The Science of Interface Pressure Mapping – Updates for Clinical Application

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Introduction

Interface pressure mapping (IPM) has long been a useful assessment tool to augment the seating evaluation. Technological improvements in both hardware and software have made steady advances across manufacturers. Likewise, progress has been made in the scientific study of the clinical application of pressure mapping. This course will focus on the science behind IPM and recent research findings which influence clinical interpretation of the map. Phenomena such as creep, the effect of the mat and the influence of cushion materials will be highlighted. Additionally, reliability of specific metrics will be discussed, with a de-emphasis on the use of single sensel peak pressure values. Emphasis will be placed on the importance of using a consistent IPM protocol within your seating clinic to make relative cushion comparisons.

Background

There is growing demand internationally for a standardized clinical guideline for IPM, with respect to both data acquisition and interpretation. In fact, the ISO Work Group on Wheelchair Seating has established a Task Group to develop a Technical Report on this subject.[1] Much can be learned from current recommended protocols.[2,3,4] However there is still room for increased consistency across IPM systems and across clinical settings. Lack of a standardized protocol limits the ability to compare clinical research findings across studies utilizing IPM and may limit external validity. This in turn may slow the growth of evidence-based practice in the field of seating and wheeled mobility.

Data Acquisition

Establishing an international standardized clinical IPM guideline is no quick task. However, the work begins “at home”. The importance of following a consistent protocol within your own clinic cannot be over-emphasized. IPM is not an exact science, but its clinical usefulness increases greatly with consistency. One variable which should be controlled is “settling time” before an actual recording is done. Current protocols are not consistent in this regard, ranging from 6 to 10 minutes.[2,3,5,6] This settling time takes into account creep – of the sensor, the tissue and the cushion material. Sensor creep, inherent in most IPM sensor technology, is the tendency for the sensors to increase their reading over time, given a constant load. Corrections for creep are made during the calibration/equilibration process. However, this correction is most accurate clinically if the time frame utilized for creep correction during the calibration matches the time frame used during data acquisition. A mismatch of these times can be sources of error.[1] Some IPM systems allow manipulation of this time factor during in-field calibration/equilibration. Tissue creep occurs relatively quickly and consistently across cushions. By comparison, cushion creep is highly dependent on its make-up. Air

cushions and cushions composed of high resiliency foams have a short settling time compared to those composed of viscous fluids/foams. Stinson et al studied the time required for the IPM values to "stabilize" using able-bodied subjects and found 6 minutes to be the recommended settling time before taking an IPM reading.[5] Study limitations sited by the authors include: (1) Data from able-bodied subjects cannot be extrapolated to persons with disabilities. (2) Only average pressure and single peak pressure values were used in analysis; both measures have limitations as discussed below. An additional limitation of this study is the fact that only one initial calibration was performed and utilized throughout the 10-week study. This is not to say that the calibration was not accurate, but that readers cannot be certain of the level of accuracy. A subsequent study on the impact of sitting time by Crawford et al using subjects with Multiple Sclerosis concluded that ≥ 8 minutes may be the optimal duration before IPM recording is done.[6]

Pilot data has been collected at Georgia Tech to further study the effects of mat sensor creep. Buttock models were used to eliminate soft tissue variability and a materials testing machine was used to apply a constant load. Measurements were taken at time 0, 1, 3, 5, 8 and 10 minutes. Up to a 51% increase in Peak Pressure Index (defined below) and up to a 44% increase in total force occurred over 1-8 minutes. The greatest increase occurred between time 0 and 1, while the least change occurred between 5 and 8 minutes. The latter supports Crawford and Stinson's findings of when IPM values "stabilize". However, it must be noted that "stable" measures occurring at the 5-8 minute time points, do not necessarily represent *accurate* measures.

The clinical take home message is to practice consistency within your clinic, if not across clients, at minimum within cushion trials for a given client. The limiting "creep factor" is that of cushion materials. The settling time should be determined based on the cushion trialed composed of materials with the most "time-dependent" properties - viscous fluids (e.g. Jay2) or visco-elastic foam (e.g. Tempur-Med). For example, a cushion set is comprised of a Roho Quadtro, a 3" HR foam cushion and a J2DC. The former two have a shorter settling time estimated at ≤ 1minute. The J2DC, with its viscous fluid pad, has a longer settling time of about 5 minutes. When acquiring data on this set of cushions, the settling time should be 5 minutes, so that the effect of the sensor creep will be consistent across cushions - enabling the best relative comparison.

<u>Mat Effect</u>

A recent study was conducted at Georgia Tech to study how the presence of four commercially available IPM mats influenced interface pressure (IP), envelopment and immersion.[7] A materials testing machine was used to load buttock models onto seven different cushions. The buttock models were instrumented with individual pressure sensors to compare measures with and without the mats present. Overall, magnitude, envelopment and immersion decreased after mat introduction, though the decrease in immersion was only about 1 mm and is unlikely to have clinical relevance. Mats hammocked across buttock contours, causing a decrease in IP magnitude and envelopment. Two of the IP mats had less effect on envelopment than the others. The cushion-mat interactions were significant for pressure magnitude and envelopment,

indicating that the mat effect differs across cushion design. In other words, any one mat affected IP, but not to the same degree across different cushions.

Key Parameters for Interpretation

Of the above referenced protocols, there is agreement with regard to three key parameters from which to "rate" a map:

1. peak pressures (this does not equate to single sensel peak values);
2. distribution of pressure with regard to symmetry;
3. total contact area.

Peak Pressure:

Historically, single peak values have been used to rate cushions. Sprigle et al studied reliable, repeatable metrics for IPM – single peak values did not make the cut.[8] Rather, the researchers recommended use of a Peak Pressure Index (PPI), which was found to be repeatable. PPI is defined as the average of the highest recorded pressure values within a 9-10cm^2 area (the approximate contact area of an IT or other bony prominence). The number of individual sensels included in the calculation depends on the spatial resolution of the mat. For example, in Xsensor this includes nine sensels, for FSA and Conformat - four. Focusing on the grouping of peak sensels also lends to assessing another important measure: gradient of pressure. A high gradient from peak to adjacent sensels indicates poor envelopment of the bony prominence. Sprigle et al also note average pressure as a reliable metric, but do not advocate for its use clinically. It is not a volatile enough measure to perform relative comparisons of products. Further, it has minimal clinical worth – assessing average pressures, which in effect masks the *distribution* of the pressure, has little clinical relevance. The Coefficient of Variance, represented as a percentage, offers more insight with respect to evenness of pressure distribution – the lower the CoV the better.

Symmetry:

Optimization of pressure distribution symmetry, comparing right and left sides, is a key goal. Focus is placed on the symmetry of at-risk sites: the IT's and greater trochanters. This parameter highlights the importance of integrating IPM findings with a comprehensive physical evaluation. Problem solving with respect to asymmetrical IPM results cannot be accomplished absent of a postural evaluation. In fact, mapping the client while seated on a mat table is a useful means to combine the two: bony prominences can be clearly matched to peak pressures, asymmetries can be elucidated and the effect of manually providing postural support/correction can be assessed.[2,4]

Contact Area:

Contact area is representative of the goal to distribute the forces (body weight) over as large an area as possible. Given the defining equation of pressure (pressure = force/area), the larger the area, the lower the pressure given a constant load. Contact area can be represented by the total number of sensels under load. Sprigle et al further recommends establishing a minimum threshold of 5mmHg to represent load – this avoids inclusion of fluctuating non-zero values and minimizes the effect of noise (IPM sensors are generally less accurate at extreme low values due to the inherent effect of

electrical noise).[8] Dispersion Index (DI) is another metric reported by Sprigle et al to have good reliability.[8] DI is the sum of pressure distributed over the IT and sacral regions divided by the sum of pressure readings over the entire mat, expressed as a percentage. Drummond et al found that "unacceptable" interface pressures occurred when >55% of the pressure was at the IT and sacral regions.[9] Though DI and Contact Area are useful measure with respect to the focus of IPM interpretation on *relative comparison* of cushions, both are limited when comparing apples to oranges. In static cushions, effective pressure distribution is achieved either via envelopment or off-loading. Neither measure by itself represents a fair comparison if one cushion envelops and the other off-loads.[10]

Summary: Be consistent. Focus on relative comparisons. Respect your clinical mind.

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