Tensegrity Medical Device – Initial Testing

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Design Requirement Summary

Customer Requirements

- CR1: Reuseable
- CR2: Rechargeable
- CR3: Light Exposure
- CR4: Time Duration / Automatic Shut-off
- CR5: Cord-free
- CR6: Cost Effective
- CR7: Compact but functional

Engineering Requirements

- ER1: Power Output (20-50W)
- ER2: Battery Life (120min)
- ER3: Unit Cost (Around $290)
- ER4: Wavelength Infrared (850-880 nm)
- ER5: Wavelength Red (650-670 nm)
- ER6: Treatment Duration (20min)
- ER7: Size (10in x 10in)

Top Level Testing Summary

Experiment/ Test	Relevant DR	Testing Equipment Needed	Other Resources
EXP1 - Heat Testing	CR3: Light Exposure ER4: Wavelength Infrared (850-880) ER5: Wavelength Red (650-670)	Infrared thermometer Data-logging temperature sensors	Fake skin model, TPU casing
EXP2 - Harness Fit Testing	CR1: Reuseable CR7: Compact but functional ER7: Size (10in x 10in)	Pressure mapping sensors, Measuring Tape	Device + Harness
EXP3 – Performance/ Duration Testing	CR2: Rechargeable ER2: Battery Life (120min) ER4 - Wavelength IR (850-880) ER5 - Wavelength Red (650-670)	Spectrometer, Multimeter	Battery, Timer
EXP4 – Behavioral Testing	CR1: Reuseable CR2: Rechargeable ER1: Power Output (20-50W) ER2: Battery Life (120min) ER6: Treatment Duration (20min)	Dog activity trackers Thermal imaging camera Veterinary monitoring equipment — to check vitals and comfort	

EXP1- Heat Testing; TPU Casing

- Objective: determine the temperature at which TPU (Thermoplastic Polyurethane) casing softens or deforms under heat at varying material thicknesses

- **ER**: Thermal resistance (safety margin), sanitation durability, structural integrity during use
- **CR**: Device comfort, reusability, and safety

- Equipment Needed:
  - TPU Samples in different thicknesses
  - Heat source (e.g., Hot plate, Programmable oven, Heating gun
  - Thermocouples
  - Weights for applying pressure
  - Tape measure (to confirm thickness)
  - Timer
  - Safety Equipment (e.g., safety googles, safety gloves)

EXP1- Heat Testing; TPU Casing

- Procedures:
  1. Prepare TPU samples in uniform shape (e.g., 5 cm × 5 cm) at thicknesses: 1mm, 2mm, 3mm.
  2. Place each sample on a pre-heated surface starting at 40°C.
  3. Increase temperature in 5°C increments every 2 minutes.
  4. At each increment:
  5. Record surface temperature using a thermocouple or IR thermometer.
  6. Observe deformation (softening, curling, sagging).
  7. Optionally, place a 500g weight on center to simulate pressure.
  8. Identify the temperature at which the sample starts to visibly deform.
  9. Repeat for each thickness.
  10. Record and photograph results for analysis.

- Desired Results:
  1. Temperature at which TPU begins to visibly deform at each thickness
  2. Establish a safe operating temperature for device casing
  3. Confirm whether TPU can withstand heat from internal components

EXP1.1 – Heat Testing; Skin

Objective: To make sure the LEDs on the device doesn't cause damage onto the skin while on (in use)

ER: Thermal resistance (safety margin), sanitation durability, structural integrity during use
CR: Device comfort, reusability, and safety

Procedure:
1. Place LED device on tissue mimic model (Lights facing the tissue mimic)
2. Turn on the LED device and run a 20-minute cycle.
3. Record temperatures every 30 seconds.
4. Use the thermal camera to capture temperature distribution after 20 minutes.
5. Remove harness and continue recording skin temperature for 5 minutes to observe cooling.

Equipment Needed:
- Tissue mimicking model
- Thermocouples
- Picolog Software

EXP2 – Harness Fit Testing

- Objective: To view how the strap/device performs while being worn by a dog, as well as make sure it's comfortable for the dog

- **ER**: Portability, Treatment Area Accuracy
- **CR**: Non-invasive, Comfortable, Secure fit

- Equipment Needed:
  - Prototype device + harness
  - volunteer (human or canine)
  - Measuring tape / soft ruler
  - Force gauge or tension tester (optional)
  - Stopwatch (for wear-time tests)

EXP2 – Harness Fit Testing (Complete)

- Procedure:
  - Attached the harness, via buckle, to Jessalyn's dog (while device was off)
  - Adjusted straps so that it fit snug (but no tight) onto the dog
  - In order to view performance of straps, we observed the dog wearing the harness during a walk and while the dog was stationary (sitting down)

- Results:
  - While walking, the device sat in place well (shifted minimally)
  - Took a bit of time adjusting from the dog (comfort wise) while sitting down

EXP3 – Performance/ Duration Testing

- Objective: To view how the battery holds up and performs over a long period of usage time. Need to observe how long the battery will last as well as the performance of the battery

- **ER**: Battery Life, Treatment Duration
- **CR**: Time duration

- Equipment Needed:
  - Prototype device
  - Lithium-ion battery
  - Thermocouples
  - Picolog
  - Stopwatch (for duration testing)

EXP3 – Performance/ Duration Testing

- Procedure:
  - Turn on device using the fully charged battery
  - Observe the battery while the device is on to see how long the battery will last
  - Every 5 minuets we will observe the heat emitting from the battery/device
  - Record this data using picolog

- Desired Results:
  - Would like to observe that the battery will last for at least 120 minuets (as advertised by manufacturer)
  - Want to make sure the battery isn't being overworked/ isn't overheating when used for a long period of time
  - Human use shouldn’t exceed 20 minuets at one time; we would like to make sure at every 5-20 minuet interval that the battery isn't overheating

EXP4- Behavioral Testing (Complete)

- Objective: How do users behave when the device is fitted, activated, and worn for a treatment session. Focusing on comfort, tolerance, awareness of light or heat sensation

- **ER**: Treatment Duration, Power Output
- **CR**: Reuseable, Rechargeable, Non-invasive, comfortable

- Equipment Needed:
  - Prototype device
  - Timer
  - Camera for passive observation
  - Behavioral scoring sheet (canine)

EXP4- Behavioral Testing (Complete)

- Procedures:
  - Fit device per user guide or protocol.
  - Activate device (or run placebo session with lights OFF).
  - Observe for 10–15 minutes while:
  - Tracking behavior (movement, fidgeting, adjustment)
  - Asking occasional check-in questions (“Is it too warm?”)

•After session:

- Ask participant to rate comfort, ease of use, trust in the device, willingness to wear again.
- Record physical signs of discomfort, if any.

•*For animal testing:*

- Observe behavior in a quiet space (tail movement, licking, ear position, body posture).
- Use owner or handler as guide for baseline behavior.

- Results:
  1. Minimal fidgeting, relaxed posture. (animal: no licking device)

Specification Sheet Preparation – ER

Engineering Requirement	Target	Tolerance	Measured/Calculated Value	ER Met (✓ or **X**)	Client Acceptable (✓ or **X**)
ER 1- Power Output	20-50 W	-/+ 10 W	20W	✓	✓
ER 2- Battery Life	120 minutes	-/+ 10 minutes	Still need to measure		
ER 3- Unit Cost	$290 (USD)	N/A	$290	✓	✓
ER 4- Wavelength (Infrared Light)	850-880 nm	-/+ 30 nm	Not using IRs as of final build	**X**	✓
ER 5- Wavelength (Red LEDs)	650-670 nm	-/+ 20 nm	625nm	**X**	✓
ER 6- Treatment Duration	20 minutes	-/+ 10 minutes	>10min	✓	✓
ER 7- Size	10x10 inches	-/+ 4.5x4.5 inches	4in x 4.25in	✓	✓

Specification Sheet Preparation – CR

Customer Requirement	CR Met (✓ or X)	Client Acceptable (✓ or X)
CR 1- Reuseable	✓	✓
CR 2- Rechargeable	✓	✓
CR 3- Light Exposure	✓	✓
CR 4- Time Duration/Shutoff	X	✓
CR 5- Cord Free	✓	✓
CR 6- Cost Effective	✓	✓
CR 7- Compact	✓	✓

QFD

System QFD

Project:		Tensegrity Medical Light Therapy
Date:		11/5/2024

1	Power Output	
2	Battery Life	9
3	Unit Cost	
4	Wavelength (Infrared light)	9
5	Wavelength (Red LEDs)	9
6	Treatment duration	3
7	Size	

Legend

A	LOVTRAVEL LED Light Therapy Pad
B	Garmin HRM-Dual Heart Rate Monitor
C	Innovo iP900BP-B Finger Pulse Oximeter

			Technical Requirements						Customer Opinion Survey				
	Customer Needs	Customer Weights	Power Output	Battery Life	Unit Cost	Wavelength (Infrared light)	Wavelength (Red LEDs)	Treatment Duration	Size	1 *Poor*	2	3 *Acceptable*	4	5 *Excellent*
1	Reuseable	4		3				1			A	B		C
2	Rechargeable	3	9	9								C	A	
3	Light Exposure	4				9	9	9		AC				B
4	Time Durat/Shutoff	1	3	3		3	9	9				AC		B
5	Cord Free	4	3	9				3	9	BC		AC		
6	Cost effective	3			9				3		A		BC	
7	Compact	2			3				9	A			B	
	Technical Requirements Units		W	min	$(USD)	nm	nm	min	in					
	Technical Requirements Target		20-50	120	290	850-880	650-670	20	10x10					
	Absolute Technical Importance		42	78	27	39	45	61	27					
	Relative Technical Importance (%)		14.38	26.71	9.25	13.36	15.41	20.89	9.75					

Thank You, Questions?