

**Making Sense of the Numbers –
Using ISO Test Data to Guide
Cushion Selection.**

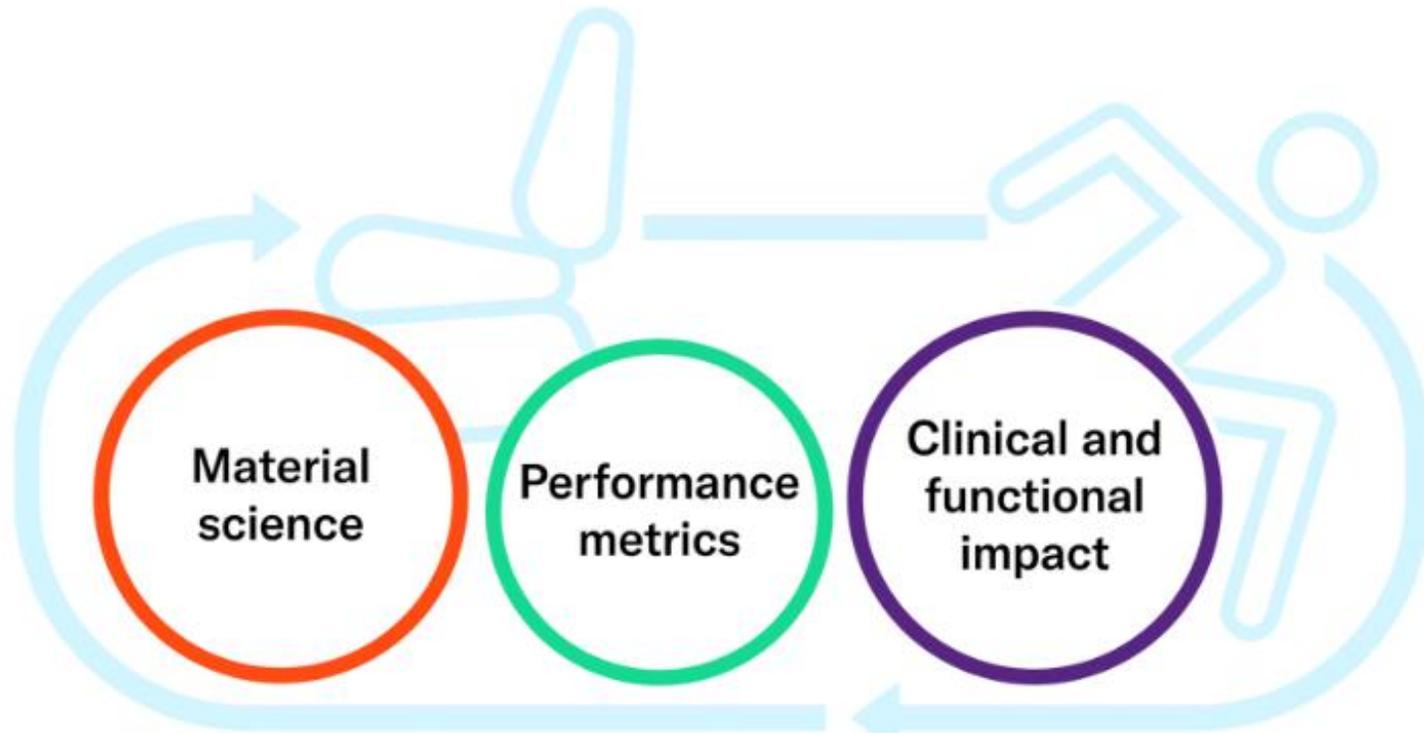


Terri Davies

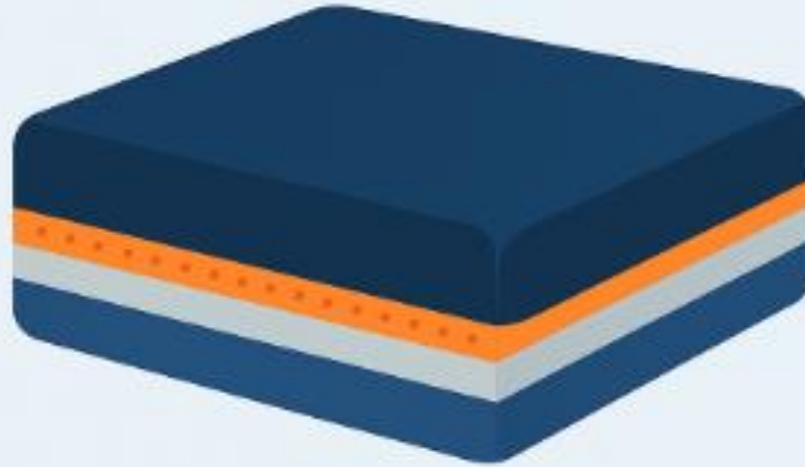
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**What do we
need to
think about
for Cushion
Selection?**



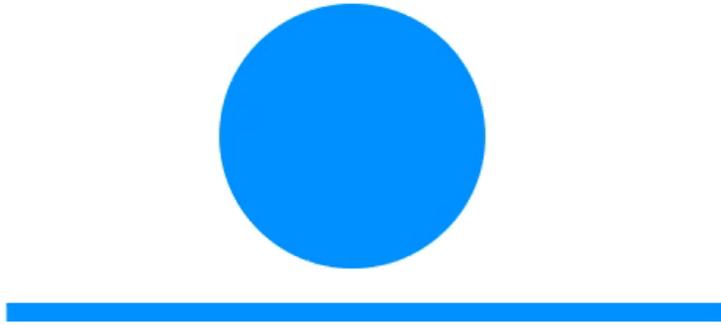
Material Science

Cushion Design & Material Science

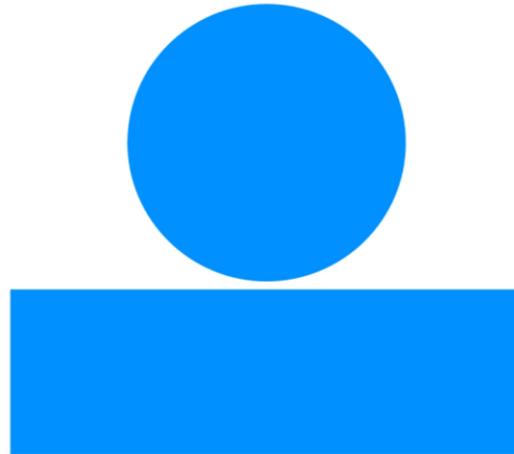


Cushion Design & Material Science

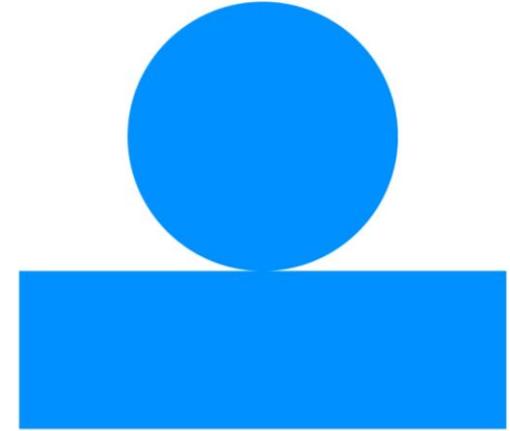
Envelopment



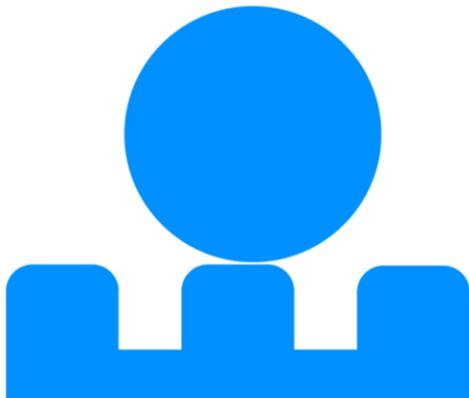
Immersion



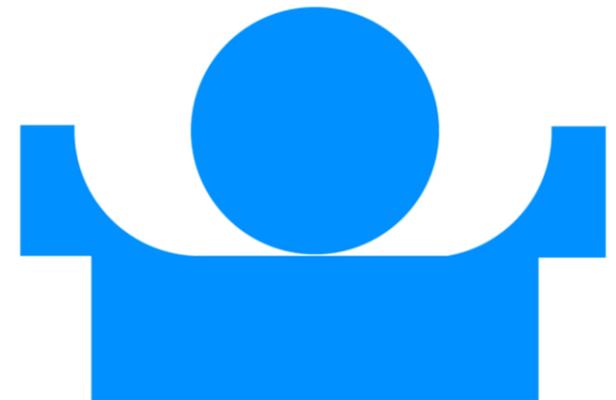
Off-loading

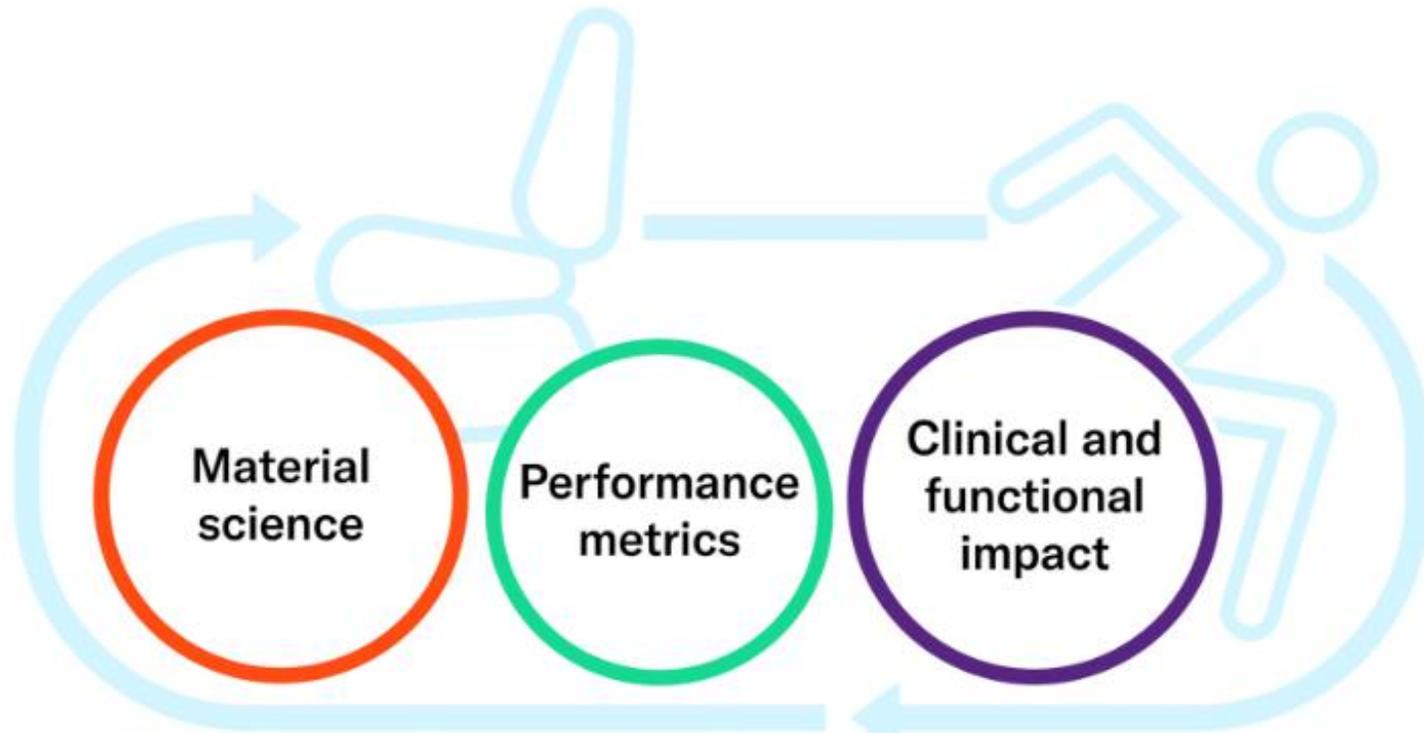


Yielding



Contact Area





Clinical and Functional Impact

4P

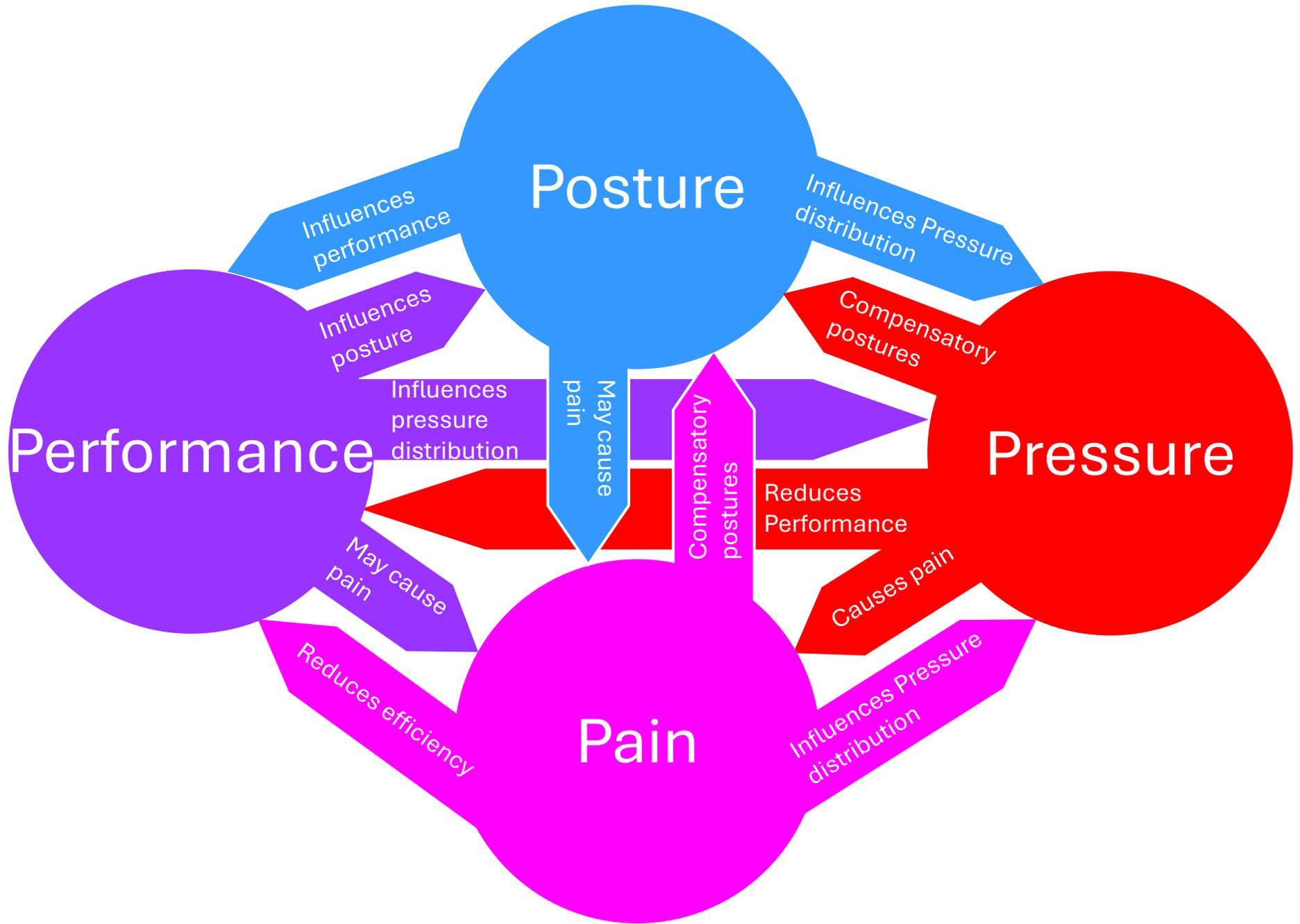
Effective Seating

Posture

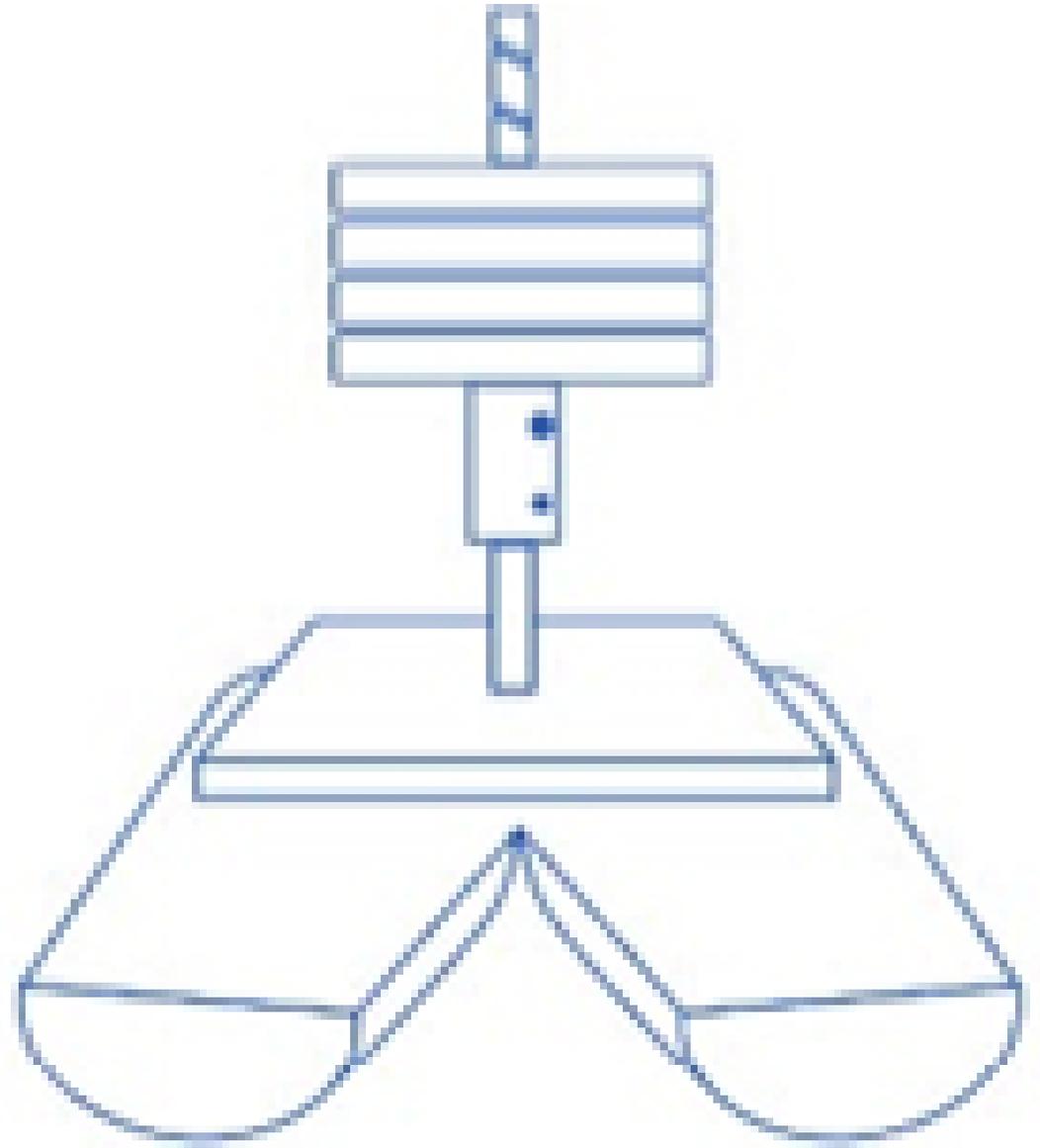
Pressure

Pain

Performance



ISO16840



The performance data includes a reference cushion, which is a 3" thick, high density polyurethane foam cushion

ISO 16840-1:2006

Wheelchair seating

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

Published (Edition 1, 2006)

This publication was last reviewed and confirmed in 2025.
Therefore this version remains current.

ISO 16840-3:2022

Wheelchair seating

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

Published (Edition 3, 2022)

ISO 16840-4:2009

Wheelchair seating

Part 4: Seating systems for use in motor vehicles

Published (Edition 1, 2009)

This publication was last reviewed and confirmed in 2020.
Therefore this version remains current.

ISO 16840-10:2021

Wheelchair seating

Part 10: Resistance to ignition of postural support devices — Requirements and test method

Published (Edition 2, 2021)

↳ This standard has **1 amendment**.

ISO 16840-11:2022

Wheelchair seating

Part 11: Determination of dissipation characteristics of sensible perspiration into seat cushions

Published (Edition 1, 2022)



University of
Pittsburgh

**Department of Rehabilitation
Science and Technology**
School of Health and Rehabilitation Sciences

Wheelchair and Cushion Standards Group

Translating Standards into Strategies

- wheelchairstandards.com

ISO 16815:2024

Wheelchair
Determining

characteristics of seat cushions intended
to manage tissue pressure

Amendment
of new Annex
A for
sized cushions

Immersion



Impact Damping



Hysteresis



Horizontal Stiffness



and ac
terna

ISO 16840-6:2015

Wheelchair seating

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

Published (Edition 1, 2015)

This publication was last reviewed and confirmed in 2023. Therefore this version remains current.

→ Expected to be replaced by **ISO/DIS 16840-6** within the coming months.

Pressure Mapping



ISO 16840-6:2015 Clause 14 –

ISO 16840-12:2021

Wheelchair seating

Part 12: Envelopment and immersion characterization of seat cushions using a dual semispherical indenter

Published (Edition 1, 2021)

↳ This standard has **1 amendment**.

Envelopment



ISO 16840-13:2021

Wheelchair seating

Part 13: Determination of the lateral stability property of a seat cushion

Published (Edition 1, 2021)

↳ This standard has **1 amendment**.

Horizontal Stiffness



Stability

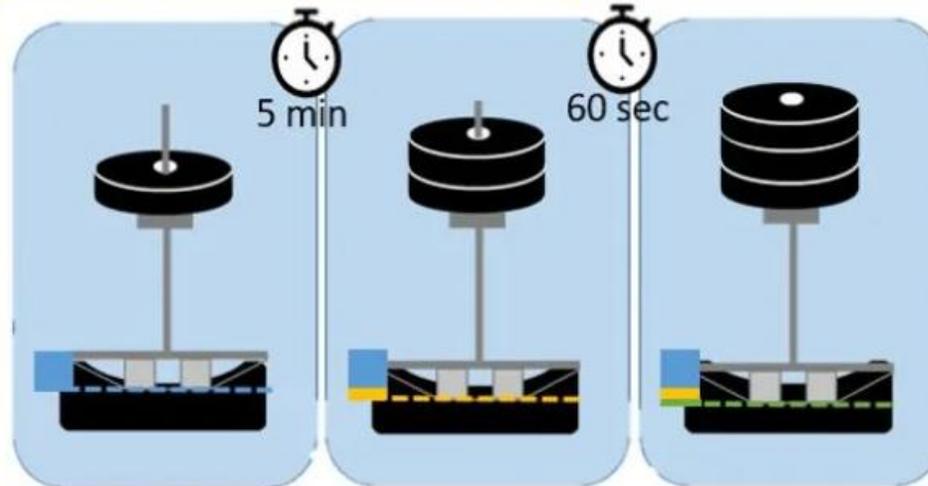


Loaded Contour Depth

This test measures the ability of a cushion to maintain tissue integrity by its ability to immerse and envelop the buttocks.



Metrics & Result Ranges*



Loaded contour depth (mm):
The depth of immersion of the basepoints (ITs) of a cushion loading indenter
Observed Range: 13-85 mm

Overload Deflection 1 (mm):
The additional immersion from the nominal load with a 33% increase in load
Observed Range: 1-8 mm

Overload Deflection 2 (mm):
The additional immersion from the nominal load with a 66% increase in load
Observed Range: 4-14 mm

Guidance

Immersion: The depth a person sinks into the cushion.

A higher **Loaded contour depth** indicates more immersion into the cushion and distribution of pressure on the soft tissue.

Cushions with higher additional immersion under the **overload** conditions have higher margins of safety against bottoming out.

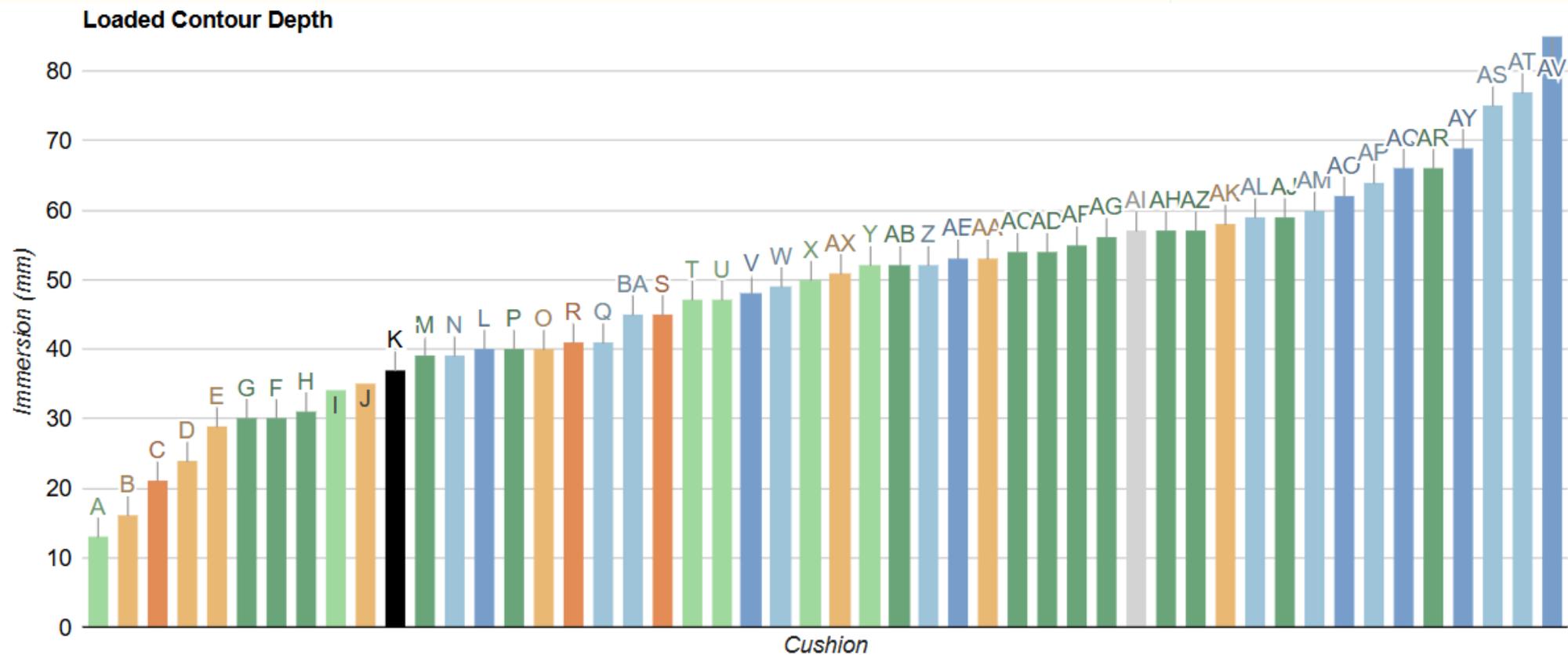
*Result Ranges declared herein were measured in testing to date and are not a defined range that results must fall within



Loaded Contour Depth and Overload Deflection

Test Descriptive Statistics:

Test	Q1	Median	Mean	Standard Deviation	Q3	Range
Loaded Contour Depth (mm)	39	51	48.3	15.2	57	13-85
33% Overload Deflection (mm)	3	4	4.3	1.5	5	2-8
66% Overload Deflection (mm)	6	8	8.3	2.5	10	4-14



LEGEND: Light orange = General Use (E2601), Dark orange = Positioning (E2605), Light green = Skin Protection (E2603), Dark green = Skin Protection & Positioning (E2607), Light blue = Adjustable Skin Protection (E2622), Dark blue = Adjustable Skin Protection & Positioning (E2624), Gray = uncategorized, Black = reference foam



Loaded Contour Depth and Overload Deflection

Test Descriptive Statistics:

Test	Q1	Median	Mean	Standard Deviation	Q3	Range
Loaded Contour Depth (mm)	39	51	48.3	15.2	57	13-85
33% Overload Deflection (mm)	3	4	4.3	1.5	5	2-8
66% Overload Deflection (mm)	6	8	8.3	2.5	10	4-14

Table 4. Comparison of Loaded Contour Depth and Overload Deflections averaged over three trials pre- and post-aging.

	PRE-AGING				POST-AGING			
	Thickness (mm)	Loaded Contour Depth (mm)	Overload Deflection 1 (mm)	Overload Deflection 2 (mm)	Thickness (mm)	Loaded Contour Depth (mm)	Overload Deflection 1 (mm)	Overload Deflection 2 (mm)
Dreamline Contour	123	70	4	9	126	74	5	10

Results

Loaded Contour Depth test results are provided in Table 2 and Figures 2-5.

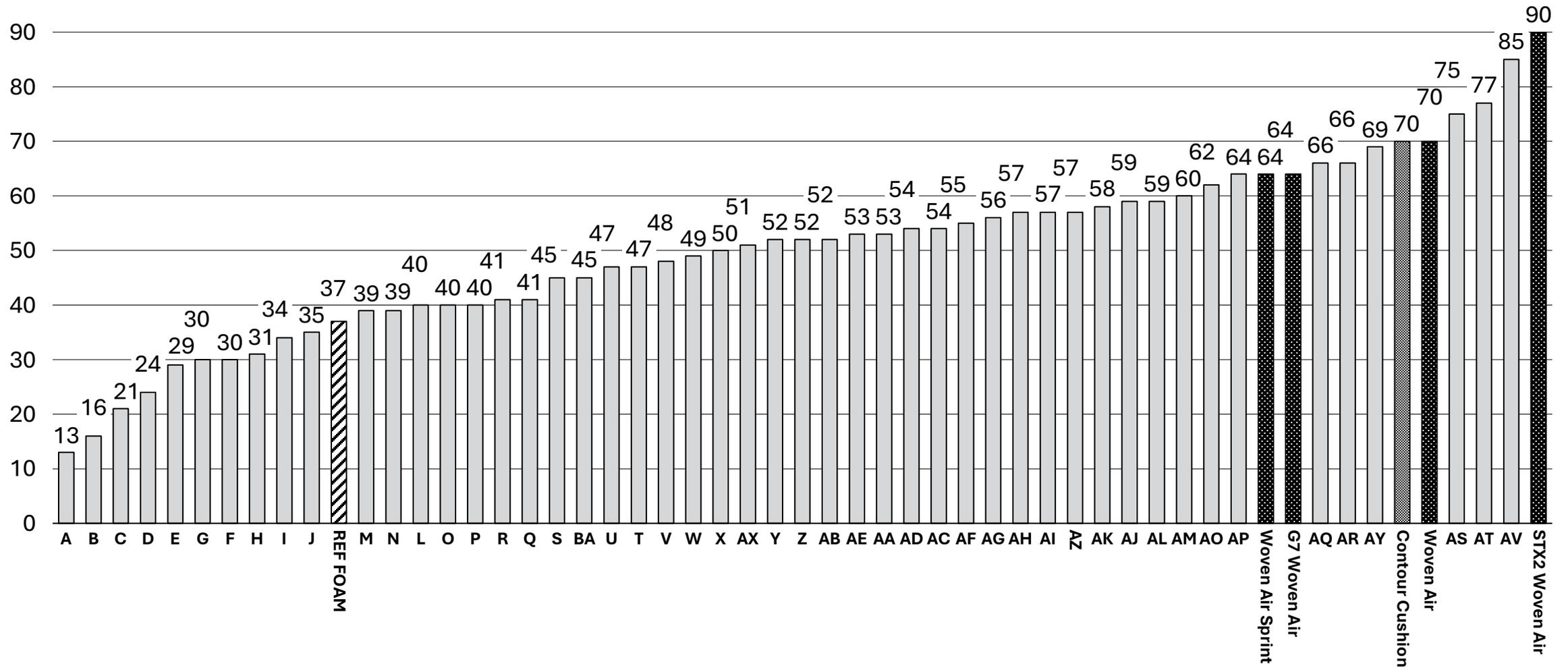
Table 2. Loaded contour depth and overload deflection results

	Loaded Contour Depth (mm)	Overload Deflection 1 (mm)	Overload Deflection 2 (mm)
Woven Air	70	4.0	7.0
Sprint	64	3.7	7.5
G7	64	5.2	10.5
STX2	90	4.4	9.4



Loaded Contour Depth and Overload Deflection

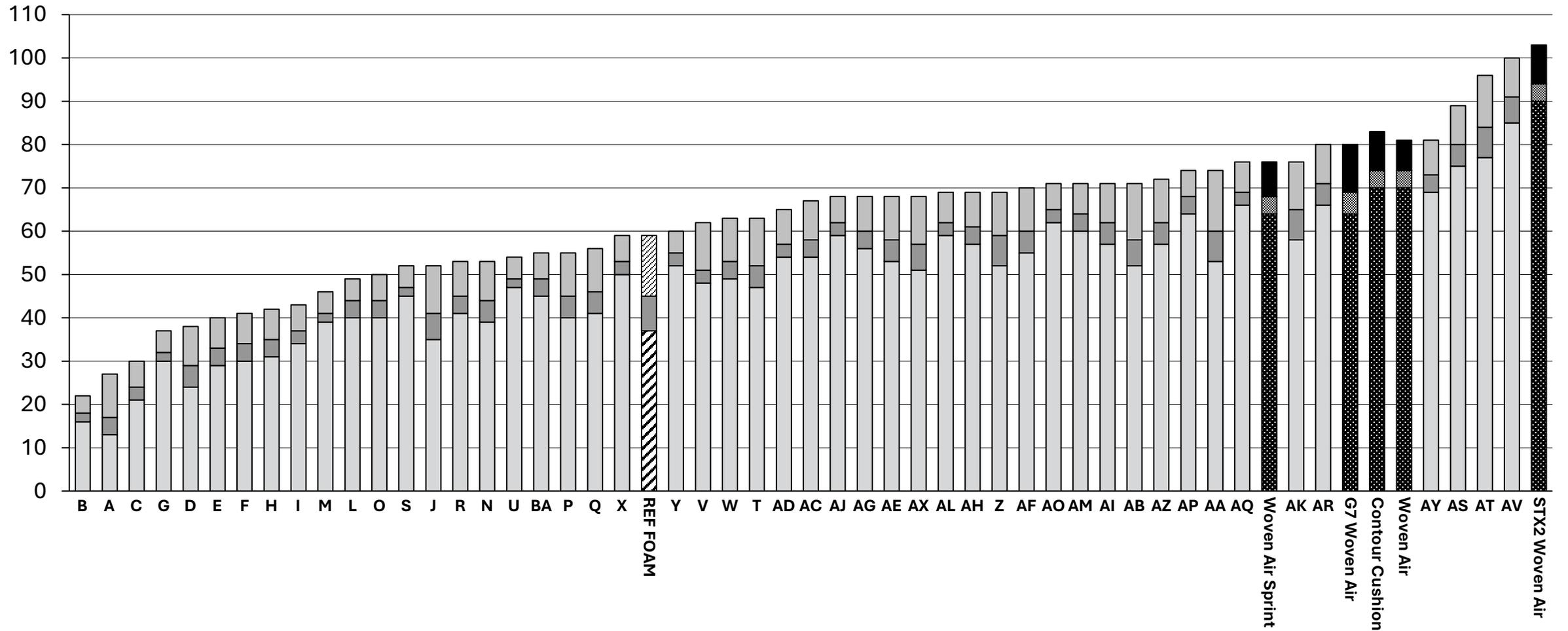
Loaded Contour Depth





Loaded Contour Depth and Overload Deflection

Loaded Contour Depth plus Overload Deflection



Permobil

Scientific Report

Guidance to individualized cushion selection based on performance metrics



Scientific Report: Guidance to individualized cushion selection based on performance metrics

This scientific report contributes to filling the gaps between clinical decision making, individual needs assessment and the lack of sufficient scientific evidence for cushion selection. Individuals' needs are essential to be considered when selecting a cushion alongside performance considerations for skin protection and stability and balance. You can download the Scientific Report below.

[Download Scientific Report](#)

<https://hub.permobil.com.au/trust-and-transparency-home>

Skin protection primary performance metrics thresholds

	Lower priority	Typical priority	Higher priority
Immersion ISO 16840-2:2018 Clause 11	<40 mm loaded contour depth	≥40 and ≤45 mm loaded contour depth	>45 mm loaded contour depth
Contact area ISO 16840-6:2015 Clause 14	<52346 mm ² contact area	≥52346 mm ² and ≤71276 mm ² contact area	>71276 mm ² mm contact area
Off-loading IT ISO 16840-12:2021 (Non-IT pressure/total pressure)*100%	<84% off-loading	≥84% and ≤88% off-loading	>88% mm off-loading

Stability and balance primary performance metrics thresholds

Lateral stability ISO 16840-13:2021	<5.9° tilt angle after 60 sec	≥5.9° tilt angle and ≤4.2° tilt angle after 60 sec	>4.2° tilt angle after 60 sec
Horizontal stiffness / forward stability ISO 16840-2:2018 Annex C	<126 N peak force	≥126 N and ≤161 N peak force	>161 N peak force

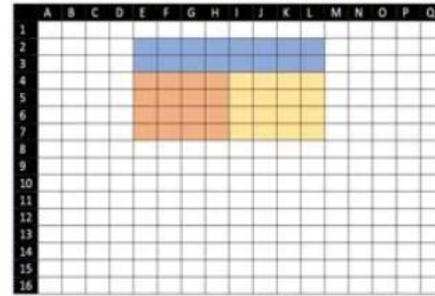
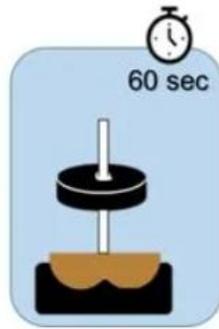
*Test results performed with small and large indenter to be combined using same thresholds.

Pressure Mapping

This test's measurements assess the distribution of pressure on a loaded cushion.



Definition of Metrics



NOTE: The left and right sides are defined from the view of the indenter, so the right zone is the right side of the indenter (as defined by when a person is sitting on a cushion) and the left zone is the left side of the indenter.

All metrics are recorded 60 seconds after the cushion is loaded

Contact Area (mm²): The total load bearing area.

Peak Pressure Index (mmHg): The maximum pressure in the right (orange) and left (yellow) base zones.

Dispersion Index (mmHg): The proportion of the total indenter weight supported in the sacral (blue), right (orange) and left (yellow) base zones.

Guidance

High **Contact Area** indicate a large base support.

Low **Peak Pressure Indices** generally indicate higher envelopment of the buttocks.

A low **Dispersion Index** indicates lower concentrations of pressure in areas representative of the sacrum and ischial tuberosities.



Pressure Mapping



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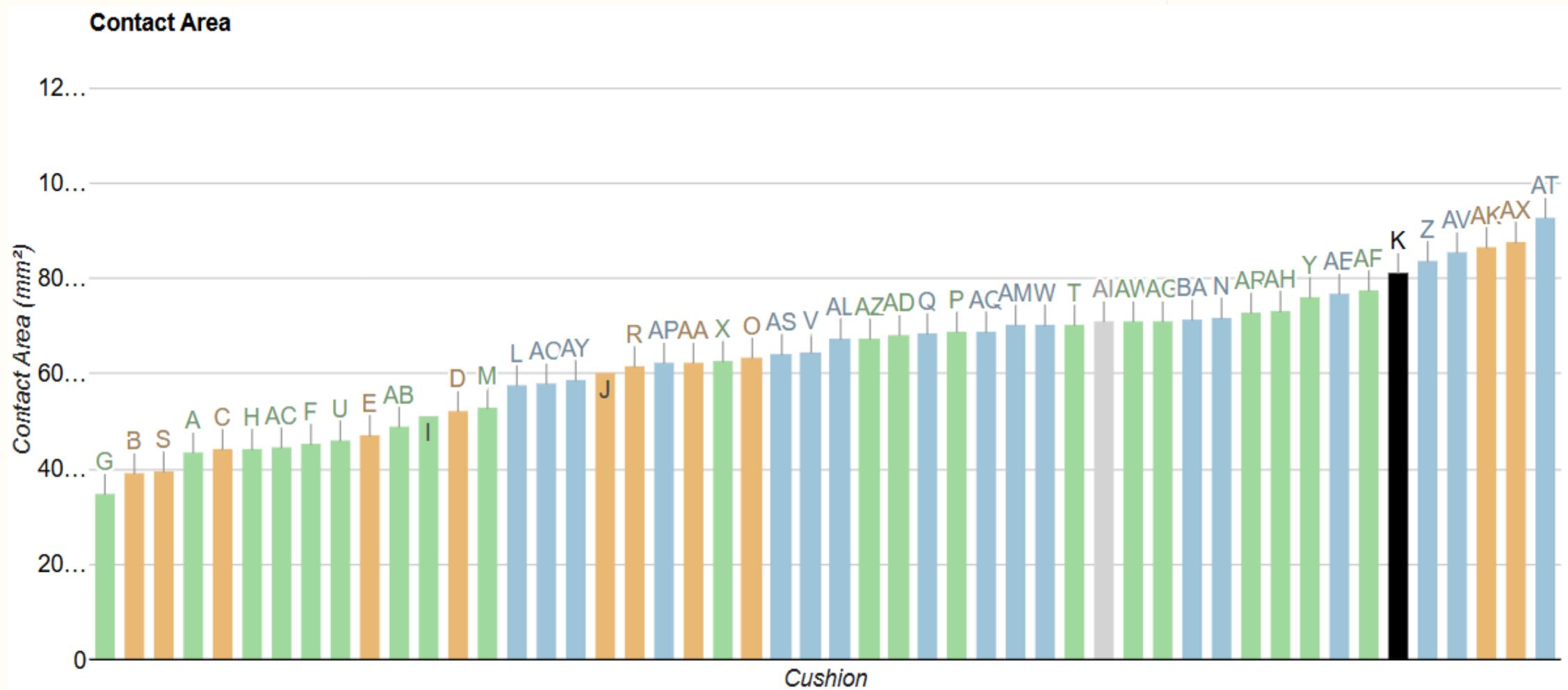
Department of Rehabilitation
Science and Technology
School of Health and Rehabilitation Sciences

Wheelchair & Cushion Performance Testing Standards

Using test standards to assess device performance

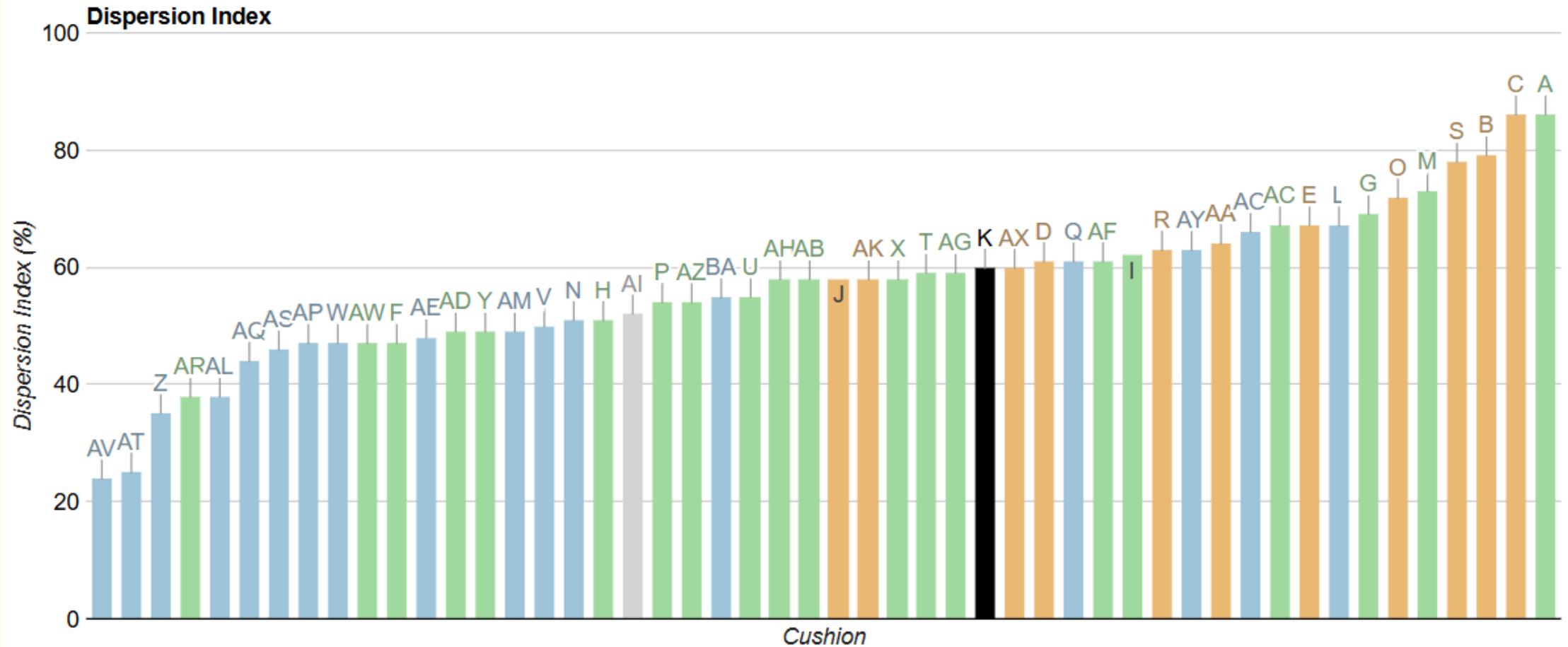
Test Descriptive Statistics:

Test	Q1	Median	Mean	Standard Deviation	Q3	Range
Contact Area (mm ²)	52346	65924	63532.2	12955.9	71276	34925-92614
Dispersion Index (%)	49	59	56.6	13	63	24-86



LEGEND: Orange = General Use, Green = Skin Protection, Blue = Adjustable, Gray = uncategorized, Black = reference foam

▼ Dispersion Index



LEGEND: Orange = General Use, Green = Skin Protection, Blue = Adjustable, Gray = uncategorized, Black = reference foam



Pressure Mapping



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Contact Area (mm ²)	52346	65924	63532.2	12955.9	71276	34925-92614
Dispersion Index (%)	49	59	56.6	13	63	24-86

	Dispersion Index (%)	Contact Area (mm ²)
Woven Air	43%	86,363
Sprint	41%	78,339
G7	53%	76,819
STX 2	39%	83,323

Dispersion Index

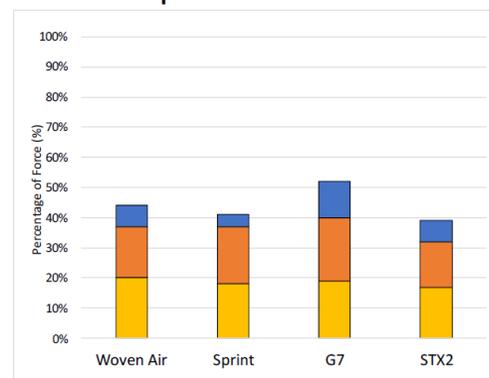


Figure 7. Percentage of force seen on the Left Base Zone (LBZ) (yellow), Right Base Zone (RBZ) (orange) and Rear center zone (CZ) (blue).

Contact Area (mm²)

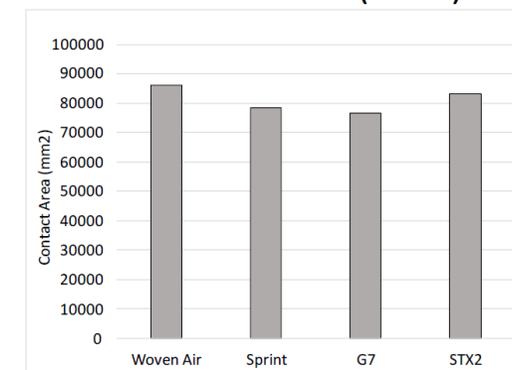
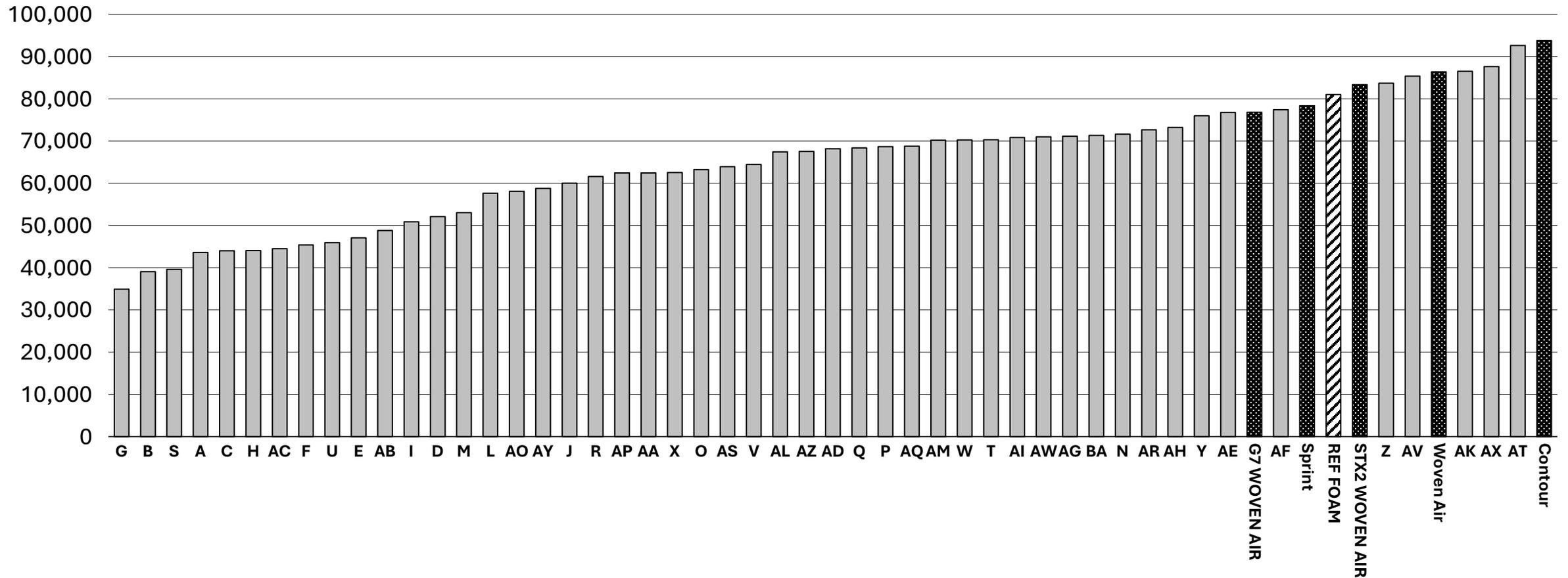


Figure 9. Contact Area



Pressure Mapping

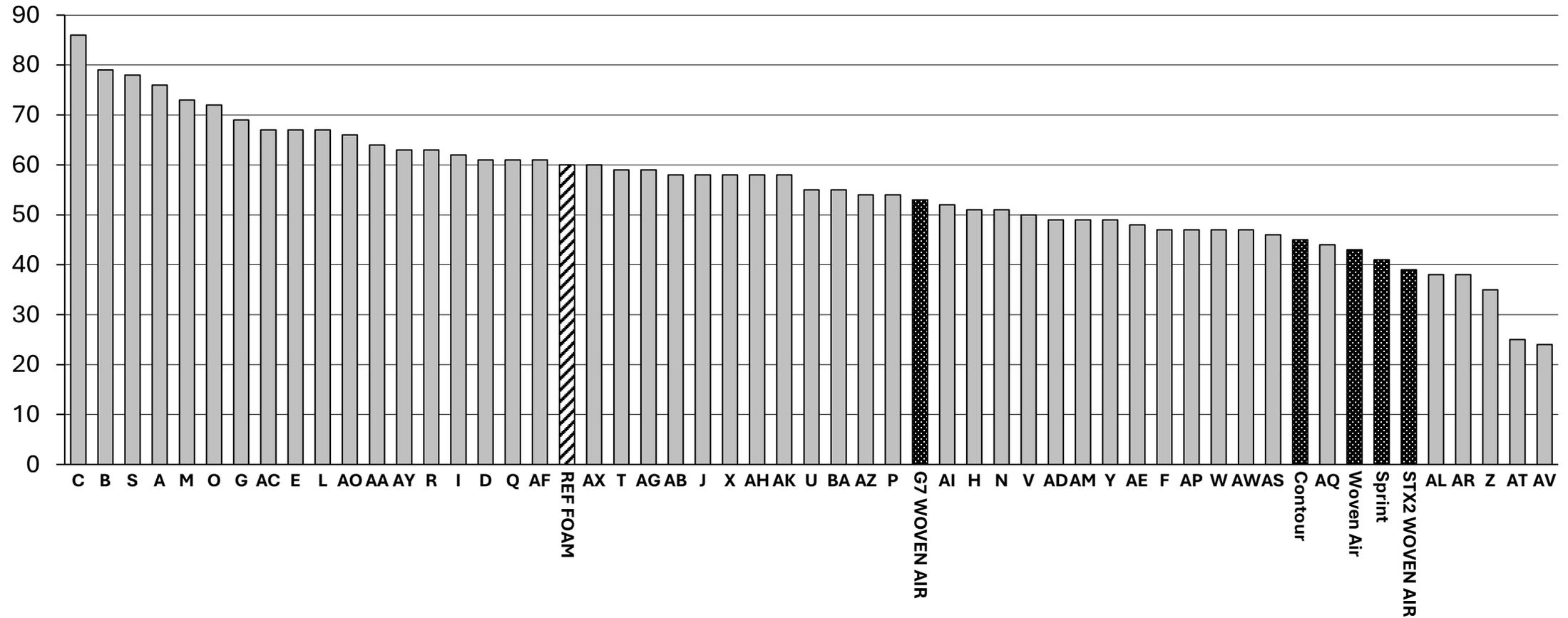
Contact Area





Pressure Mapping

Dispersion Index – lower the better

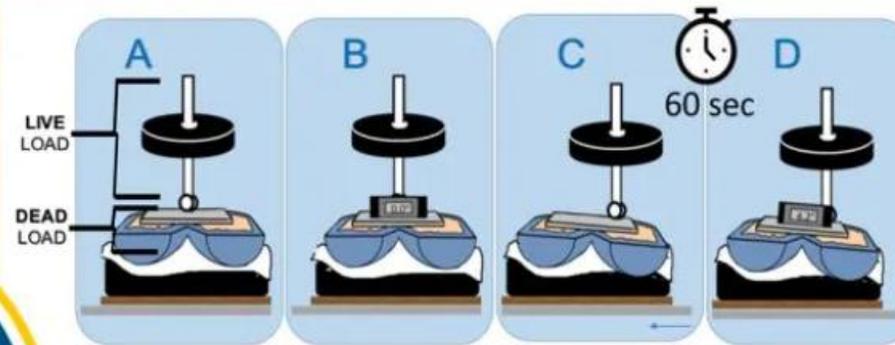


Lateral Stability

This test characterizes the cushion's ability to stabilize a user when leaning to the side.



Definition of Metrics



Average Tilt Angle (°):

The change in orientation of the indenter after a lateral shift in the center of mass, measured at 10s increments for 60s following the shift.

Observed Ranges:

Avg tilt angle at 10s: 2.4°-6.9°

Avg tilt angle at 60s: 2.7°-7.5°

Guidance

A cushion with a lower **Average Tilt Angle** would provide more support for a person when they lean to the side.

A higher **Average Tilt angle** may indicate that more effort would be needed to return to a neutral position.

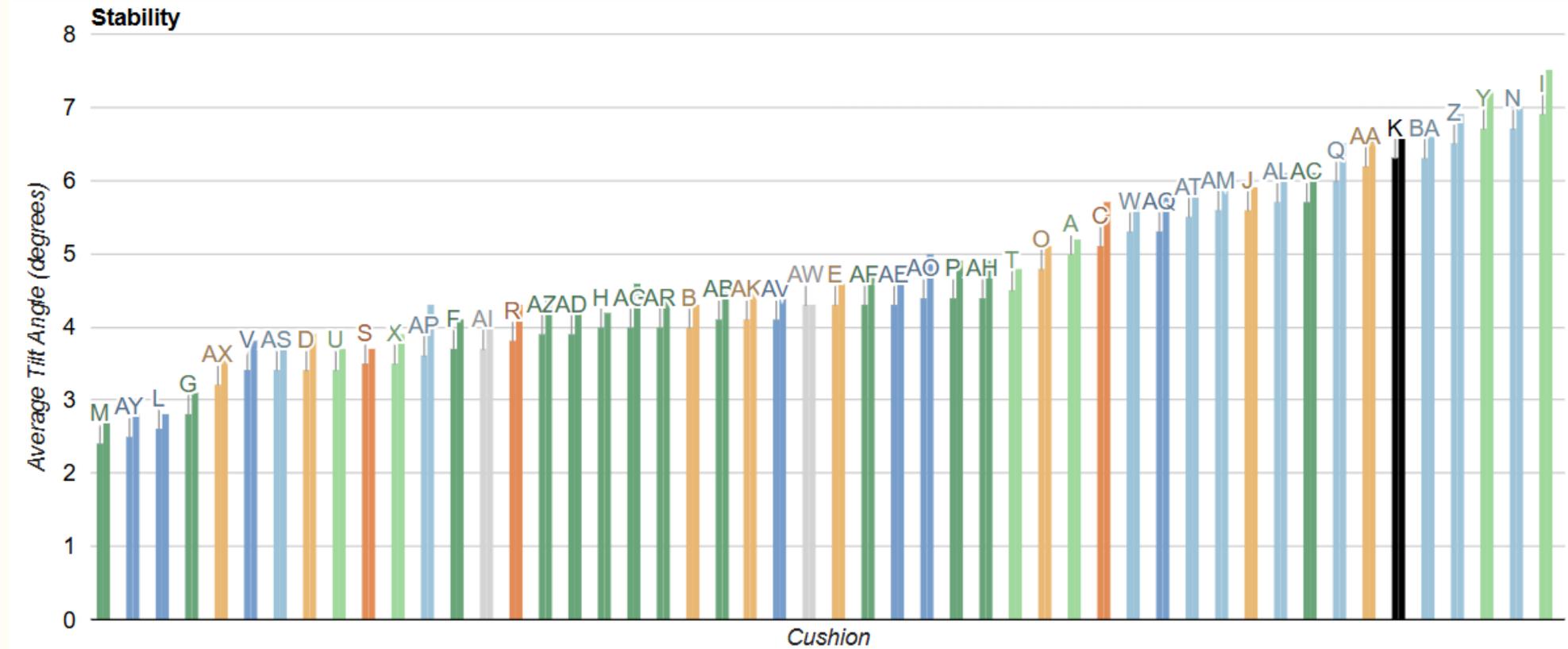


Lateral Stability

Test Descriptive Statistics:

Test	Q1	Median	Mean	Standard Deviation	Q3	Range
Stability Tilt Angle @ 10s (°)	3.7	4.3	4.5	1.18	5.5	2.4-6.9
Stability Tilt Angle @ 60s (°)	4.2	4.6	4.9	1.2	5.9	2.7-7.5

▼ Stability



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Lateral Stability

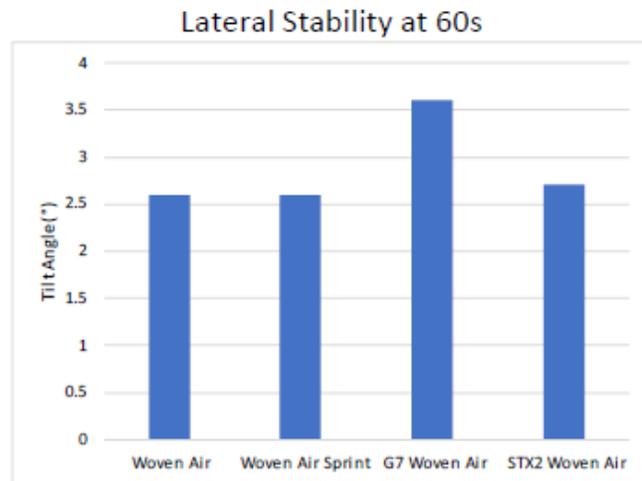


Figure 15. Average tilt angle at 60s.

Table 4. Average lateral tilt (degrees) of five trials at each time point

	Lateral tilt (°) at					
	10s	20s	30s	40s	50s	60s
Woven Air	2.5	2.54	2.58	2.6	2.62	2.62
Sprint	2.46	2.52	2.56	2.56	2.62	2.62
G7	3.24	3.38	3.46	3.48	3.54	3.58
STX2	2.46	2.54	2.58	2.6	2.64	2.66

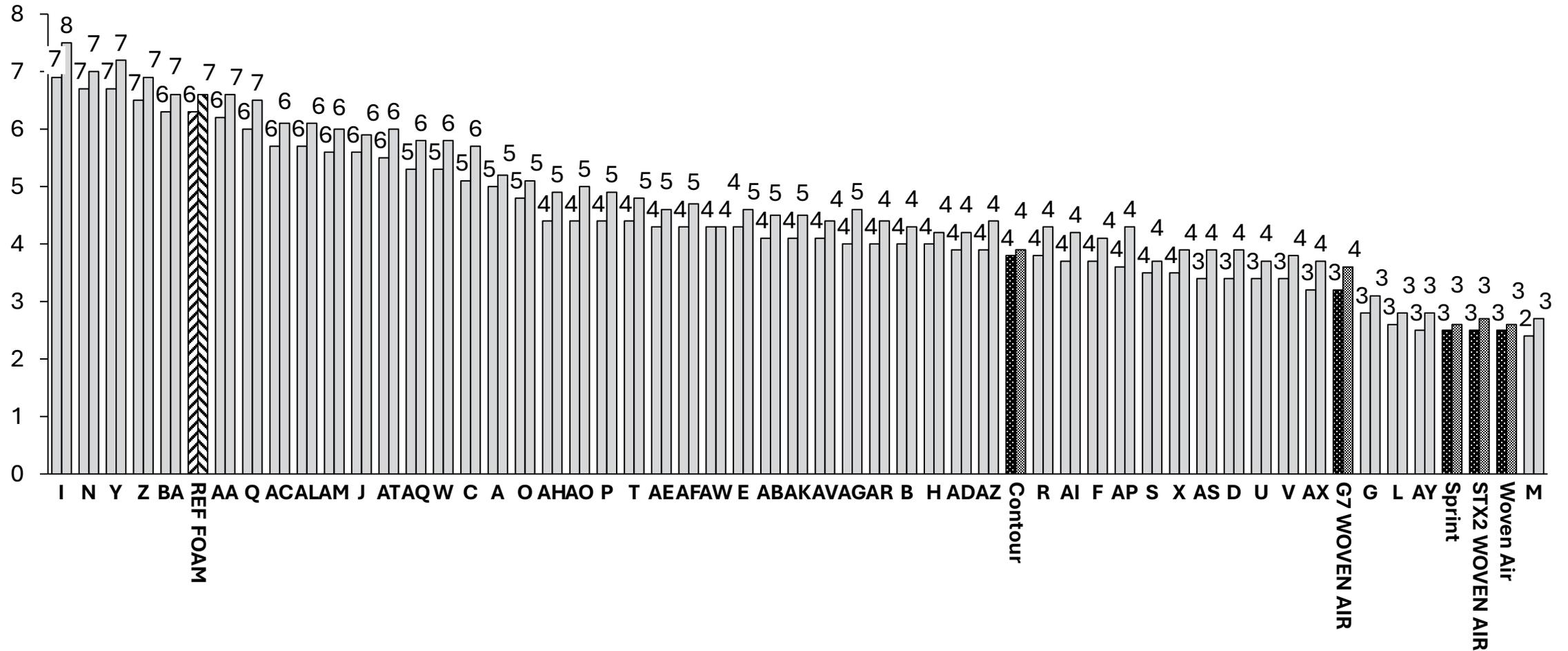
Test Descriptive Statistics:

Test	Q1	Median	Mean	Standard Deviation	Q3	Range
Stability Tilt Angle @ 10s (°)	3.7	4.3	4.5	1.18	5.5	2.4-6.9
Stability Tilt Angle @ 60s (°)	4.2	4.6	4.9	1.2	5.9	2.7-7.5



Lateral Stability

Tilt Angle– lower the better

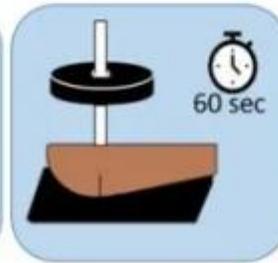
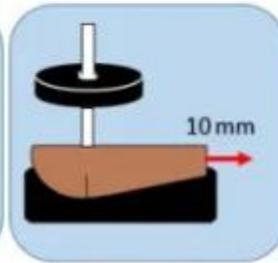
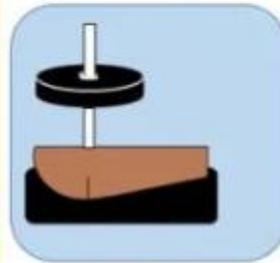


Horizontal Stiffness

This test characterizes the cushion's response to slight horizontal movements in the forward direction, indicating stability and risk to soft tissue due to shear.



Metrics & Result Ranges*



Peak Force (N):

The maximum horizontal force required to displace a cushion loading indenter 10 mm

Observed Range: 63-369 N

Force at 60 sec (N):

The final force achieved during the 60 sec settling time after movement

Observed Range: 42-254 N

Guidance

A higher **Peak or Final Force**, or a higher horizontal stiffness, may offer more stability but also an increased chance of tissue deformation due to shear forces between seat cushion and buttocks.

*Result Ranges declared herein were measured in testing to date and are not a defined range that results must fall within



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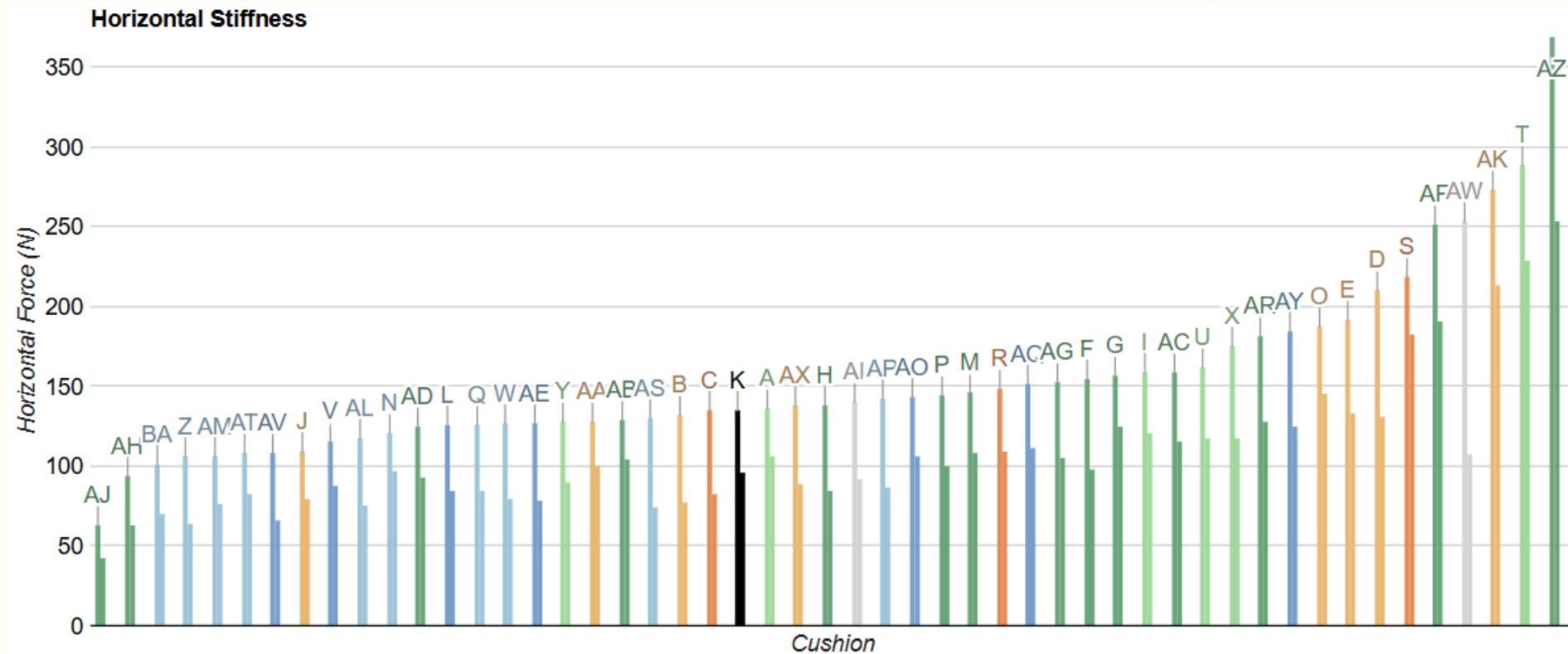
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Wheelchair & Cushion Performance Testing Standards

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Test Descriptive Statistics:

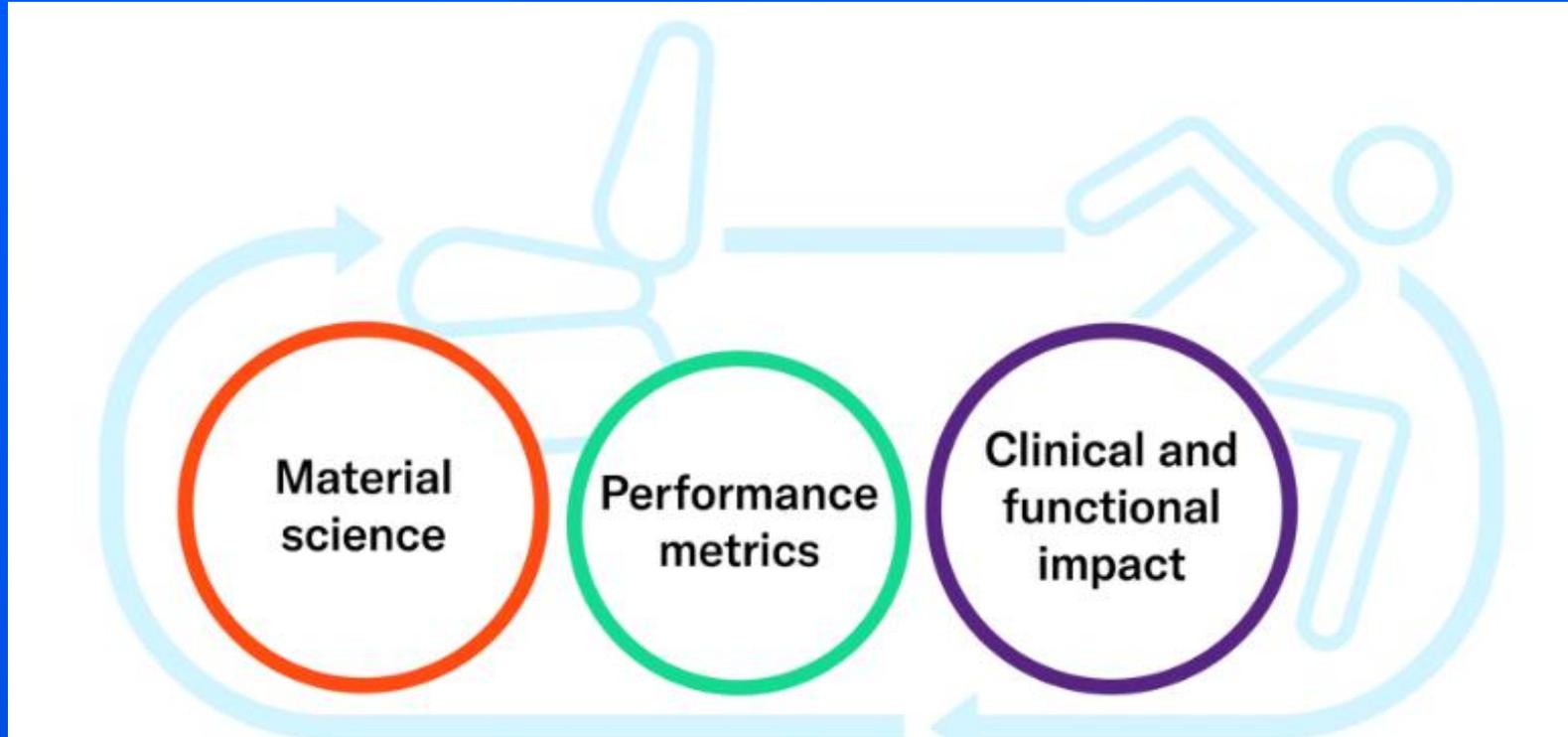
Test	Q1	Median	Mean	Standard Deviation	Q3	Range
Horizontal Stiffness Peak Force (N)	126	138	154	54.6	161	63-369
Horizontal Stiffness Final Force (N)	82	98	107.3	41.8	118	42-254



LEGEND: Light orange = General Use (E2601), Dark orange = Positioning (E2605), Light green = Skin Protection (E2603), Dark green = Skin Protection & Positioning (E2607), Light blue = Adjustable Skin Protection (E2622), Dark blue = Adjustable Skin Protection & Positioning (E2624), Gray = uncategorized, Black = reference foam

- 33% regularly - always tired
- 28% regularly - always in Pain
- 32% instability with reaching
- Those who feel unstable in sitting and reaching were 3.9 and 4.6 time higher to experience fatigue
- Pressure injuries 2.9 time higher with LOS

Putting it all together



Questions

References

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