

## Materials

- **Base fabric:** Neoprene (2–3 mm) or chloroprene blend
  - **Role:** Waterproof shell, mild insulation, buoyancy
  - **Key specs:** Chlorine/salt resistance, stretch 150–200%, thermal comfort for 28–32°C pools
- **Compression fabric:** Medical-grade elastane (20–30% Lycra in nylon/poly blend)
  - **Role:** Targeted compression panels to reduce spasticity and improve proprioception
  - **Key specs:** Graduated compression 15–25 mmHg, 4-way stretch, moisture management
- **Reinforcement:** Ripstop nylon or Kevlar patches
  - **Role:** High-stress area durability (shoulders, hips, seams, harness points)
  - **Key specs:** Tear strength > 100 N, abrasion resistance > 20,000 cycles
- **Airbag bladder:** TPU-coated nylon (70–210D)
  - **Role:** Lightweight, airtight inflatable chambers
  - **Key specs:** Airtightness < 5 cc/m<sup>2</sup>/day, burst pressure > 0.3 MPa, RF-weldable seams
- **Seals and valves:** Silicone rubber and TPU films
  - **Role:** Watertight gaskets, over-pressure relief, check valves
  - **Key specs:** Skin-safe (ISO 10993), Shore A 40–60, low compression set
- **Sensor windows:** Clear PU film
  - **Role:** Optical path for PPG/SpO<sub>2</sub>, isolation for electrodes
  - **Key specs:** Optical clarity, thickness 0.2–0.5 mm, hydrolysis resistant
- **Electronics housing:** Polycarbonate or ABS with overmolded TPU
  - **Role:** Impact-resistant, waterproof pods for HR, SpO<sub>2</sub>, IMU, battery, BLE
  - **Key specs:** IP68 sealing, IK07 impact rating, corrosion-resistant fasteners
- **Closures:** Waterproof zippers, magnetic or Velcro flaps
  - **Role:** Donning/doffing, removable modules, service access

- **Key specs:** Salt/chlorine resistant coils, double storm flaps
- **Thread and adhesives:** Bonded nylon thread, urethane adhesives
  - **Role:** Structural stitching, seam sealing
  - **Key specs:** Bonded thread size 92–138, seam tape compatibility with neoprene/TPU

## Design architecture

### Layering and zones

- **Outer shell:** Neoprene panels for hydrodynamics and waterproofing.
- **Compression layer:** Elastane panels mapped to major muscle groups (quads, hamstrings, calves, paraspinals) with graduated compression.
- **Reinforcement grid:** Ripstop/Kevlar patches at load paths and seam intersections.
- **Internal bladder channels:** TPU airbag chambers around chest, back, and hips, away from rib pressure points.

### Sensor placement

- **Heart rate/PPG:** Forearm or upper arm cuffs under PU window; secondary ECG dry electrodes at sternum/left axilla.
- **SpO<sub>2</sub>:** Finger sleeve or ear-clip integrated into hood/cap with PU window.
- **Motion (IMU):** Triaxial units at sternum, pelvis, and ankle for gait and balance metrics.
- **Redundancy:** Dual HR sources + motion inactivity trigger to prevent false positives.

### Safety systems

- **Trigger logic:** Vitals threshold + motion inactivity + water submersion flag to deploy airbags.
- **Airbag layout:** Horseshoe collar + posterior dorsal panel to orient face-up without neck hyperextension.
- **Manual override:** Pull-tab and app button; mechanical lockout to prevent accidental inflation.
- **Pressure control:** Over-pressure relief valves and segmented bladders to avoid chest compression.

## Hydrodynamics and comfort

- **Panel shaping:** Anatomical seams following fascial lines to minimize restriction.
- **Thermal management:** Perforated neoprene under low-risk zones; mesh vent channels away from electronics.
- **Buoyancy balance:** Distributed foam inserts to maintain neutral buoyancy while allowing resistance training.

## Modularity and maintenance

- **Removable pods:** Snap-in electronics for cleaning and radiology compatibility.
- **Service ports:** Zippered access for bladder inspection and battery replacement.
- **Sanitation:** Materials compatible with hospital disinfectants; smooth non-porous surfaces on contact areas.

## Integration with mobile app

- **Connectivity:** BLE 5.x with secure pairing; offline data caching.
- **Alerts:** Multi-channel alarms (haptic on suit, audio on phone, visual notifications).
- **Data:** HR, SpO<sub>2</sub>, activity, session metrics; export for physiotherapy, lab tracking, nutrition.
- **Profiles:** Therapist-defined thresholds and exercise plans; patient-friendly UI with large icons.

## Ergonomic and sizing considerations

- **Fit system:** S/M/L/XL with adjustable straps at torso and thighs; plus-size patterns with darted panels.
- **Compression tuning:** Swappable panel kits to tailor mmHg per patient.
- **Donning aids:** Loop handles, guided zipper tracks, color-coded alignment markers.

## Testing and validation checkpoints

- **Waterproofing:** IP68 immersion tests; seam leak rate.
- **Airbag reliability:** Cycle tests 1,000+ inflations; deployment time < 2 seconds.
- **Biocompatibility:** ISO 10993 for all skin-contact components.

**Durability:** C Timestamp, PatientID, HeartRate, BodyTemp, WaterPressure, MotionScore

2025-11-20T10:00:00Z,P001,90,36.7,1.2,7.2

2025-11-20T10:00:05Z,P001,92,36.8,1.3,7.5

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2025-11-20T10:00:15Z,P001,93,36.9,1.3,7.4

2025-11-20T10:00:20Z,P001,91,36.8,1.2,7.3

Aqua-Sense-Smart-Aquatic-Therapy-Suit/

|

  |— data/

  |  |— suit\_sensors.csv

  |  |— suit\_configuration.json

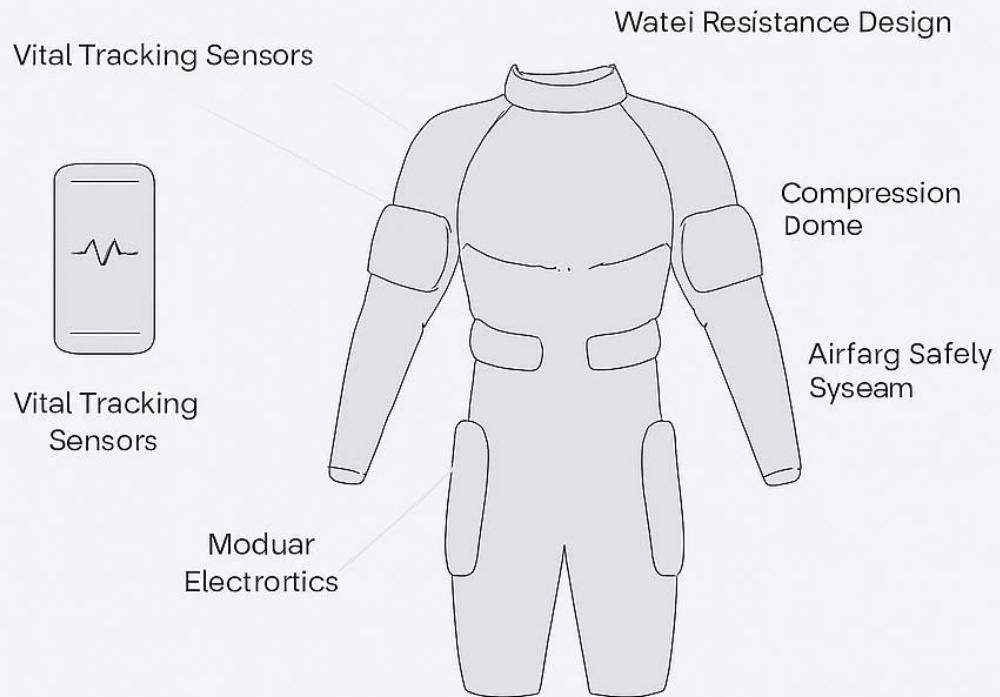
  |  └— therapy\_outcomes.csv

- Chlorine/salt exposure, UV aging, tensile/tear strength.
- **Usability:** Donning time, range-of-motion trials, comfort scores.

### Practical design notes

- **Balance compression vs. buoyancy:** Keep chest compression moderate to avoid respiratory restriction in water.
- **Avoid sensor shadowing:** Route seams and reinforcements away from optical windows.
- **Cable management:** Internal flat flex cables with strain relief; no free wires in water.
- **Fail-safe defaults:** If sensors fail, airbags default to manual-only mode with clear alert.
- **Serviceability first:** Tool-less module removal encourages hygiene and rapid repairs.
- Your wireframes are ready now.

# Design



# Materials

