (Todd and Thacker, 1994). Each IT was treated as a cylinder of radius 1.5 cm with a hemispherical point. The weight of the upper torso was divided into two loads; one applied to the top surface of the IT, and the other was applied as a uniform pressure on the top surface of the buttock. The values of these loads were found by fitting the results of the finite-element model to measured values obtained with a Novell Pliance^{TM} pressure sensitive mat (1024 1.5 cm^2 capacitive sensors).

Results & Discussion

Cushion thicknesses of 0 to 16 cm were studied. However, almost all of the reduction is obtained with an 8 cm cushion where the maximum interior stress is reduced from 29.3 N/cm^2 for a hard seat to 16.0 N/cm^2. In fact, the shear stress *increases* slightly for thicker cushions. The maximum interior stress is indeed greater than the maximum interface pressure, but they are not in constant proportion. For a hard seat, the interface pressure is 79% of the maximum interior pressure, whereas for a 16cm seat it is 57%.

Bibliography

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Other Presentations

- UW-L Third Annual Celebration of Undergraduate Research and Creativity, April 3 to April 7, 2000 UW-LaCrosse.
- UW-System Symposium for Undergraduate Research, May 22-23, 2000 UW-LaCrosse.

Meeting Information

- American Society of Biomechanics
- 24th Annual Meeting
- University of Illinois at Chicago
- July 19-22, 2000
- Train Travel
- Mani Bidar, Tom Kernozek

Budget

- Train Ticket $130.00
- Accommodations (2 nights) $96.00
- Registration $50.00
- Total $276