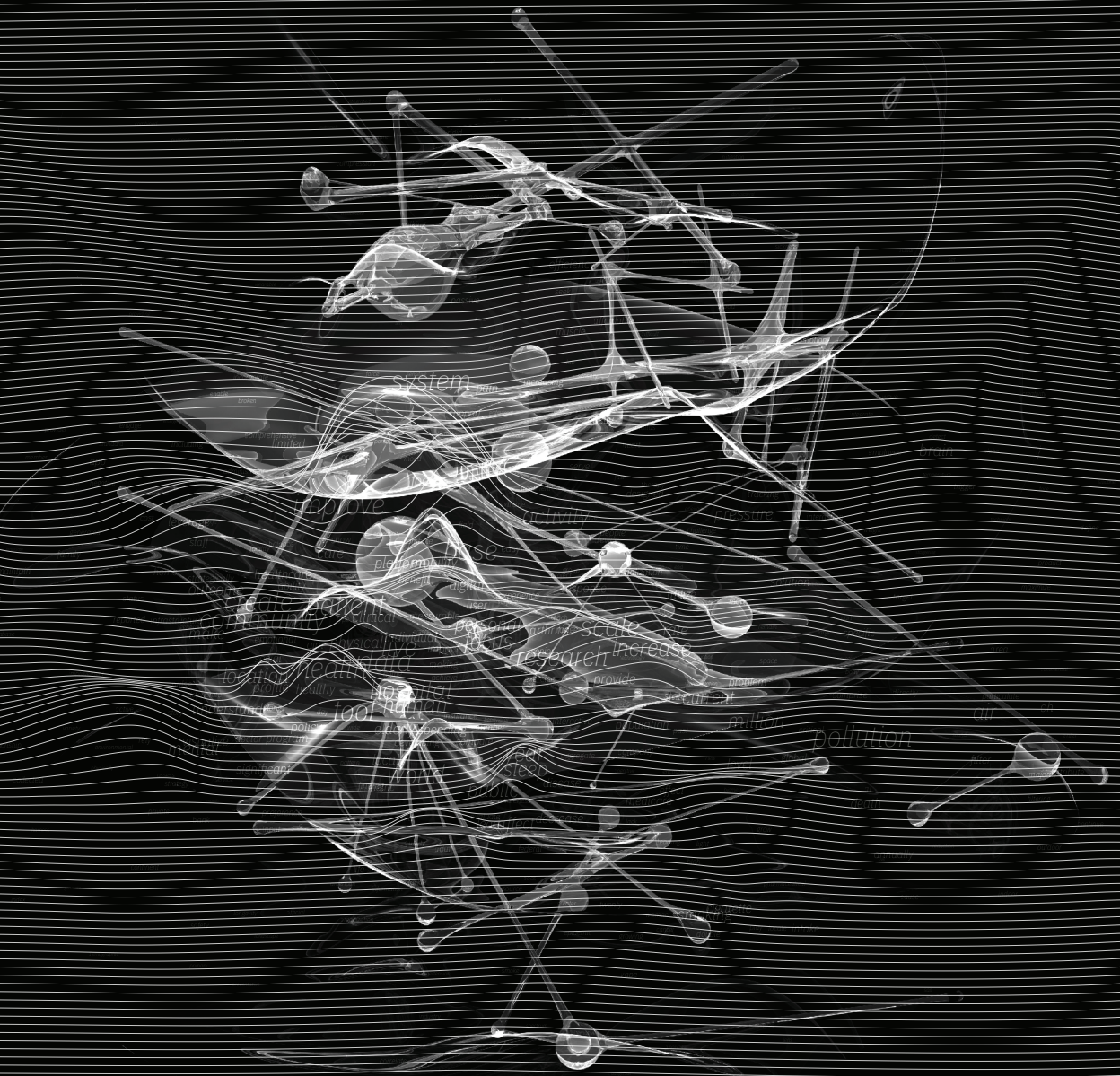
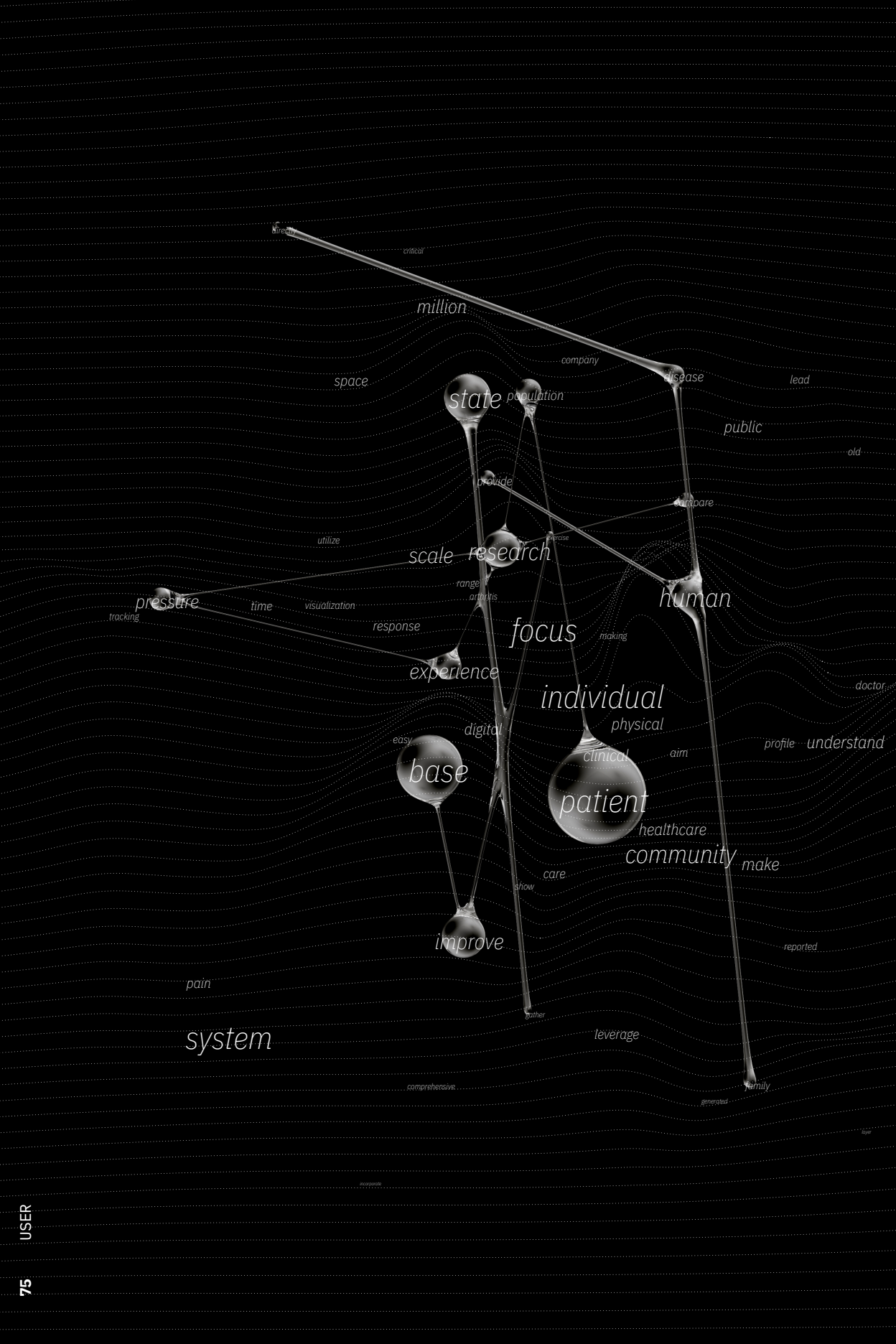
mde Master in Design Engineering at Harvard

HEALTH SYSTEMS



Master in Design Engineering at Harvard
Collaborative Studio
Volume 1 (2017-2018)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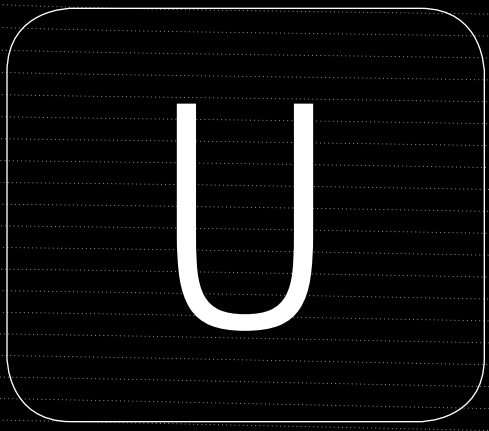
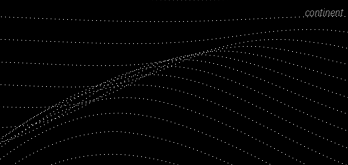


USER

How do I actively utilize resources? At the center of products, platforms, and interfaces are users. As users, we are empowered to control the way we experience the world around us. With human-centered design and studies on the impact of design decisions, these projects begin to understand the role of users in informing health outcomes along specific issues in healthcare.



U₁ MALCOLM TEN

An enhanced data collection platform for patient-reported outcomes

U₂ MOMENT

Focus training through a multi-sensory chair experience

U₃ SYNCSENSE

Motion-sickness mitigation for air travelers

U₄ MOBILIZE

A comfortable, concealable, affordable exosuit for assisting arthritis patients

U₅ FLEXFIT

A fitness ecosystem supporting seniors and their families with physical activities

U₆ ANOPHELINE VECTORS

Visualizing environmental change with longitudinal disease vectors

MOMENT

Focus training through a multi-sensory chair experience

Moment is a multi-sensory chair aimed to help individuals with Attention-Deficit/ Hyperactivity Disorder (ADHD) develop their ability to focus. Inspired by research showing that individuals with ADHD have a lower ratio of beta-to-theta brainwave activity when compared to the general population, the Moment chair targets this disparity and creates both a physical space and a digital interface to improve an individual's ability to focus. When a user engages with Moment, an array of sensory stimuli are activated, allowing for beta-to-theta brain activity to be affected. With meditative breath-rate visualization, scent, light, and sound, the Moment chair offers an oasis from distraction and a ritual to train your mind.

Nicki Adler, Saad Rajan, and Kiran Wattamwar

↓AN OASIS FOR FOCUS

Moment is a multi-sensory chair designed for a holistic therapy experience for anyone along the attention spectrum. The system is thoughtfully designed to consider ergonomics, cognitive states, multiple sensory inputs, and lifestyles to create a ritual of focus.

Problem

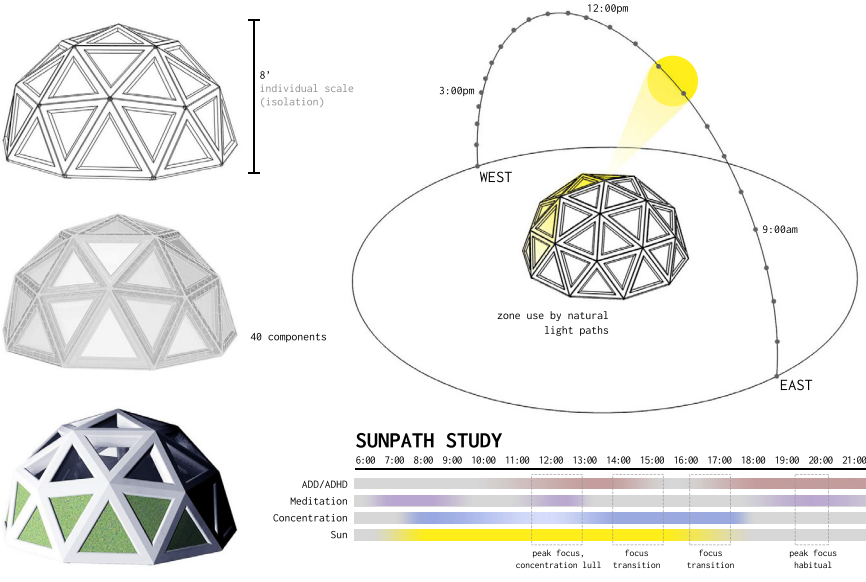
Moment is a multi-sensory chair aimed at helping individuals improve focus, as based on neural activity models of populations with Attention-Deficit/Hyperactivity Disorder (ADHD). Research indicates that individuals with ADHD have a lower beta-to-theta brainwave activity ratio compared to the general population during periods of intense focus. Based on this cluster of studies, the Moment chair hypothesizes that inducing brain activity to match the general population's will improve an individual's ability to focus.

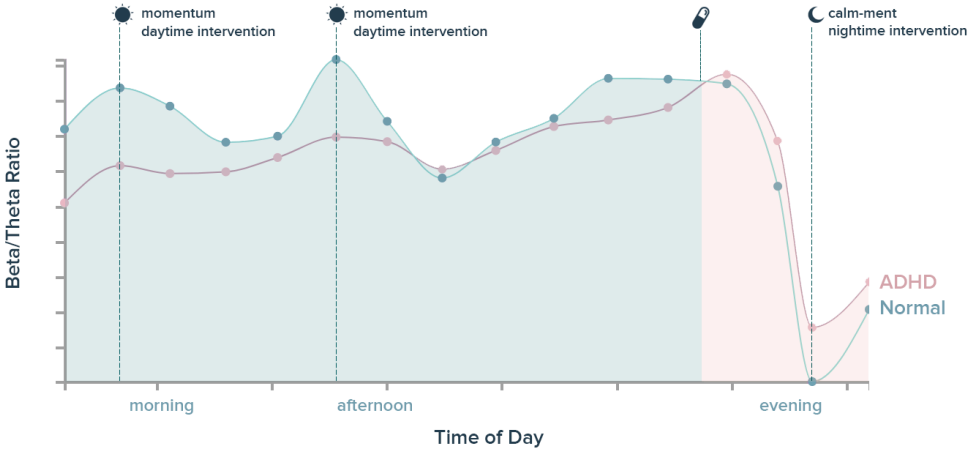
In a world of incessant notifications, infinite access to information, and addictive media baked into daily life, society's collective ability to concentrate is eroding. These phenomena, combined with pressure to boost cognitive performance, have led to record use of addictive stimulant drugs like Adderall and Ritalin. Moment counteracts the distraction and distress of modern times as a drug-free method of boosting performance and concentration. It ultimately seeks to help society control its reactions to ever-increasing stimuli. The design concept aims to help users focus on the moments, projects, and relationships that are most important.

Solution

Environmental factors measurably impact one's well-being. By reversing the paradigm and calibrating the environment, there are ways to reclaim control over one's well-being. Inspired by global meditation practices and mindfulness rituals, and informed by measured focus patterns in the brain, the Moment chair provides an oasis from a busy day.

It is also possible to modulate brain activity (specifically, the beta-to-theta ratio) by presenting sensory signals to the user at specific target frequencies. Combining these key insights, the Moment chair utilizes an array of sensory stimuli to induce brain activity and includes neural sensors to measure that activity. With a series of aurally prompted breathing exercises, alongside a meditative breath-rate visualization, scent, and light, the Moment chair is a rich sensory experience and a training ground for improving focus. By shaping the chair with smooth curves, minimally intrusive technology, and the feel of a protective shell, Moment is both a sanctuary and a productive environment to affect one's state of mind.





↑SUNPATH STUDY (ABOVE)

As a device that can easily fit in one's office or home, the use of natural light can directly affect concentration or meditation levels. This study analyzes the impact of light throughout the day.

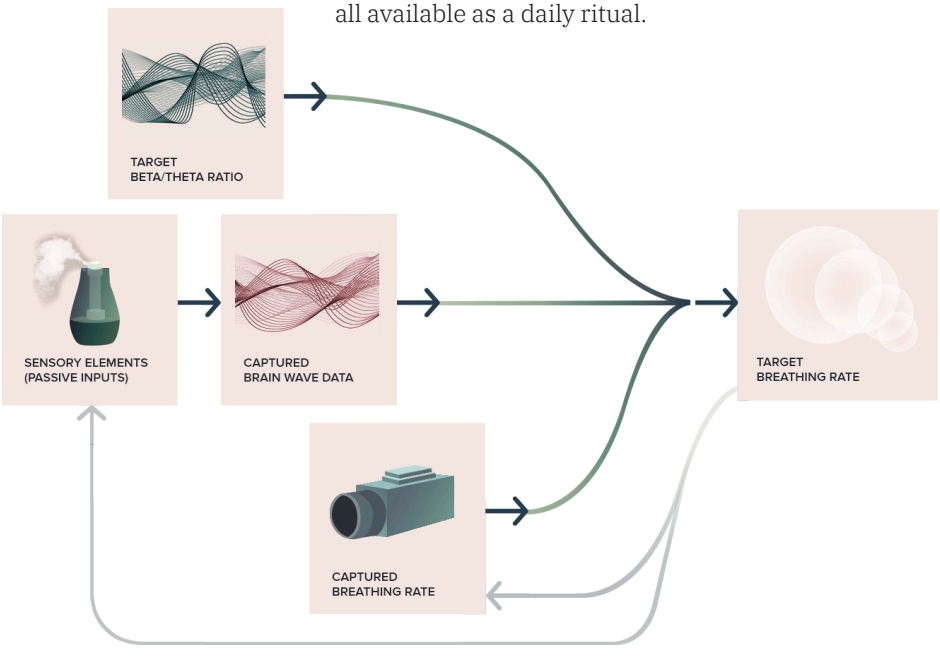
↑SCHEDULE (BELOW)

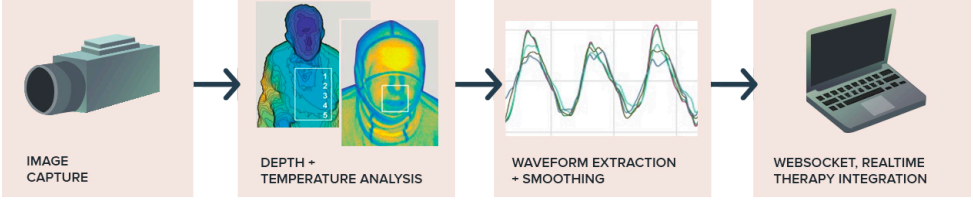
The beta and theta waves of people with ADHD vary throughout the day at a different rate than normal rates. Theta waves are associated with daydreaming, and beta waves are associated with focus. Moment facilitates intervention points to promote momentum and enervation in daytime focus activities, or "calm-ment" at night to help wind down the day.

↓BIOMETRIC CALIBRATION

The user's breathing rate and brain activity together determine the breath-rate activity, where targets are adjusted and the visualization updates in real time. To accompany changing brain activity and breath-rate targets, sensory elements like sound, scents, and light are activated at certain frequencies. The technical diagram below shows the integrated feedback mechanism for biometric calibration.

Moment collects user data during the programmed exercises to measure how the programming is affecting brain activity in real time, and adjusts the activity (for example, target breath rate) accordingly. The feedback loop allows for each session to be individually tailored for each Moment experience. Despite its technical foundation, the Moment chair abstracts the technology, allowing for an organic user experience. From the anatomical curves to the raw wood, Moment is designed to immerse, relax, and captivate. The sensory elements of the chair (light, aromatherapy, sound, and visual cues) are informed by research on their impacts on state of mind, but also by time-tested cultural traditions. Most importantly, Moment is centered on a user's individuality, adjusting its programming for unique brain activity profiles, routines, and functions, all available as a daily ritual.





↑ CNC-MILLED CHAIR

The physical body of the Moment chair is the composite of several 2-dimensional cuts of wood made by a CNC mill. Assembled together, the Moment chair's contours represent a wave with smooth lines that mimic the sensory elements and breathing task integrated inside it. Aside from the physical body, the chair also features an embedded projector and a smooth surface covering the interior of the hood, which is where the breath-rate activity is projected within the chair. Inside the head cushion rests the body of a brain activity monitor, and additional components that users can attach to their temples to get a reading of their brain activity, while a detached FLIR camera captures their breath rate by monitoring temperature changes near the users' nose or mouth.

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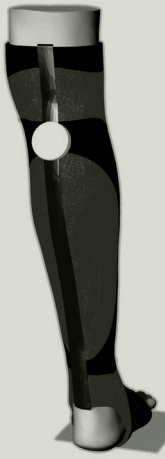
MOBILIZE

A concealable exosuit for improving walking efficiency

Mobilize is a comfortable, concealable, and affordable exosuit for increasing muscle efficiency and decreasing joint pain while walking. While walking is already an extremely efficient process handled by the human body, muscle movements can still be used to activate external systems like passive exoskeletons to make walking even more efficient.

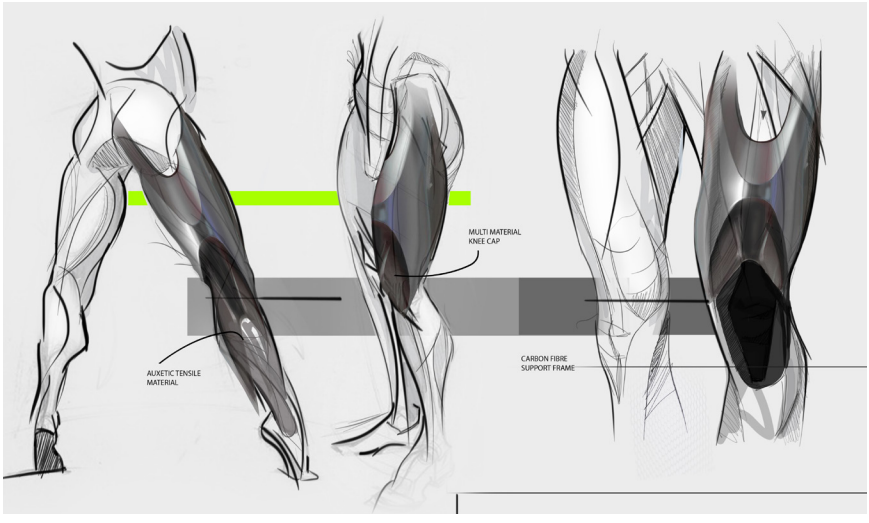
Using auxetic springs that work to complement muscle movement, the Mobilize exosuit uses a tensile structure to support walking. In parallel, the suit uses rigid structural elements to support joints, providing structure and compression. Together, these elements assist with muscle movement and joint pain, two major pain points for arthritis patients. An affordable, discrete, wearable device can improve mobility for a wide range of people who do not want their mobility constraints to be visible to others through the use of canes or walkers. Mobilize lets users take dignity and strength in their strides.

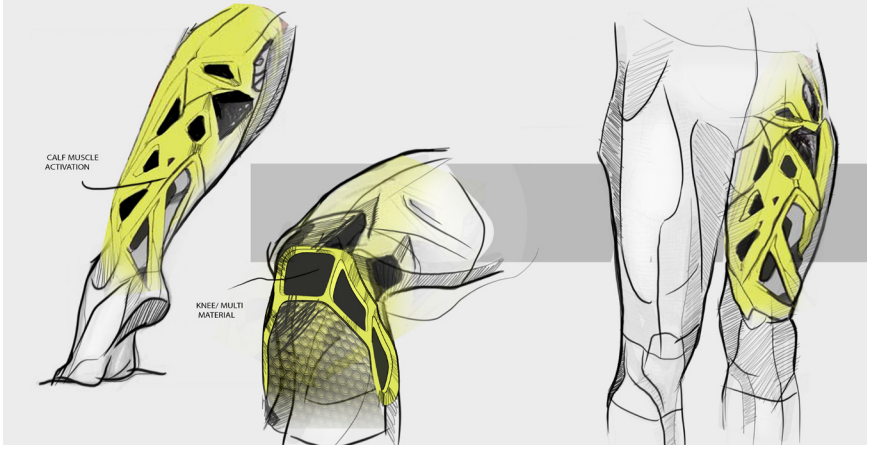


Jeronimo Beccar, Arjun Menon, and Kiran Wattamwar

↲ STRIDE SUPPORT

Since energy use is not distributed evenly during the walk cycle, Mobilize assists its users by harnessing excess energy that is lost in certain parts of a stride and redirecting it towards more strained parts.


MULTI MATERIAL
KNEE CAP
AUXETIC TENSILE
MATERIAL
CARBON FIBRE
SUPPORT FRAME


CALF MUSCLE
ACTIVATION
KNEE/ MULTI
MATERIAL


MUSCLE
MECHANICS

Problem

More than 50 million adults have already been diagnosed with some form of arthritis within the U.S. (Arthritis Foundation). Walking is an essential part of mobility for members of aging America, but even the simplest of actions become painful and difficult for those with arthritis.

Many exosuits designed to reduce the load (and therefore strain) on a wearer have been in development, but they are made with rigid materials that are meant to be worn on the exterior of a person's clothes. These are not easy to integrate into daily lifestyles with dignity, and are not seamless.

Exosuits currently on the market are primarily targeted towards defense and factory applications, with little focus on most of the population battling the consequences of arthritis. Other products currently address the needs of arthritis patients separately, without integrating them into a single system. Partial solutions like compression garments (usually designed for athletes), spring shoes, canes, pain medicines, and therapies for muscle development are difficult to weave into a single consumer product that performs well.

Usually, these needs are not combined into all-purpose systems that are truly integrated and effective in increasing muscle efficiency. Without a viable market solution to appeal to the mass market, sufferers of arthritis look to temporary relief solutions or drastic changes like surgeries and medication rather than seeking external aids that can continue to keep people mobile and active.

↲ EXPLORATION PROCESS

The core of this project rests on its materiality – from comfort to effectiveness, the success of a wearable exosuit meant for the masses depends entirely on its attention to detail in choosing the right materials.

Relying on materials like tensile polymers, the team designed its own auxetic stretchy materials, shaped by the contours of the human leg and calf muscles, to function as a spring in the tensile mechanism. This was cast in silicon with a custom mold, as a first pass.

Because this section of the garment was meant to support and mimic human musculature and increase muscle efficiency, this auxetic spring was tested for tensile properties like shore hardness, and compared to what was recorded by other academic research focused on muscle efficiency with passive systems.

↲ MATERIAL CONSIDERATIONS

The team investigated a collection of other materials, like stretchy fabrics, that could feasibly provide compression and comfort while withstanding daily wear, to construct the actual body of the suit.

Ultimately, Spandex was the best and most familiar option to users, which could make the garment integrate better into a daily wear cycle. Stiffer and supportive foams like Dela Foam and polyurethane foams were sewn into supports for a connected knee-brace, ankle brace, and shoe sole, to offer more compression and structural support in these areas where joint pain is the most prominent.

↑ FUTURE ITERATIONS

After performing a topology optimization on where the rigid supports would best be placed, the team considered the construction of rigid structural elements made of carbon fiber, which would offer a lightweight and thin shell to the areas of the exosuit that need a fixed structure. Other methods, like printing tensile materials directly onto fabrics to incorporate gradients of rigidity in a more streamlined way, might offer this exosuit more fertile ground in consumer applications in the future. Though the final suit was not realized in its intended form, the blueprints of the suit and its individual components offer promise that a wearable exosuit for arthritis patients is on the horizon.

Solution

The combination of a rigid support system and a tensile passive system can increase muscle efficiency, reduce joint pain, and promote better gait for patients with developing arthritis and decreased mobility. Mobilize aims to synthesize the benefits of orthotics, passive exosuits, and compression by focusing on soft, wearable materials. By using such materials, the Mobilize exosuit addresses its core design competency: the opportunity for concealment and daily use. Based on surveys with people with arthritis, it was evident that many people who could benefit from exo-suits do not consider them as options when choosing solutions to mitigate the effects of arthritis.

Canes and walkers fall within the same category, because they are not concealed and reduce the user's dignity. With a strong focus on material, the Mobilize exosuit is stretchy in areas of expansion and rigid where the body does not compress or expand. This combination accommodates movement but provides compression along joints to reduce pain. Guided by research in academia, the tensile structure and clutch redistribute energy along the walk cycle to increase muscle efficiency. Finally, the Mobilize exosuit incorporates a multi-material injection molding of stiff and flexible polymers that is applied directly onto the garment's base layer to increase comfort for users.

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