TECHNICAL REPORT

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Wheelchair seating —

Part 9:
Clinical interface pressure mapping guidelines for seating

Sieges de fauteuils roulants —

Partie 9: Lignes directrices pour l'utilisation d'un système de mappage de pression

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Foreword

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 173, *Assistive products for persons with disability*, Subcommittee SC 1, *Wheelchairs*.

ISO 16840 consists of the following parts, under the general title *Wheelchair seating*:

— *Part 1: Vocabulary, reference axis convention and measures for body segments, posture and postural support surfaces*

— *Part 2: Determination of physical and mechanical characteristics of devices intended to manage tissue integrity — Seat cushions*

— *Part 3: Determination of static, impact and repetitive load strengths for postural support devices*

— *Part 4: Seating systems for use in motor vehicles*

— *Part 6: Simulated use and determination of the changes in properties of seat cushions*

— *Part 9: Clinical interface pressure mapping guidelines for seating* [Technical Report]

— *Part 10: Resistance to ignition of non-integrated seat and back support cushions — Requirements and test methods*

— *Part 11: Determination of perspiration dissipation characteristics of seat cushions intended to manage tissue integrity* [Technical Specification]

— *Part 12: Apparatus and method for cushion envelopment testing* [Technical Specification]

Introduction

The purpose of this Technical Report is to provide information as to where interface pressure mapping (IPM) can fit into a clinical assessment of an individual and their seating system, to highlight what can be achieved, and bring awareness of the limitations.

The use of IPM in the clinic is increasingly used to support clinicians in the evaluation of individual seating systems for individual clients. To get the best value from IPM requires a knowledge of the basic concepts of the interface pressure distribution (see Clause 2), the ability to define and apply a correct protocol for the application of IPM (see Clause 4), the ability to prepare correct documentation of the IPM (see Clause 5), and the skill in interpreting the collected data (see Clause 6).

The aim of an IPM test session can be different in a clinical or rehabilitation environment. In some cases, it can be a tool to compare the behaviour of different pressure care or postural cushions. It can also be used to support the clinician in finding the best match between cushion and client. Various applications looking at the broader picture are covered in Clause 3. Whichever the application, the main objective behind using an IPM needs to be clear from the beginning.

Wheelchair seating —

Part 9: Clinical interface pressure mapping guidelines for seating

1 Scope

This Technical Report has been produced to guide users in the performance of the tasks that are directly involved in the clinical use of interface pressure mapping (IPM) or are synergistic with its use in a comprehensive wheelchair seating evaluation.

This Technical Report does not cover other aspects of the clinical assessment process (e.g. taking a medical history), nor the prescription or treatment process which might arise from an assessment. These guidelines are not meant to be a substitute for clinical reasoning and judgement within the context of a complete assessment.

This Technical Report refers to the state of the art of IPM experiences in a seating scenario. Most of the principles covered can be extrapolated to whole body (in bed) or to foot assessments, for example.

2 Definitions and glossary

2.1 Calibration

Calibration is a process wherein the sensing mat is subjected to known forces. The sensor responses are monitored and modelled in the software.

NOTE A record is kept of the responses (called a calibration file) and whenever the sensors output a similar response, the result is related to the previously known forces. In most cases, this is done by placing the mat in a purpose-built chamber with an air-filled bladder. The bladder is inflated and the pressure in the bladder is measured. It is assumed to be evenly pressurized over the mat.

Calibration allows for the software to accommodate changes with time (creep) or pressure (hysteresis) exhibited by the sensors.

Recalibrate the mat whenever the readings look unreliable, after excessive use, or at the manufacturer's recommended interval. Keep track of the uses of the mat and the date of the last calibration. Old calibration files should be retained (old calibration files can be loaded for comparison to determine change over a period).

2.2 Coefficient of Variation (CoV)

The CoV is expressed as a percentage:

$$Coefficient\ of\ Variation = \frac{Standard\ deviation}{Mean} \qquad (1)$$

NOTE This is one of the statistical measures available to assess how evenly the pressure is distributed across a support surface. The lower the CoV, the lower the variability in the data set.

2.3 Conformity

The ability of the IPM mat to adapt to irregular shapes without creasing.

2.4 Contact area

Contact area is the area under load

NOTE 1 The contact area is approximated by the total number of sensors under load.

NOTE 2 Contact area is representative of the aim to distribute the 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. Reference[8] recommended that the minimum threshold to be used should be 5 mmHg to avoid inclusion of fluctuating non-zero values and minimize the effect of noise.

2.5 Creep

There are three different manifestations of creep that are of concern: sensor creep, cushion creep, and tissue creep. Sensor creep, inherent in most IPM sensor technology, is the tendency for the sensors to change their reading (output) over time given a constant load (input).

NOTE Most IPM systems, for which this is a factor, have built-in software correction for sensor creep. Creep is normally only corrected for during the time the mat is reading. Stopping and starting the readings may interfere with the creep corrections.

2.6 Dispersion Index (DI)

The DI is defined as the sum of pressure distributed over the ischial tuberosity (IT) and sacral-coccygeal region divided by the sum of pressure readings of loaded sensors over the entire sensor mat, expressed as a percentage.

$$\text{Dispersion Index} = \Sigma A/(\Sigma A + \Sigma B) \qquad (2)$$

where

A is the pressures of the IT and sacral-coccygeal area;

B is the pressures outside the IT and sacral-coccygeal area.

NOTE The DI represents the concentration of pressure in high risk areas versus low risk areas and can be indicative of a support surface's ability to redistribute pressures. DI is also a metric reported to have good reliability in Reference.[7] In Reference [4] it was found that interface pressures were "unacceptable" when >55 % of the pressure was at the IT/sacral regions. DI, as compared with pure contact area, may be a more useful metric when performing relative comparisons between cushions. Effective pressure distribution can be achieved either via envelopment or off-loading of the high risk sites. If one cushion off-loads and the other envelops, DI may offer a better "apples to apples" method of comparison than contact area alone.

2.7 Envelopment

The ability of a support surface to conform so to fit or mould around the irregular shape of the body.

2.8 Fomite

An inanimate object or substance (such as clothing, furniture, or soap) that is capable of transmitting infectious organisms from one individual to another.

2.9 Hysteresis error

Hysteresis error is the difference in two measurements of the same quantity when the measurement is approached from opposite directions.

NOTE 1 Hysteresis generally manifests itself in IPM applications as the difference in a given pressure reading depending on whether that pressure was reached by increasing from a lower pressure or decreasing from a higher pressure.

NOTE 2 Hysteresis is a natural phenomenon which occurs in all types of electrical, magnetic, and mechanical devices. A hysteresis loop is generally used to characterize hysteresis. If a sensor is held at a constant pressure, there is a corresponding electrical output value for that pressure. It would be expected that if that applied pressure rose or fell, the corresponding electrical output value would rise or fall in synchronicity with the applied pressure. Sensor hysteresis is a dynamic effect where the sensor output "lags" behind the corresponding applied pressure as the applied pressure rises or falls (i.e. for a rising pressure, the displayed pressure will be lower than the pressure applied at the sensor and vice versa).

NOTE 3 Hysteresis can be reduced in two ways: by selecting a material which will be used in the sensor which inherently possesses less hysteresis or by compensating for hysteresis via a calibration algorithm in the software.

2.10 Immersion

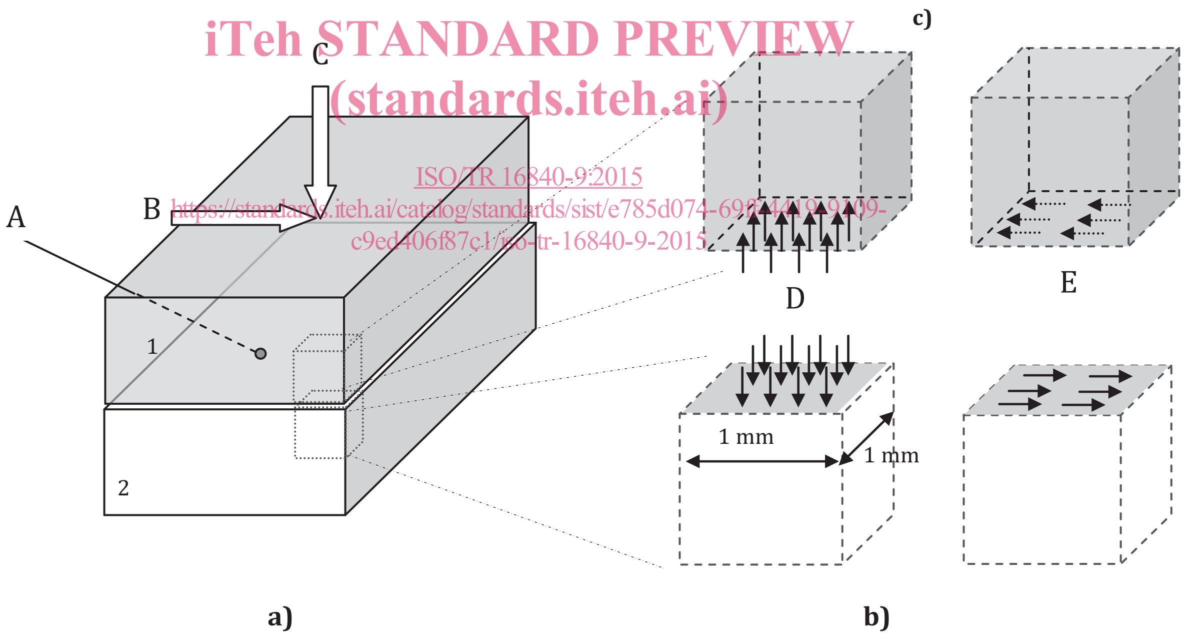
The depth of penetration into a support surface measured in the vertical plane.

NOTE 1 This is how far the body sinks into the cushion.

NOTE 2 It is important to immerse without bottoming out.

2.11 Pressure, stresses, and forces

For the seated person, the person's tissues and the support surface the person is seated on undergo potential deformations due to the effects of perpendicular and horizontal stresses and forces as summarized in Figure 1.



Key

A contact surface

B shear force

C perpendicular force

D pressure

E shear stress

Figure 1 — Forces and stresses acting between two objects a) forces acting on object 1 and transmitted to object 2 b) pressure and shear stress acting on the upper surface of a unit volume of object 2 at the 1-2 contact surface c) pressure and shear stress acting on the lower surface of a unit volume of object 1 at the 1-2 contact surface

2.11.1 Axial strain (ε)

The deformation (relative change of dimension) due to the action of stress in the stress direction (see Figure 2).

NOTE Axial strain is dimensionless.

2.11.2 Perpendicular force (FP)

A force occurring at right angles (90°) to an element's surface.

NOTE FP is measured in Newtons (N).

2.11.3 Pressure (p)

Pressure is the perpendicular force (FP) divided by the area of the element's surface to which the perpendicular force is applied.

$$\textit{Pressure [MPa] = Normal force [N]/Area [mm}^2\textit{]} \tag{3}$$

NOTE 1 The units of pressure used in most applications are pounds per square inch (PSI), Pascals (N/m^2), or millimetres of mercury (mmHg).

NOTE 2 Unit conversions

1 Pa = 1 N/m^2

1 kPa = 1 000 Pa

1 MPa = 1 000 kPa

1 mmHg = 133,322 Pa

1 PSI = 6 894,757 Pa

NOTE 3 An IPM image is a visual representation of the normal pressures between two contact surfaces of two (usually deformable) bodies such as the top surface of a cushion cover and the material covering a person's backside.

2.11.3.1 Average pressure

Average pressure is defined as the average value of the pressure recorded by a group of sensors of predefined location and disposition around a significant landmark.

NOTE 1 The predefined groups of sensors can be called control areas or masks. As an extreme case, the overall average pressure can be calculated over the contact area.

NOTE 2 Overall average pressure across the whole cushion is not of clinical relevance because it is too general a metric for differentiating cushions.

2.11.3.2 Peak pressure

Peak pressure is the highest value of the pressures recorded by the sensor units in the mat.

NOTE 1 From a general view point, there can be a single absolute peak pressure as well as several relative peak pressures.

NOTE 2 If data collection is taken over time, there will also be a maximum peak pressure over a given time interval.

NOTE 3 The location of the peak pressure on an image can change over time in the case of a dynamic recording.

2.11.3.3 Peak pressure index (PPI)

PPI is the pressure average value calculated within a 10 cm^2 area (i.e. the approximate contact area of an ischial tuberosity) around the highest recorded peak pressure values).

NOTE 1 A high gradient from peak to adjacent sensors indicates poor envelopment of the bony prominence.

NOTE 2 Historically, single peak pressures were used to rate cushions. Reference[7] studied reliable metrics for IPM, and single peak measures were not repeatable. The result was that researchers recommended the use of a peak pressure index.

2.11.4 Shear force (FS)

A force occurring parallel with an element's surface.

NOTE FS is measured in Newtons (N).

2.11.5 Shear stress (τ)

The shear force divided by the area of the element's surface to which the shear force is applied.

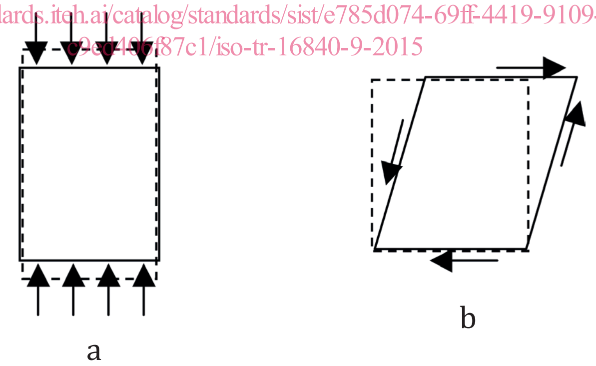
NOTE Shear stress is measured in kiloPascals [kPa] or equivalent units.

$$\textit{Shear stress [MPa]} = \textit{Shear force [N]/Area [mm}^2\textit{]} \quad (4)$$

2.11.6 Shear strain (γ)

The distortion (change in the shape) of an element due to the action of shear stress.

NOTE Shear strain is dimensionless.



Key

a axial strain

b shear strain

Figure 2 — Axial and shear strain of a unit surface due to pressure and shear stress

2.11.7 Friction force

Friction is the force resisting the relative motion of two objects with surfaces in contact.