



ThermoChill Knee Brace



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Osteoarthritis (OA) is the most common form of arthritis and affects 32.5 million US adults

Diagnosed and Future Projections* of Arthritis

ARTHRITIS WILL INCREASE AS THE POPULATION GROWS AND AGES

*Doctor Diagnosed



Data from: National Health Interview Survey 2013–2015

The Cost of Osteoarthritis

Absenteeism costs

\$10.3

billion

Total costs

\$136

billion

Average direct cost

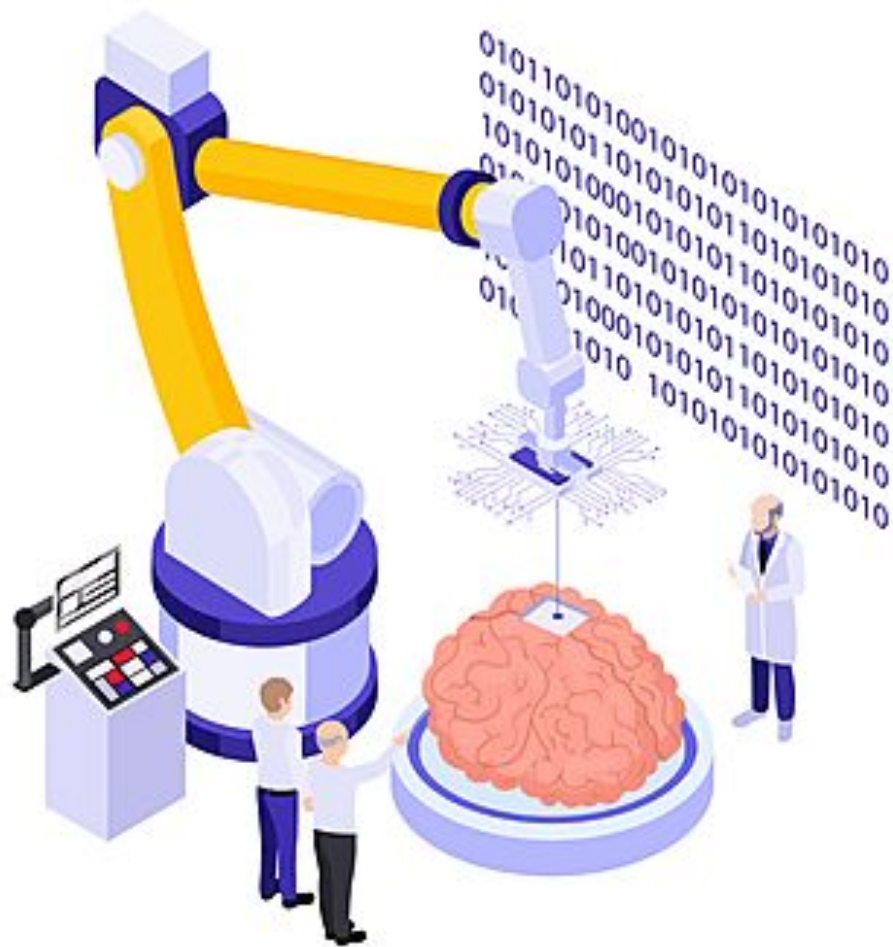
\$11,000

person/year

Arthritis has a greater impact on POC than Whites due to documented racial disparities

Why did I pick this area?

- Family history
- Ingrained accessibility issues



Current solutions

Surgical Solutions	<ul style="list-style-type: none">• Only a <u>small fraction</u> of those with OA require surgical treatment
Pharmaceutical Solutions	<ul style="list-style-type: none">• Many people <u>cannot</u> take medication due to side effects
Commercial Knee Braces	<ul style="list-style-type: none">• Often hard to utilize correctly and effectively



Needs Statement

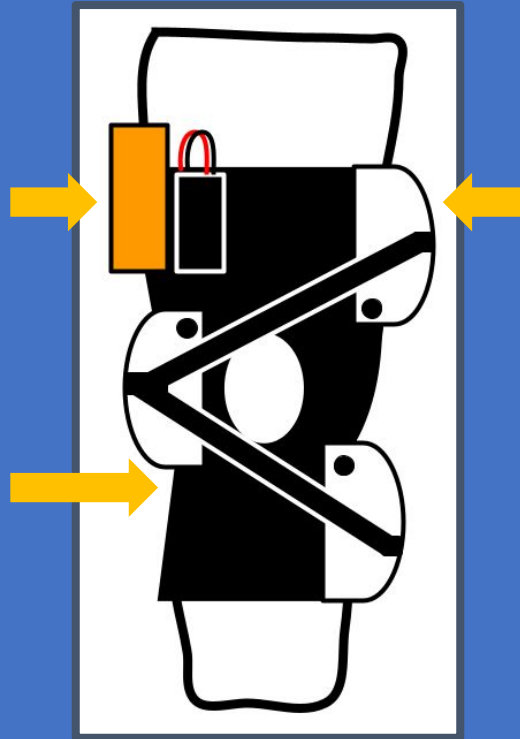
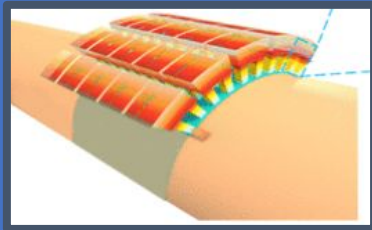


A comprehensive, accessible, non-surgical, and non-pharmaceutical device to relieve pain for elderly patients with mild to moderate knee osteoarthritis that may be at risk for a decreased quality of life from a knee replacement surgery or have required medications that conflict with osteoarthritic medication.

Finalized Concept

Control and battery box
with controls to operate
the air pockets and
sleeve

Heating/cooling sleeve
with thermoelectric
coolers



Inflatable air pockets to
distend the knee and
relieve pressure against
knee cartilage (reduces
inflammation)

An app system that is
easy to use (including for
the elderly and
non-English speakers) to
maintain and use the
device

Iteration Timeline!

Added component to the app for doctor access

- Allows only the doctor to control treatment and simplifies experience for patient

Patient: Please select the Patient Interface to access controls for your brace.

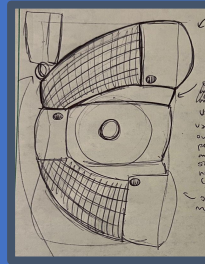
Doctor: Please select the Doctor interface to set controls for the brace.

Patient Interface

Doctor Interface

Changed the heating/cooling sleeve and pneumatic air pocket system to be separate components

- Made system more customizable and generally lightweight



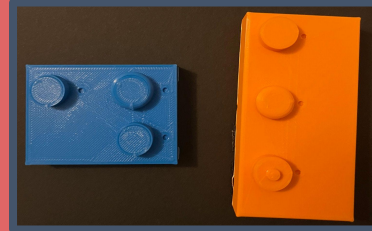
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Iteration Timeline!

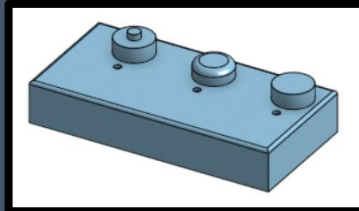
Textural differentiation of buttons

- Accommodates visually impaired



Changed design of electronics box to be bigger

- Accommodates elderly users better

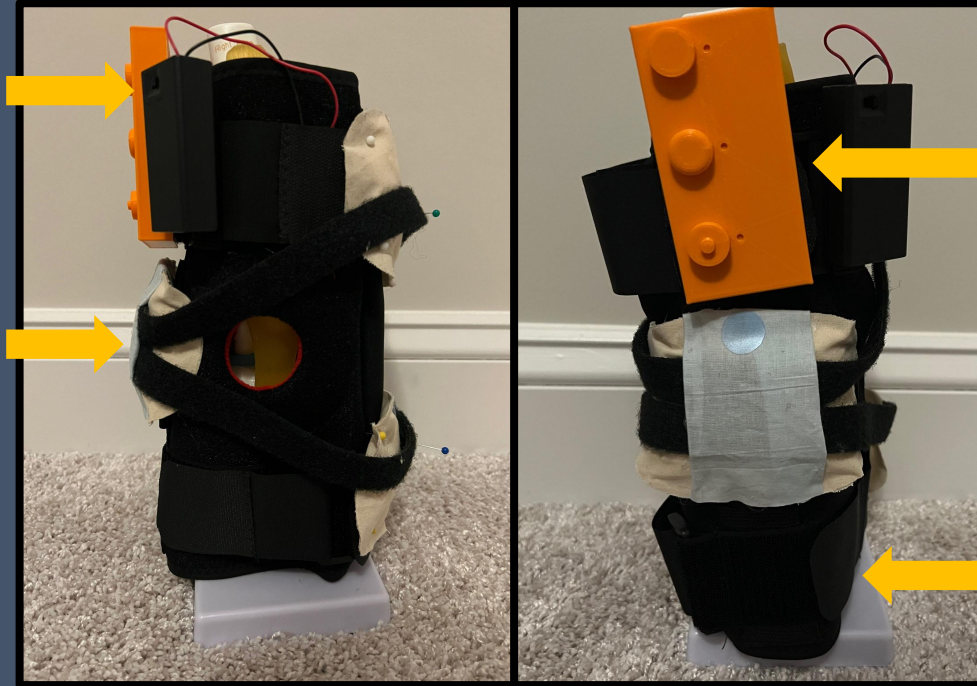


Added speaker to electronics box

- Better notifications of when to start cycles

Final Brace Prototype

Operates on battery box (2 AA batteries)



Pneumatic air-bladder system on exterior

- Air valves to inflate with bicycle pump
- Air pressure sensors
- Velcro system

Electronics/Control box

- Buttons are big enough for elderly/people with dexterity issues to press

Heating and cooling sleeve to be worn during heat/cool cycles on interior

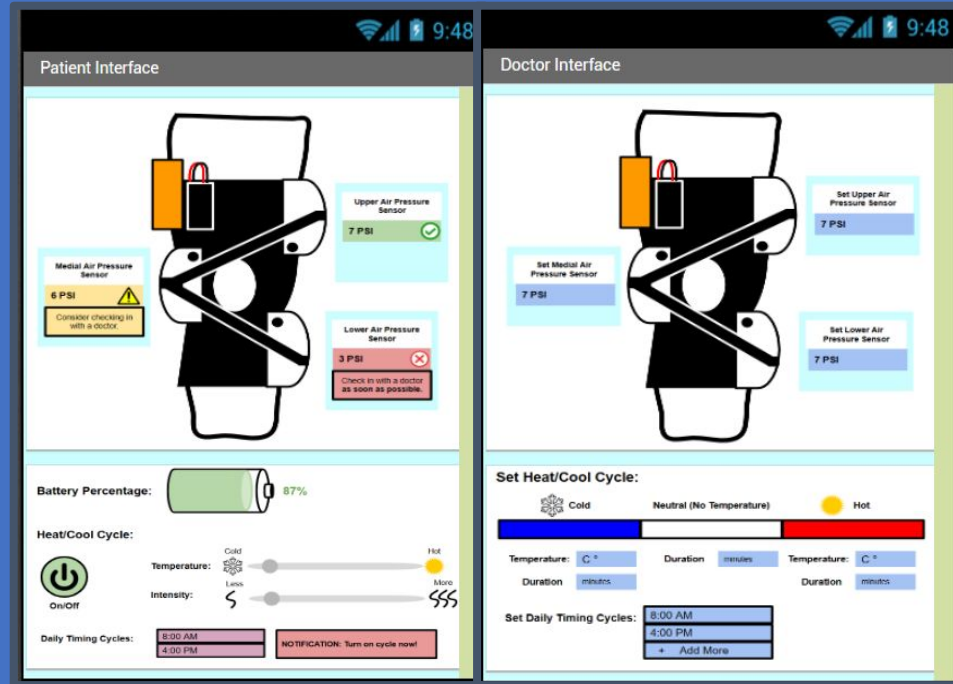
Final App Prototype

Picture based

- Explanations accompany icons to reduce ambiguity

Button size enlarged for elderly/visually impaired

Heating/cooling and intensity operates 'a la carte'



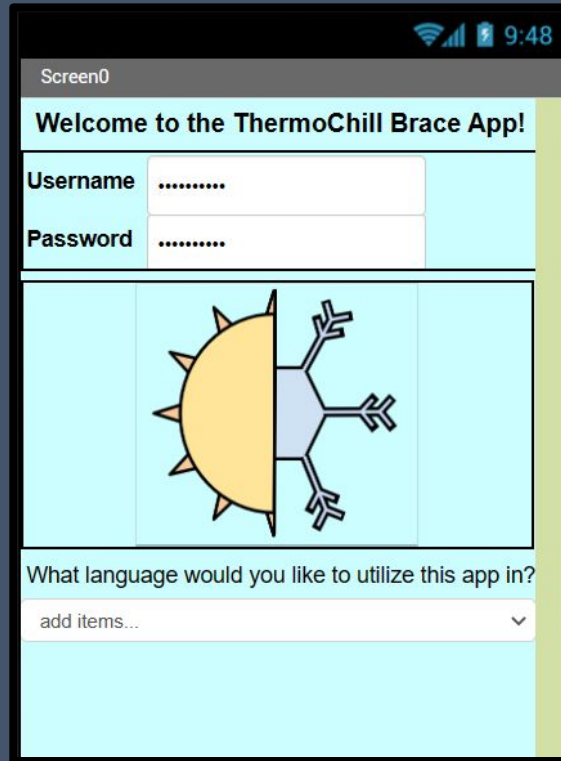
Allows doctor to 'lock' settings each time they adjust for reduction of patient error

Color scheme for alerts/warning/input

Final App Prototype

Soothing color scheme (green and blue) for trust and healing

Accounts for non-english speakers



Screen0

Welcome to the ThermoChill Brace App!

Username

Password

What language would you like to utilize this app in?

add items... ▾

The screenshot shows a mobile app interface with a light blue background. At the top, there's a status bar with signal, battery, and time (9:48). Below that, a header bar says 'Screen0'. The main content area has a title 'Welcome to the ThermoChill Brace App!' followed by two input fields for 'Username' and 'Password'. Below these is a large image of a yellow sun on the left and a blue snowflake on the right. At the bottom, there's a question 'What language would you like to utilize this app in?' with a dropdown menu showing 'add items...' and a downward arrow.

Scan to
check out the
app on MIT
App Maker!



Further Testing

- Human trials with [Knee Injury and Osteoarthritis Outcome Score \(KOOS\)](#)
- [Surveys and interviews](#) from representative sample of people suffering with OA
- [Fault Tree analysis and Critical Task analysis](#)

KOOS KNEE SURVEY

Today's date: ____/____/____ Date of birth: ____/____/____

Name: _____

INSTRUCTIONS: This survey asks for your view about your knee. This information will help us keep track of how you feel about your knee and how well you are able to do your usual activities. Answer every question by ticking the appropriate box, only one box for each question. If you are unsure about how to answer a question, please give the best answer you can.

Symptoms

These questions should be answered thinking of your knee symptoms during the **last week**.

51. Do you have swelling in your knee?

Never Rarely Sometimes Often Always

52. Do you feel grinding, hear clicking or any other type of noise when your knee moves?

Never Rarely Sometimes Often Always

53. Does your knee catch or hang up when moving?

Never Rarely Sometimes Often Always

54. Can you straighten your knee fully?

Always Often Sometimes Rarely Never

55. Can you bend your knee fully?

Always Often Sometimes Rarely Never

Stiffness

The following questions concern the amount of joint stiffness you have experienced during the **last week** in your knee. Stiffness is a sensation of restriction or slowness in the ease with which you move your knee joint.

56. How severe is your knee joint stiffness after first waking in the morning?

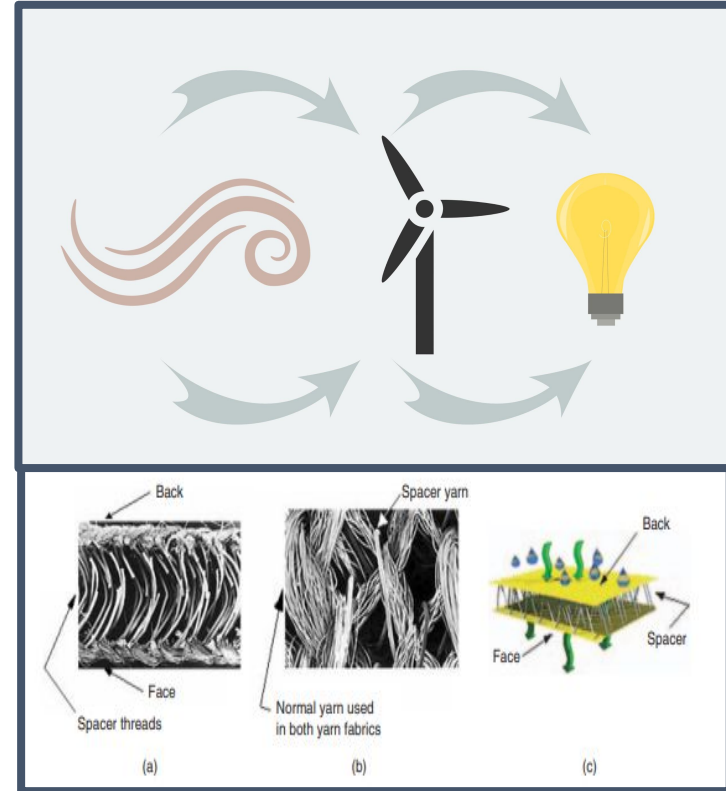
None Mild Moderate Severe Extreme

57. How severe is your knee stiffness after sitting, lying or resting later in the day?

None Mild Moderate Severe Extreme

Future Work

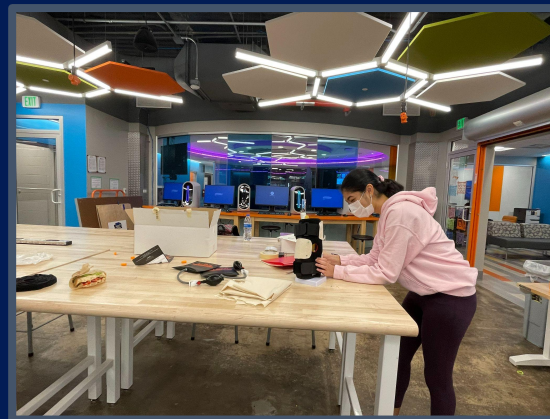
- Inclusion of patient forum on app
- Consideration of comfort of material
- Consideration of environmental impact of materials used in brace





THANK YOU!

Any Questions?



Me working at the Duke CoLab!



And an especially big thank you to my trainers and mentors: Kimi, Hannah, Chinelo, Shruthi, and Dr. Madonna!

Bibliography

[Study: Noninvasive Treatment May Relieve Painful Knee Arthritis \(hss.edu\)](#)

[BME PhD student helps design wearable arthritis device and create start-up | Biomedical Engineering | College of Science and Engineering \(umn.edu\)](#)

[Understanding acute and chronic inflammation - Harvard Health](#)

[Noninvasive ultrasound stimulation of the spleen to treat inflammatory arthritis | Nature Communications](#)

[Noninvasive Devices Targeting the Mechanics of Osteoarthritis - ScienceDirect](#)

[Osteoarthritis Treatment | Arthritis-health](#)

[Effect of Cold, Warm or Contrast Therapy on Controlling Knee Osteoarthritis Associated Problems \(researchgate.net\)](#)

[Cureus | A Review on Osteoarthritis Knee Management via Contrast Bath Therapy and Physical Therapy | Article](#)

[Design and development of a smart knee pain relief pad based on vibration and alternate heating and cooling treatments - IOS Press](#)

[UX Design for Seniors: Examples and Tips \(eleken.co\)](#)

[The number of people with osteoarthritis worldwide is on the rise \(news-medical.net\)](#)

Bibliography

[A Preliminary Assessment of a Novel Pneumatic Unloading Knee Brace on the Gait Mechanics of Patients With Knee Osteoarthritis - Della Croce - 2013 - PM&R - Wiley Online Library \(nclive.org\)](#)

[Pneumatic Osteoarthritis Knee Brace | J. Biomech Eng. | ASME Digital Collection](#)

[Wearable Thermoelectric Cooler Based on a Two-Layer Hydrogel/Nickel Foam Heatsink with Two-Axis Flexibility | ACS Applied Materials & Interfaces](#)

[Ultra-high performance wearable thermoelectric coolers with less materials | Nature Communications](#)

[The effect of local muscle vibration on clinical and biomechanical parameters in people with knee osteoarthritis: A systematic review - PMC \(nih.gov\)](#)

[Optimal Size and Spacing for Mobile Buttons \(uxmovement.com\)](#)

[Design of flexible inorganic thermoelectric devices for decrease of heat loss - ProQuest](#)

[OA Prevalence and Burden - Osteoarthritis Action Alliance \(unc.edu\)](#)

[A Study of the Structure and Properties of Novel Fabrics for Knee Braces \(sagepub.com\)](#)

[A Guide to Interface Design for Older Adults | Toptal®](#)