"A New Approach to Pressure, Friction, Shear and Microclimate Management in Wheelchair Seating – Imagine the Possibilities"

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Disclosure: I (Mark Payette) have an affiliation with Tamarack Habilitation Technologies, Inc. as an employee with involvement in product research.

This presentation is a report to show progress made in designing and developing a radically new wheelchair seat design. The design goals include the management of <u>all</u> of the local pressure ulcer generation factors and a new <u>process</u> for producing a custom-formed seat surface which can be done rapidly, and with the immediate and direct input and control of seating team personnel (supplier, clinicians, and consumer) at the provision site and time.

The National Pressure Ulcer Advisory Panel recognizes four physical conditions <u>at</u> these ulcer sites which contribute to tissue trauma <u>and</u> which relate to seat materials and design. They are 1. Pressure; 2. Friction with its associated shear forces; 3. Heat; and 4. Moisture.[1] The wheelchair seat support surface (cushion) is under development, and addresses and minimizes <u>all four</u> of these local factors.

<u>The Pressure Factor</u>

When contact pressure is too great, usually in a bony area, blood cannot flow through the capillaries sufficiently to bring oxygen and nutrients to the cells and metabolic <u>by</u>products are not carried away. If that high contact pressure persists too long, the cells begin to die.[1, 2] Until very recently, the pressure-induced ischemia model of ulcer generation has exclusively dominated the design of wheelchair seat cushion and other body support surface products to the near-exclusion of the other three tissue trauma factors.

<u>The Friction Factor</u>

The second factor on the list, and perhaps the <u>most</u> destructive, is friction and the elevated shear stresses it causes. Friction at the skin surface causes shear stress and strain (deformation) within the skin and soft tissues. Shear strain can be very destructive.[3, 4] In fact, Bennet, et. al. detected capillary occlusion at greatly reduced pressure (approximately 50%) when shear loads are superimposed. There is also evidence that the friction-induced shear stress caused by short duration friction loading causes direct fracturing of sub-dermal biological micro-structures.[2]

There is a common misconception that friction loads can only cause surface damage such as abrasion and dermal blisters. However, friction loads at the skin surface <u>do</u> result in shear stress and strain changes at deeper levels.[1, 2, 3, 5, 6]

A second misconception is that friction loads and their damaging effects occur only as the wheelchair user (or person in bed) is moving or being moved. Actually, very damaging levels of residual friction-induced shear distortion persist after a person settles into their wheelchair or bed.

Micro-movements occurring during subtle positioning changes and functional activities add to the residual friction while sitting or lying and increases damage over time. It is known that tissues at bony areas are at very high risk because that is where the enabling pressure and shear strain magnitude will be greatest.[3, 4]

Scar tissue must also be recognized as especially vulnerable to shear damage. Friction loads and shear stresses will concentrate at a scar because it is less elastic than surrounding tissue. When scar tissue is accompanied by adhesions to underlying tissue or bone, the risk of re-injury is even higher.[7] This is a likely reason for the high pressure ulcer recurrence rates.

The Microclimate Factors

Heat/temperature comes in as a pressure ulcer-generating factor because a one degree Centigrade rise in temperature will increase cell metabolic rate by approximately 10%.[1,8] The temperature of the skin also impacts the strength of the stratum corneum - at 35 degrees C the mechanical strength of the stratum corneum is 25% of skin at 30 degrees C.[1, 9]

Moisture is the last on the list of the four local physical factors in ulcer generation. The outermost layer of skin, the Corneum, is physically weaker when moist. The Corneum, like many other materials, exhibits a higher coefficient of friction (COF) when moist than when dry.[10] So, any support surface feature which enhances air circulation will carry a double benefit. It will help maintain epidermal integrity and the evaporative cooling will delay onset of tissue necrosis.

THE QUADRUPLE APPROACH; PULLING IT ALL TOGETHER

This unique new approach for a wheelchair seat support surface consists of a weight-bearing structure with a simple Tabby weave pattern of straps which are attached to a specialized frame. During the forming process, the length of each strap is controlled by its own individual mechanical device. The frame provides a firm area of support under the thighs.

The perimeter of the posterior section of the frame is contoured to provide clearances for bony areas (the Sacrum and Greater Trochanters). The woven straps crossing the sub-pelvic area are suspended from the perimeter of the frame in a way which allows each strap to lengthen individually as needed in response to downward pressure. This allows the woven surface to assume the contours of any individual pelvis. Beyond that, the design allows a trained provider to easily lengthen two or more intersecting straps to reduce or remove weight-bearing loads from any wounded or at-risk areas. During the custom forming process, the use of a pressure mapping mat is helpful. Since the undersides of the woven straps are exposed and palpable, a knowledgeable provider can easily palpate, without forcing a hand between the straps and the user's underside, to identify areas requiring additional pressure relief and to make those changes while the patient remains seated, undisturbed. When the provider has made any necessary adjustments, the "pay-out" ends of the straps are firmly anchored to the frame and the "pay-out" hardware is removed for re-use by the ATP.[11]

The seat support surface (cushion) design is completed by a novel two-piece fabric cover assembly. The surface of the upper (outer) cover is divided into two very contrasting friction zones; the area beneath the pelvic boney anatomy provides a very low friction zone, the entire thigh area retains a relatively "normal" high friction zone. The sub-pelvic area of the cover is made of a patented low-friction composite material panel exhibiting an ultra-low COF of less than 0.2. The low-friction interface area under the pelvis effectively isolates those at-risk sites from damaging levels of friction-induced shear. In addition, that material is air-and-liquid permeable, helping to reduce temperature and moisture levels for very favorable microclimate conditions. This low-friction interface technology is called GlideWear®.

The lower, second cushion cover component, is made of a reticulated spacer fabric. The open nature of the spacer fabric and strap gaps allows air access for drying and cooling. Bench testing results performed at an independent test lab show this new design to be capable of significantly improving the microclimate factors of temperature and moisture. (Table 1) Plans are in place for a study at the Minneapolis VA to investigate this new technology's microclimate performance with human subjects in 2016.

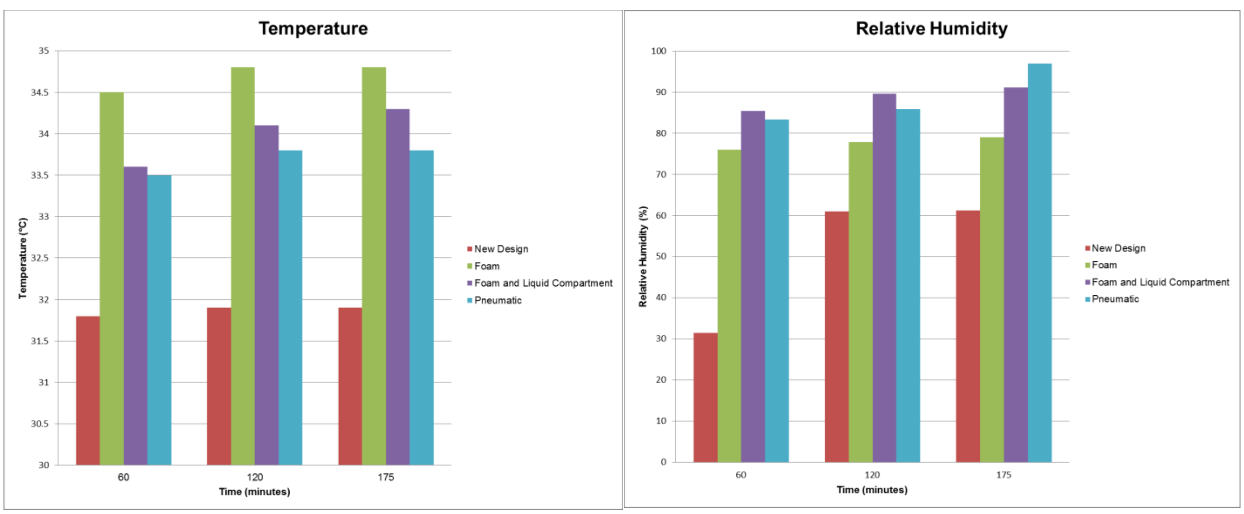

Table 1 Heat and Water Vapor test data [12]

The wheelchair seating technology just described can be adapted to be an independent cushion or it may be integrated directly into the wheelchair frame design. An integrated approach reduces total equipment weight and eliminates one mobility system component.

Currently there are a small number of individuals Beta testing this design successfully, with use beginning in 2013. As of December 2015 n=8. The manufacturer envisions further evaluations, mostly in the greater Minneapolis area, esp. at the Minneapolis VA, across 2016. (Table 2)

User	DX	Reason for Use	Time in use	Outcome	Acceptance	Functional Issues
1	SCI-para	multiple, severe, non healing wounds	40 months	wounds closed - wounds improved	easy and fast	none
2	SCI-para	severe pain and discomfort	18 months	pain free comfortable	easy and fast	none
3	SCI-para	wound prevention and stability	6 months	wound remaining closed and is stable	easy and fast	transfers more difficult
4	SCI-quad	discomfort	5 months	comfortable	easy and fast	none
5	SCI-para	wound and unilateral hip ext contractur	5 months	wound closed and contracture accomodated	easy and fast	none
6	SCI-para	posture, pain and comfort	4 months	improved posture, pain relief and comfortable	easy and fast	transfers more difficult
7	SCI-para	wound, discomfort	2 months	wound closing comfortable	easy and fast	transfers more difficult
8	SCI-para	wound	1 month	wound closing	easy and fast	none

Table 2 Beta Testing User Feedback Tamarack Habilitation Technologies, Inc.

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