State of the Science: ROHO® Wheelchair Cushions

A Narrative Review of ROHO - Specific Research Evidence and Clinical Implications

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Introduction

Pressure injuries (PIs) remain one of the most serious complications for individuals with limited mobility, particularly those using wheelchairs. ROHO®[1] wheelchair cushions have been extensively studied for their role in mitigating the mechanical and physiological factors that contribute to skin and soft tissue breakdown.

ROHO neoprene products have been available for over 50 years and are designed with four primary principles:

Lets you in - The unique design allows for immersion into the cushion, reducing both pressure and discomfort to the skin and soft tissues.

Matches your shape - The flexible air cells of ROHO cushions match an individual's shape which can provide more evenly distributed forces across contact areas of the body.

Moves with you - The air cells follow the motions of the individual, providing support and freedom of movement while constantly adapting to the changes that happen throughout the day.

Works with you, not against you - The smooth surface reduces surface shear and friction while the cells transfer air between one another and adapt as you move.

The literature consistently supports the clinical effectiveness of ROHO cushions, particularly in populations at high risk due to immobility, sensory impairment, or prolonged sitting. Herein, we review and synthesize this evidence, focusing on four main areas of research: a) preventing and managing PIs, b) skin integrity and PI outcomes, c) stability and load distribution, d) microclimate management and e) dynamic loads and real-world conditions. This review focuses exclusively on research that explicitly cites ROHO-brand wheelchair cushions. While many studies evaluate air-cell or air-inflated cushions as a class, we included only those in which the ROHO product was clearly named, ensuring that all findings pertain specifically to ROHO designs.

ROHO neoprene cushions come in a variety of off-the-shelf configurations to best meet the needs of each individual (see Table 1 below). They can also be customized for advanced positioning and pressure management requirements.

1. ROHO®, High Profile®, Low Profile®, Quadtro Select®, and Contour Select® are registered trademarks of ROHO, Inc. Vicair®, Adjuster™, and Xsensor® are trademarks or registered trademarks of their respective owners.

Table 1. Summary of ROHO® cushion configuration options

	Description	*Options / Models*
Cell Height  (e.g., ROHO High Profile® Single Compartment)	Controls overall cushion height and provides sufficient immersion for pelvic bony prominences.	Low Profile®: 2 ¼″ Mid Profile: 3 ¼″ High Profile: 4 ¼″
Neoprene Cushion Configurations  (e.g., ROHO Mid Profile Dual Compartment)	Supports positioning and stability needs, such as pelvic obliquities.	ROHO Single Compartment ROHO Dual Compartment ROHO Enhancer
Cushions with IsoFlo® Memory Control  (e.g., ROHO Contour Select®)	Locks air between chambers for stability and minimizes side-to-side/ front-to-back motion.	ROHO Quadtro Select® with IsoFlo ROHO Contour Select
Neoprene Hybrid Cushion Configurations  (e.g., ROHO Hybrid Elite Dual Compartment)	Combines air-cell technology with contoured foam base for stability and targeted immersion.	ROHO Hybrid Elite Single Compartment ROHO Hybrid Elite Dual Compartment ROHO Hybrid Select

For additional product information, please see: Permobil Seating & Positioning Cushion Brochure

The specific ROHO* products that appear repeatedly include the ROHO High Profile single-compartment air cushion (often simply "ROHO High Profile" or "ROHO HP"), the ROHO Low Profile air cushion, dual- or multi-compartment ROHO designs such as ROHO Quadtro Select High Profile and Low Profile (sometimes described more generically as dual-compartment air cushions), and unnamed but clearly ROHO branded "aircell" or "air-flotation" cushions.

Pressure Injury Prevention and Management

The defining feature of ROHO® cushions is their ability to provide immersion (i.e., the ability for the user's body to sink into the air cells) and envelopment (i.e., the air cells' ability to conform to the shape of the user's body as they immerse into it). Immersion and envelopment are two biomechanical properties that allow the cushion to mold itself to the user's unique anatomy and distribute pressure evenly. These key methods of pressure redistribution are specifically noted in the EPUAP/NPIAP/PPPIA Clinical Practice Guideline (2019). Through immersion and envelopment, this ROHO design reduces peak interface pressures at bony prominences such as the ischial tuberosities and sacrum, which are common sites for PI development.

Several studies using pressure mapping systems have confirmed this effect. For example, Yuen and Garrett (2001) conducted a study using an alternating treatments design in a single patient with T8 paraplegia. This design involves switching between interventions (in this case, ROHO Enhancer, Jay Extreme, and Pindot Ulti-Mate cushions) across multiple sessions, with baseline and final phases to identify the most effective option. Pressure mapping with the Xsensor system showed that the ROHO Enhancer cushion produced significantly fewer high-pressure points (i.e., ≥100 mmHg) at the buttock–cushion interface than the other two cushions. The study concluded that ROHO Enhancer provided the most effective pressure relief, and the patient also reported greater comfort with the ROHO cushion. Similarly, Trewartha and Stiller (2011) conducted a single-case experimental study involving three individuals with Spinal Cord Injury (SCI), comparing ROHO Quadtro Select High Profile cushions with Vicair® Academy Adjuster™ cushions. Using the Xsensor® Pressure Mapping System, they found that ROHO cushions consistently recorded fewer cells with pressures ≥100 mmHg than the Vicair for all three participants. The Vicair cushion had 3.22 times more cells registering ≥100 mmHg than the ROHO cushion, indicating a substantially higher risk of compromised tissue health with the Vicair cushion.

Further, Aissaoui et al. (2001) examined nine wheelchair users with paraplegia performing a standardized reaching task while seated on three cushions: a 3-inch ROHO air-flotation cushion, a 2-inch flat polyurethane foam cushion, and a 3-inch generic contoured foam cushion. They focused on dynamic stability via center of pressure displacement and velocity, but also measured peak pressure at the ischial region. Although the contoured foam allowed greater excursion and velocity of the center of pressure, the ROHO air cushion produced substantially lower peak ischial pressures. Peak ischial pressure for the flat foam was reported at roughly 275 mmHg and for the generic contoured cushion around 235 mmHg, whereas the ROHO air-flotation cushion reduced peak ischial pressure to about 143 mmHg.

Gil-Agudo et al. (2009) studied large sample of forty-eight individuals with SCI, each tested on four cushions: a low-profile ROHO air cushion, a high-profile ROHO air cushion, a dual-compartment ROHO air cushion, and a gel and firm foam cushion. Using a matrix of pressure distribution sensors, they reported that the dual-compartment ROHO cushion consistently yielded the most favorable pressure metrics, including the lowest maximum pressure, mean pressure, and standard deviation of pressure, as well as the lowest pressure under the ischial tuberosities. It also produced the largest total contact area and the largest proportion of surface area bearing moderate rather than high pressure. The single-compartment low- and high-profile ROHO cushions also outperformed the gel-foam cushion, but the dual-compartment design achieved the best overall pressure redistribution. This supports the idea that multi-compartment ROHO products, which allow differential inflation and better accommodation of asymmetries, can confer an additional advantage beyond simply having tall air cells.

The work by Guimarães and Mann (2003), which compared a low-cost "Tuball" cushion designed to be used in countries with limited access to cushions such as ROHO or foam in both nondisabled and disabled participants, reinforces how strongly ROHO cushions perform on basic pressure metrics. In that study, the ROHO cushion and the low-cost Tuball both provided significantly better pressure distribution than flat foam. Under repeated fatigue loading, both the ROHO cushion and the Tuball withstood the equivalent of at least one year of use without structural failure, whereas the foam cushion broke down, again underlining the durability and load-bearing performance of the ROHO air-cell design.

De León-Hernández et al. (2025) developed a methodology for fabricating custom-contoured cushions based on pressure mapping, with the aim of reducing high-pressure areas and increasing contact area in wheelchair users. They manufactured custom cushions for ten wheelchair users and compared four surfaces: a flat foam block, a Jay X2 gel-foam cushion, a ROHO High Profile air cushion, and the custom-contoured cushion. Using pressure mapping, they evaluated peak pressure, peak pressure index, mean pressure, and contact area. The custom-contoured cushion generally exhibited the lowest peak pressures and most favorable pressure indices, but the ROHO High Profile cushion also performed well, clearly outperforming flat foam and often matching or coming close to the Jay X2 in mean pressure and contact area. In some metrics, the difference between the ROHO High Profile and the custom-contoured cushion was not statistically significant. This pattern suggests that custom-contoured cushions can improve on even well-performing commercial air cushions in some users, but that ROHO High Profile cushions provide a strong baseline of pressure redistribution against which custom solutions are measured.

Other smaller clinical or lab studies are consistent with these findings. For instance, in the comfort and posture study by Gonçalves and colleagues (2015) involving able-bodied participants, the ROHO air cell cushion was the preferred surface among six commercially available cushions, and although that study focused on subjective ratings (i.e., questionnaire), it aligns with the broader impression that ROHO cushions provide a favorable combination of pressure relief and perceived comfort.

Taken together, these data support a fairly robust conclusion: across clinical and laboratory pressure-mapping studies, ROHO air-cell cushions reliably reduce peak ischial pressure and redistribute load more effectively than the studied flat foam and gel-foam cushions, and multi-compartment ROHO models, such as dual-compartment or Quadtro-type designs, generally perform at least as well as, and often better than, single-compartment high-profile or low-profile ROHO cushions.

Clinical conclusions

While there is no one perfect solution for all individuals, it is clear that ROHO neoprene cushions excel in pressure management through the principles such as immersion and envelopment. These factors can contribute to the overall reduction in risk of developing PIs. Through this literature review, it is evident that clinicians need to consider the compartmentalization of the air for characteristics such as comfort, stability, and accommodating postural impairments.

Additionally, pressure mapping technology was used in several studies as a way to compare peak pressures and overall pressure distribution. While it was documented that ROHO cushions can have less high-pressure areas, it is important to note that pressure mapping is just one tool to use when determining the solution that best matches the person's complex needs.

Skin integrity and PI outcomes

Only a few papers report actual skin outcomes such as incidence of new PIs, and in most cases ROHO® cushions are only one part of a broader prevention strategy. Nevertheless, they provide some insight into how ROHO cushions perform in real-world PI prevention and management.

The most direct evidence comes from the prospective observational work by Meaume and colleagues (2017). They followed 152 high-risk wheelchair users, most with SCI, who were seated on ROHO single-compartment air cushions or ROHO multi-compartment air cushions over a 35-day period. Seventy-eight participants were in the single-compartment group and seventy-four in the multi-compartment group. The average sitting time per day was around ten hours in both groups. Over the study period, new PIs developed in only 2.6% of patients on single-compartment ROHO cushions and 4.0% of those on multi-compartment ROHO cushions. There was no non-ROHO comparison group, and the incidence is low in absolute terms, which makes it difficult to attribute causality, but the data are consistent with the cushions supporting a low short-term incidence of PIs in a very high-risk population when used as part of a structured prevention program. The authors also highlight how ROHO multi-compartment cushions were often chosen in the presence of significant seating asymmetry, emphasizing the role of adjustable air compartments in accommodating pelvic obliquity and other postural deviations that might otherwise drive localized loading.

Two case reports from Park and Lee (2019) add a more granular, clinically flavored perspective. In these cases, SCI patients attended a seating clinic because of uncomfortable posture and concern about skin risk. The intervention combined posture control training with explicit management of cushion inflation using visual feedback from an X-sensor pressure-mapping system. For one case, the authors describe a change to a “ROHO low-Quadtro type” air-cell cushion, with subsequent adjustments to air volume. After these adjustments, the contact area increased and mean pressure decreased, and the authors report improvement in subjective comfort and absence of further skin problems. Given the single-case nature and intensive therapist involvement, one cannot isolate the effect of the cushion alone, but the report illustrates how ROHO multi-compartment cushions, when actively managed, can be tuned to lower mean pressures and expand contact area in a clinically meaningful way.

Other studies that include ROHO cushions focus more on pressure distribution than PIs but still report on skin status. In the Yuen and Garrett (2001) single-case study, the participant did not develop any redness or irritation while using the ROHO, Jay, or Pindot cushions over the thirteen days of pressure mapping, despite clear differences in interface pressure. Similarly, in trials where able-bodied participants sat for limited periods on ROHO cushions, such as Hsu and colleagues’ (2018) work, there were no adverse skin events, though these were short-term laboratory exposures and not long-term clinical follow-up.

Overall, the state of the science regarding ROHO cushions and PI outcomes is that ROHO cushions are consistently deployed in high-risk populations and appear compatible with very low short-term PI incidence when properly chosen and managed. However, it is worth noting that the field currently lacks large randomized controlled trials that directly compare specific ROHO models to other brands on long-term PI incidence and healing. Much of the PI evidence is observational, and in some cases ROHO cushions are treated as the default high-end support surface rather than as an experimental variable.

Clinical conclusions

A ROHO cushion can be viewed as an important part of an overall PI risk reduction strategy based on the studies that support its use in high-risk populations with limited incidence of new PI development. Selection of a ROHO cushion should also be considered as part of a whole seating system intervention.

Note that there is a high use of case studies related to PI development, which is appropriate for the individualized nature of seating and mobility interventions. This further emphasizes that PI management is highly individualized and requires a skilled and thorough seating and mobility evaluation.

Stability and load distribution

A frequent concern in clinical practice is that highly immersive air-cell cushions might compromise stability and functional performance compared with firmer or more contoured foam or gel surfaces. Several studies explicitly address this balance between pressure relief and stability.

Aissaoui and colleagues (2001) provide a clear example of this trade-off. In their dynamic reaching study, the generic contoured foam cushion allowed the center of pressure to travel a greater distance and at a higher velocity during a reaching task than either the 3-inch ROHO® air-flotation cushion or the flat foam cushion. This suggests that the contoured foam permitted more trunk motion, which can be interpreted either as enhanced reach and movement or as reduced stability, depending on clinical goals. At the same time, the contoured and flat foam cushions produced far higher peak pressures under the ischial tuberosities than the ROHO cushion. In effect, the ROHO cushion traded a small reduction in dynamic range of motion for a large reduction in peak pressure.

Cooper and colleagues (2000) examined a different aspect of function: shear and displacement during sit-to-stand and stand-to-sit transitions in a powered wheelchair that could change configuration. They used a 50th percentile anthropometric test dummy seated on either a low-profile ROHO cushion or a Jay Active cushion and measured angular differences and translational displacements between the dummy and the seating system. The ROHO cushion produced slightly larger thigh-to-seat displacements than the Jay (about 3.0 cm versus 2.5 cm in sit-to-stand, and 3.5 cm in stand-to-sit), but overall displacements were small and backrest-to-back angular differences were modest. The authors concluded that both cushions produced relatively limited shear displacements during transitions, implying that low-profile ROHO cushions can be used in dynamic seating systems without introducing excessive shear displacement. From a functional standpoint, this supports the use of low-profile ROHO cushions in users who frequently change posture or use powered tilt or stand functions.

Gonçalves and colleagues' (2015) preliminary study with able-bodied subjects provides a more subjective window into function and stability. Participants sat on six different commercially available wheelchair cushions, including a ROHO air cell cushion, and rated each on comfort, perceived stability, and posture. The ROHO cushion emerged as the most preferred overall, while a water-based cushion was the least preferred. Although this work did not measure objective reach or posture, it suggests that able-bodied users do not necessarily perceive ROHO cushions as unstable or difficult to sit on, despite their deformable, immersive nature.

In summary, the literature suggests that ROHO cushions do not inherently prevent dynamic activities or induce large shear during posture transitions. However, high-profile air-cell cushions may slightly limit trunk excursion compared with firm contoured foam. Low-profile ROHO cushions, in particular, appear to offer a reasonable compromise between functional stability and tissue protection.

Clinical conclusions

Single compartment ROHO cushions intentionally allow air to flow between cells for skin protection and pressure management; however, this movement of air may create instability for some individuals. Although there is a displacement of air within the cushion, this may be beneficial when performing dynamic repositioning tasks such as shifting weight or transitioning from sit to stand in a power standing wheelchair.

Prioritizing seating and mobility goals will provide insight into how the movement of air will impact an individual's overall function when balanced with skin protection. Additionally, selecting a ROHO cushion that has compartmentalization of air, such as a ROHO QUADTRO, may be an appropriate solution.

Microclimate: temperature and humidity

Microclimate at the skin–cushion interface, especially heat and moisture, is increasingly recognized as an important factor in PI risk. The following summaries include both human and bench studies that examine how ROHO® cushions handle microclimate.

Hsu and colleagues (2018) conducted a randomized controlled trial with seventy-eight able-bodied participants assigned to sit for two hours on one of three cushions: a dual-compartment ROHO Low Profile air-filled cushion, a foam–fluid hybrid cushion, and a medium-density foam cushion. Using digital temperature and humidity sensors placed under the ischial tuberosities and thighs, they measured skin temperature and relative humidity before sitting and at fifteen-minute intervals. Participants seated on the foam–fluid hybrid cushion showed significantly lower skin temperatures than those on the ROHO Low Profile air cushion and on foam. The relative humidity increased similarly over time on all three cushions and did not differ significantly between cushions. By the end of the two-hour period, all conditions produced an elevated relative humidity plateau, suggesting that simply changing cushion type, at least among these three, might not be sufficient to control moisture accumulation during unrelieved sitting.

In contrast, Freeto and colleagues' (2016) bench study using a Sitting Simulator (SMES - a life-sized model of the lower body that can press down on a cushion and also mimic body temperature and sweating) examined the behavior of several commercial cushions, including two ROHO air-cell cushions (a ROHO High Profile and a ROHO Low Profile) and a gel-based Jay cushion, under controlled conditions. The SMES applied a 300 N load at an interface temperature of about 37°C and delivered moisture at a controlled rate to the ischial region while continuously measuring interface temperature and humidity. In these tests, the two air-based ROHO cushions began to cool slowly from a maximum of roughly 33.5°C down toward 31°C, whereas the gel-based Jay cushion maintained a steady state around 34.5°C and a novel modular gel cushion stayed cooler for at least fifteen minutes longer than any commercially available cushion. Interestingly, the final temperature for the ROHO High Profile cushion was the lowest of all cushions tested, suggesting advantageous heat dissipation, but at the cost of higher humidity: the ROHO High Profile showed nearly fifty percent higher humidity than some comparators by the end of the two-hour test.

Taken together, these findings present a nuanced picture. ROHO Low Profile cushions, when used by human participants in a warm environment, do not necessarily confer a clear advantage or disadvantage in humidity compared with foam or foam–fluid hybrids, although they may run slightly warmer than highly conductive fluid-based designs. At the same time, bench testing suggests that ROHO High Profile cushions can have favorable temperature behavior, tending to cool under load and end up cooler than some gel cushions, but they may trap more moisture at the interface.

Clinical conclusions

The combination of pressure, elevated skin temperature and moisture can increase the risk of PIs when occurring over bony prominences; however, the limited evidence shows that it is challenging to determine how best to manage microclimate through cushion interventions such as a ROHO.

If a person is experiencing problems with heavy sweating, incontinence, wound or maceration, attention to moisture management (e.g., absorbent, breathable covers, clothing choices, and education about weight shifting) remains essential, even if the cushion itself performs well on temperature.

Dynamic loads and real-world conditions

Most pressure studies consider quiet, static sitting, but most wheelchair users complete dynamic tasks such as propulsion, reaching, and transfers can alter interface loads. A scoping review by Paquin et al. (2023) looks at pressure and shear during dynamic activities such as propulsion, drawing together a diverse set of studies, several of which use ROHO® Low Profile cushions and other ROHO models. Although Paquin and colleagues (2023) are not focused solely on ROHO, their synthesis indicates that dynamic conditions tend to increase mean and peak pressures and often change the distribution of load over time, regardless of cushion type. Some dynamic studies, such as those that include ROHO Low Profile and Jay Active cushions during propulsion, suggest that although all cushions experience increased peaks with movement, cushions with better baseline pressure redistribution retain their relative advantage during dynamic activity. However, the data are sparse, often limited to small samples and short observation windows.

Mendes and colleagues (2019) contribute some more direct real-world dynamic content. They assessed ten wheelchair users with SCI using three cushions, primarily the Jay Evolution Air and Varilite Meridian Wave, while measuring mean and peak pressure, contact area, and peak pressure index in static sitting and during wheelchair locomotion. One participant's own cushion was a ROHO Quadtro Select High Profile. The authors note that, at a group level, certain air cushions, including the Jay Evolution Air and the ROHO Quadtro Select High Profile, produced the best mean pressure values. However, because the ROHO Quadtro Select High Profile was only used by one participant, the data cannot be generalized, although they do show that, in at least one real-world case, the ROHO Quadtro Select High Profile achieved low mean pressures even under dynamic conditions.

Clinical conclusions

When selecting a wheelchair cushion, it is imperative to consider all activities that a person will be completing while seated. Beyond static sitting, propelling or driving their chair, what are their typical activities of daily living? The way a cushion is configured may result in varying outcomes if one is sitting still compared to scooting to the edge of the cushion to work on a computer or to complete a catheterization. ROHO cushions are designed to constantly restore forces and move with the person throughout the day. Movements can be small, micro adjustments such as slightly leaning forward to type on a keyboard or larger, macro adjustments such as performing a side-to-side weight shift.

Conclusion: Overall state of the science on ROHO® cushions

ROHO cushions, across multiple generations and models, consistently demonstrate superior pressure redistribution compared with flat foam and many gel-foam cushions, and they compare favorably with other high-end air-cell designs. Dual- and multi-compartment ROHO cushions in particular tend to provide the best combination of low peak pressure and large contact area. Clinical and case-based evidence suggests that when ROHO cushions are integrated into comprehensive seating and pressure management programs and their inflation is actively managed, they support low short-term PI incidence in high-risk populations and can effectively off-load vulnerable regions while maintaining acceptable function and comfort. An important caveat, however, is that definitive long-term randomized evidence is lacking, especially regarding hard outcomes such as PI incidence, healing rates, and long-term quality of life. Functionally, ROHO cushions do not appear to preclude dynamic activities or cause excessive shear during posture changes, though some evidence suggest that highly immersive high-profile designs may slightly constrain trunk excursion compared with firmer, contoured foam. Microclimate behavior is mixed: ROHO cushions can be relatively cool under load but may trap more moisture than some foam–fluid hybrids or specialized designs (see Table 2 below).

In sum, the current state of the science supports the view that ROHO cushions are high-performing skin-protection cushions with strong evidence for superior pressure redistribution and credible, though mostly indirect, support for their role in PI prevention when properly prescribed and managed. Important gaps remain in long-term randomized trials, in detailed understanding of their behavior under real-world dynamic loads, and in directly linking internal tissue deformation patterns on different ROHO models to clinical outcomes.

Table 2. Summary of Model-Specific Performance Characteristics

ROHO Model / Type	Key Characteristics	Pressure & Load Distribution	Function & Stability	Microclimate / Other Notes
High Profile (single-compartment)	4-inch air cells; high immersion and envelopment	Lowest peak pressures; benchmark status; deep immersion (Gil-Agudo et al., 2009; Sprigle & Pubillones, 2018; Sonenblum et al., 2018)	Reduces trunk motion vs. foam; low shear during transitions (Aissaoui et al., 2001; Cooper et al., 2000)	Cools over time but retains humidity; deep-tissue deformation (Freeto et al., 2016; Sonenblum et al., 2018)
Low Profile (single- or dual-compartment)	2-inch air cells; lower immersion, more stability	Good pressure relief; less immersion than High Profile (Gil-Agudo et al., 2009; Mendes et al., 2018)	Good stability, comfort; acceptable shear (Gonçalves et al., 2015; Cooper et al., 2000)	Slightly warmer than hybrid cushions; humidity similar (Hsu et al., 2018)
Dual-/multi-compartment (e.g., Quadtro Select)	Compartmentalized air cells; adjustable for asymmetry	Best redistribution; superior to single-compartment ROHO (Gil-Agudo et al., 2009; Meaume et al., 2017)	Improved stability when tuned; beneficial in seating asymmetry (Park & Lee, 2019)	Limited microclimate data available
Unspecified ROHO air-cell cushions	Early or not clearly-labeled ROHO designs	Lower peak pressures than foam/gel (Yuen & Garrett, 2001; Aissaoui et al., 2001; Trewartha & Stiller, 2011)	Often highest comfort ratings (Gonçalves et al., 2015)	No microclimate studies identified

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