Designing with Intimate Materials and Movements: Making "Menarche Bits"

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ABSTRACT
Menarche is the first occurrence of menstrual bleeding and it usually begins between the ages of 9–15. This makes menarche a crucial transition among other social, physiological and behavioural changes during puberty. In this soma-based research-through-design project we design an open-ended prototyping kit: Menarche Bits. The aim of Menarche Bits is to open a design space for young adolescents to create body-worn technologies that support them in making space for their experiences of menarche and trusting their menstruating bodies. Menarche Bits consists of heat elements and shape-changing actuators that can be worn directly on the body by adhering to the skin or being inserted into pockets in a stretchable fabric as part of a garment. We describe the soma design process behind Menarche Bits as an example of how body-worn technologies can intimately interact with the body and its movement, temporality and material changes.

Authors Keywords
Women's health; soma design; research through design; menarche; shape-changing technologies; soft robotics.

CSS Concepts
• Human-centered computing~Interaction Design

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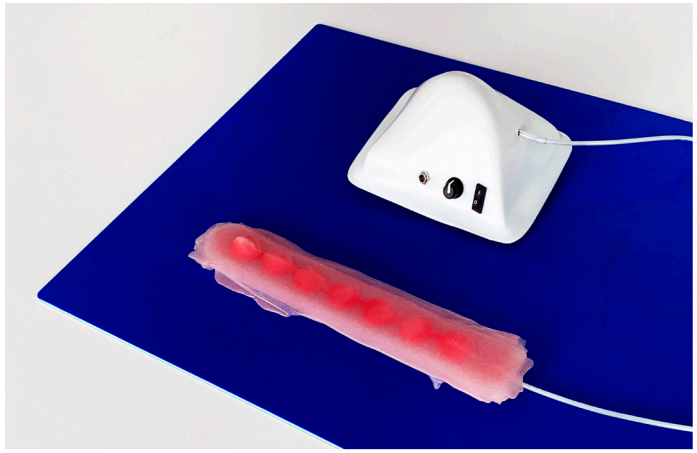


INTRODUCTION

Menarche is the onset of menstruation, yet menstrual cycles may not become regular for several years. Menarche is often considered a pivotal event of puberty and it is experienced in relation to other physiological, social and behavioural changes in adolescent life. The experience of menarche can be associated with uncertainty, embarrassment, bodily pain, increased self-objectification and a lack of knowledge and communication [19]. Menarche can influence adolescents' participation in activities, such as school and sports, their social relations and perception of themselves. In recent years, interaction design and HCI have contributed with novel design work and research on menstruation [5,26], menstrual cycles [8,9], and menopause [29], yet menarche and the early years of menstruation have been largely unexplored (with the exception of educational tools [18,27,28]). In our work, we take a holistic approach to menarche by understanding it as both a bodily-rooted and socially experienced life transition. We build on recent work with bodily fluids (such as saliva [12], cervical mucus, and menstrual blood [31]), and our parallel work on touching and being in touch with the menstruating body [31]. We contribute further by using first-person experiences of living in menstruating bodies to design not only with the material but also the movement of the menstruating body.

In this pictorial, we present the soma design [15] process behind Menarche Bits. Our contribution is twofold: (1) we present how we opened our design space through a somaesthetic approach to menarche (including our methodological choices and design artefacts), and (2) we present Menarche Bits (including how they were made and how they can be used).

Menarche Bits

Menarche Bits (front page) is an open-ended prototyping kit that aims to open a design space for young adolescents to create body-worn shape-changing technologies that support them in making space for their experiences of menarche and trusting their menstruating bodies. Menarche Bits is composed of soft, skin-worn shape-changing interfaces made of fluidic chambers actuated by air that respond to pressure by the wearer. The bits have silicone shapes in varying textures, sizes and geometries to adhere on different parts of the body. The kit includes shapes with behaviour orchestrated by design (sequential control of air chambers simulating bi-directional haptic feedback) and modular hexagon shapes that can be plugged into one another using tube fittings to allow for the wearer's creative input.

DESIGN PROCESS

Menarche Bits is part of an ongoing research-through-design project in Stockholm, Sweden. The initial design phase, spanning one year, was collaborative within the research team and led by the first author. Our team is comprised of women (ages 26-37) from Asia, Europe, North and South America. Inspired by feminist HCI [4], a women's health agenda [1,3] and soma design [15], we have engaged our first-person experiences of menarche and the menstruating body, while acknowledging that these may not represent all people's experiences of menstruating [14]. We all have experienced menstruation, although not all of us were menstruating during the design process. We chose to attune our somas to our previous menarche experiences before involving people closer to menarche. This initial phase will be followed by design workshops with young adolescents who recently started to menstruate.

Soma Design

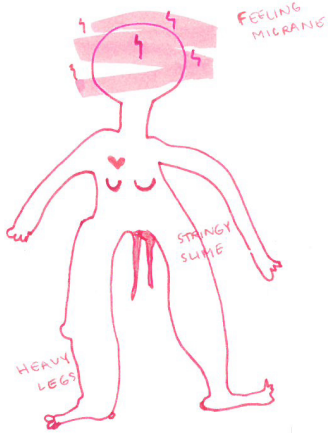
Soma design is a novel design approach that incorporates the body and movement in the design process [2,22]. Rooted in experiential, felt, and aesthetic experiences, soma design asks designers to engage with their own lived experiences and cultivate their "soma" (mind *and* body) to spur novel design ideas [15,16]. By engaging in body practices and moving in unfamiliar ways, designers are inspired to question their habitual movements and everyday life, finding grounds for constructing new meanings and movements [32]. We were inspired to draw on soma design because we wanted to go beyond words and the narratives that are told about menstruation, towards understanding and expressing which sensations, feelings and movements are experienced during menarche. Furthermore, we wished to take account of the full somaesthetic experience of menstruating, build an appreciation of menarche, and design for technologies that are close to the body.

A Somaesthetic Approach to Menarche

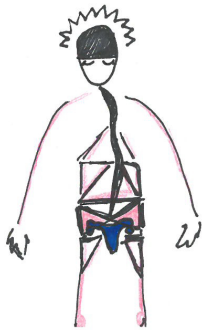
We expected that taking a somaesthetic approach to menarche could pose several challenges, as menarche is a sensitive topic that is uniquely experienced and it involves intimate areas of the body, which can make such a process uncomfortable or awkward and challenge social rules and personal limits. In addition, the lived experiences of menstruation can be repressed and habitual which can make them difficult to engage with. For these reasons, it became important to establish and nurture a safe, trustworthy and playful environment, and leverage defamiliarization methods to "make strange" [31] how we moved, felt and lived our menstruating bodies. Our design process was characterised by slow and deep engagements with the menstruating body and the materials that entangle the body with its surroundings. We were interested in exploring the (leaky) boundaries of the body and how the body's movements are always shaped by its sociocultural context. We "stayed with the trouble" [25] of the messiness and irregularity of the menstrual cycle and its painful and sometimes uncomfortable experiences, and we tried to nurture an appreciation [16] of it by working with experiential qualities of *trust* and *making space*. Since reflections through the design process were crucial for the final outcome of Menarche Bits, we articulate them in detail.

trust : having trust in the menstruating body and the knowledge that the body embodies and communicates.

making space : allowing people who menstruate to take physical space (be loud, be big, be bold, be seen, be heard); to make space for their menstruation to take space; to be a crucial bodily experience that (also) can shape how they live their everyday life.



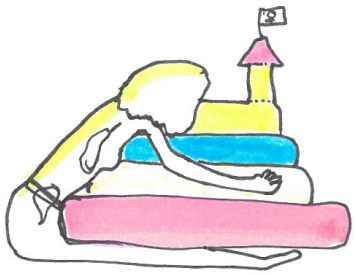
pull us into the pelvis

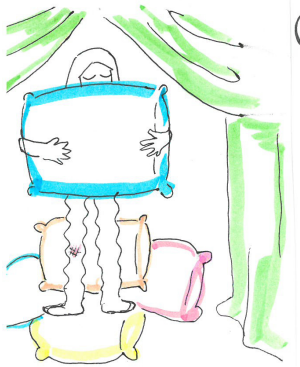


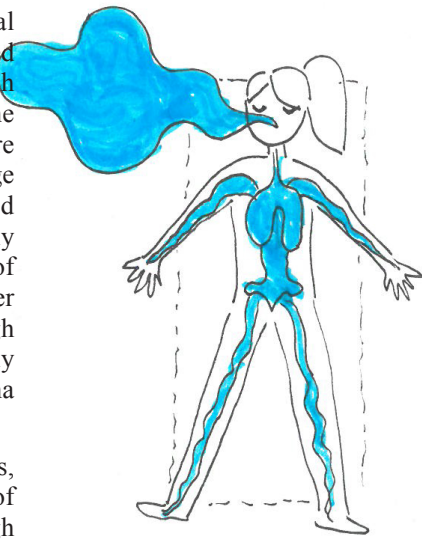
1. Engaging First-Person Experiences through Bodily Practices and Material Exploration

During two months we intensively explored bodily practices, movements and materials to bring us closer and "make strange" our experiences of menstrual cycles and menarche. We engaged in bodily practices such as yoga and Feldenkrais lessons centred around the pelvis (pelvic floor and hip bones), and tried breathing patterns that activated the diaphragm and pelvic floor. We used yoga mats, big pillows and comfortable stretchable clothes in these practices. We also drank different teas suggested for different phases in the cycle. We attended to our menstrual cycles to understand how these bodily practices varied throughout our monthly hormonal changes. After each session, we drew on two small pieces of paper; one image of our current bodies that we wanted to share with the group (as seen on this page), and one image we did not want to share, which was then crumpled and kept in a box. Simultaneously to the bodily practices, the first author explored the materiality of the menstruating body by collecting and looking at her menstrual blood, saliva and cervical mucus through a microscope. She kept a diary to record her daily reflections. Lastly, we also explored the toolkit Soma Bits [32].

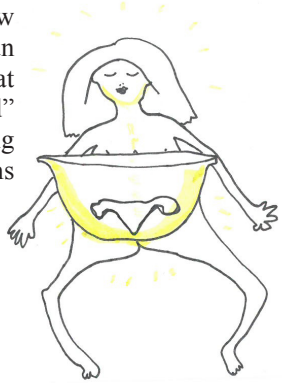
Through these first-person practices and explorations, we developed a deeper awareness and curiosity of menstrual cycles anchored in and expressed through our bodies. We developed a way of thinking about the menstruating body as something that spans between the materiality of the bodily fluids, the pelvic floor and pelvic area, and the whole soma. Through slow and calming bodily movements we explored how experiences of pain, stress, shame or uncertainty can be opened and transformed through movements that "pull us into the pelvis" and by "breathing in liquid" allowing the body to flow/become fluid. Our ongoing drawings of bodies represent different constructions of the menstruating body and our attunement to it.

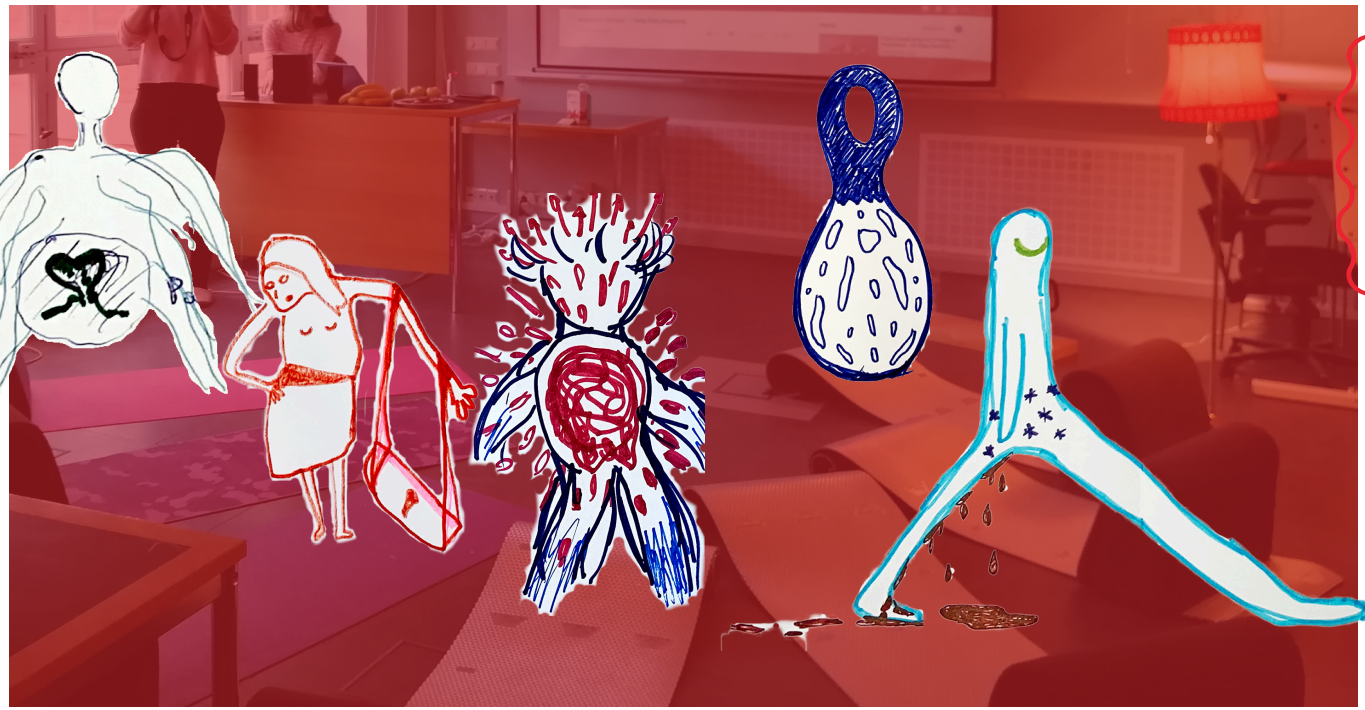




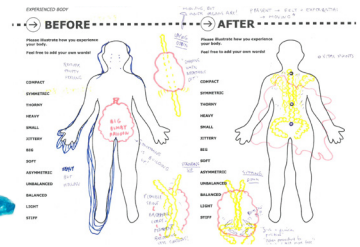


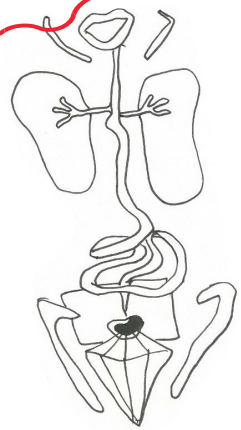
breathing in liquid





menstrual monster : a way to challenge menstrual normativity; challenge the "controlled" and universal body; accepting the messy; acknowledging the pain; a way to embody (or not) one's relation to their menstruation; an appropriation of the **body maps** used in soma design.





2. Expressing Menstrual Experiences

To broaden and challenge our first-person experiences of menarche and menstrual cycles, we organised two workshops. The purpose was to creatively engage with menstrual experiences through a participatory and movement-based process.

Workshop on Bodily Transitions of Menstruation

In the first workshop, we invited participants to accompany us in exploring bodily transitions of menstrual cycles and hormonal changes. The workshop involved the authors and four participants from our research group who all have first-person experiences with menstruation. We prepared the room with yoga mats, big pillows, warm light, cookies and tea. The three-hour workshop involved four main activities between which the participants shared their experiences. We started the workshop by serving raspberry leaf tea, which is said to work against menstrual cramps. Following this, the first author guided an inward-looking meditative exercise to evoke a menstrual memory. With this memory in mind, the participants were asked to draw their "menstrual monster" in a small personal booklet, and they were invited to share it with the group. Then, we engaged with more bodily movements to attune to our bodies and its inner memories and current experiences. Firstly, we did a breathing exercise, where by breathing deeply into the diaphragm it may be possible open a connection between pelvic floor muscles and lower stomach, back, chest, mouth and jaw; creating a whole-body energizing experience. This breathing exercise worked as a precursor to a Feldenkrais lesson "Pelvic-o-clock", which involves moving the pelvis around in small, detailed circular movements while laying on the back. After these bodily movements, we asked the participants to go back to their drawing of the menstrual monster, and draw how the monster develops through time. We concluded the workshop by asking the participants to share their drawings and their experiences with the bodily movements.

Throughout the workshop, the participants opened up about their very first experiences of menstruation, experiences of changing contraceptives, and experiences of menopause, with their menstrual monsters as the starting point for telling these stories. We found that it was crucial to take time for each individual's story, and that it worked well to shift between bodily movement, individual drawing and conversations. The participants appreciated the comfortable and cosy space that we had prepared, and noticed the tension between exploring longer life cycles and shorter menstrual cycles. One participant expressed that designing with menarche also means designing for discomfort and pain.

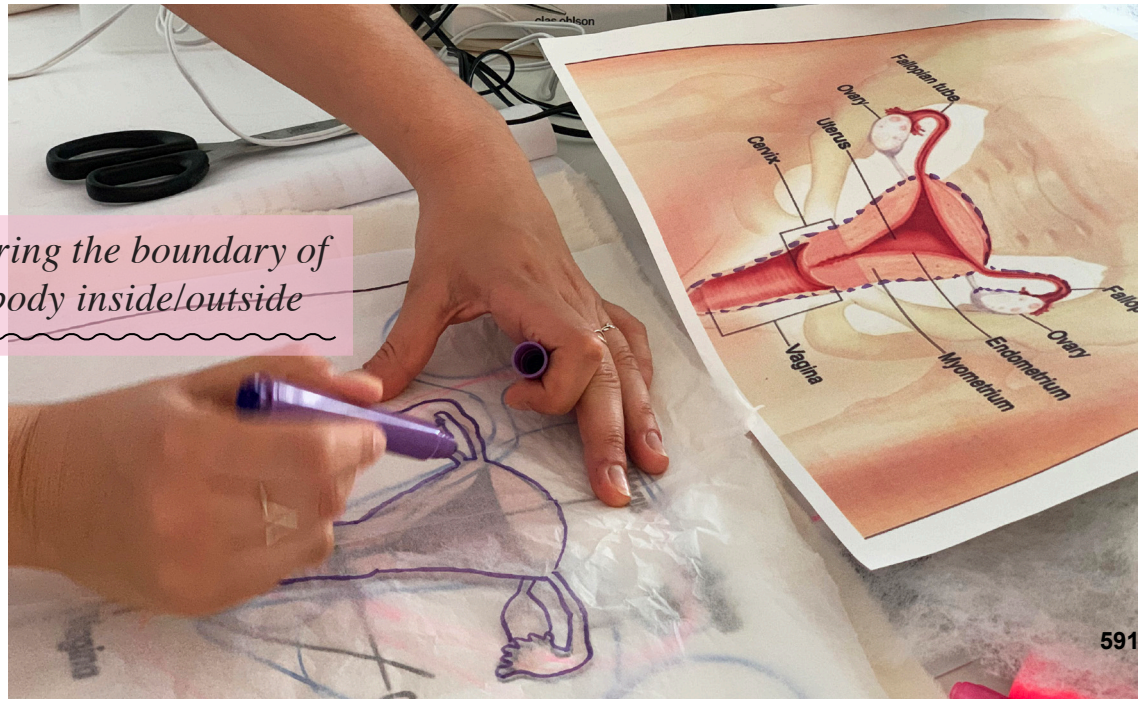
Workshop with Soma Connaisseuse

In the second workshop, we invited a fertility awareness educator (a "soma connaisseuse" [22]), who is also an experienced contact improvisation coach, to give a body-based lesson for our research team on bodily movements that she related to menstruation. In a two-hour session, the soma connaisseuse led the research team through what she describes as an "initiation ritual" where we traveled from menarche to menopause. The movements involved slowly opening up and relaxing the body while lying and sitting on the floor, and bringing attention and awareness to the pelvis and pelvic floor. We practiced different breathing patterns, and breathing in synchronicity with relaxing the pelvic floor. While slowly standing up, we shaked to release tensions in the body. Lastly, we were led through three stages of a life cycle (menarche, fertile years, menopause). For each, we were invited to "meet ourselves" in a specific time of our lives and move to music with eyes closed, in any way that felt comfortable to us depending on what we wanted to express to ourselves.

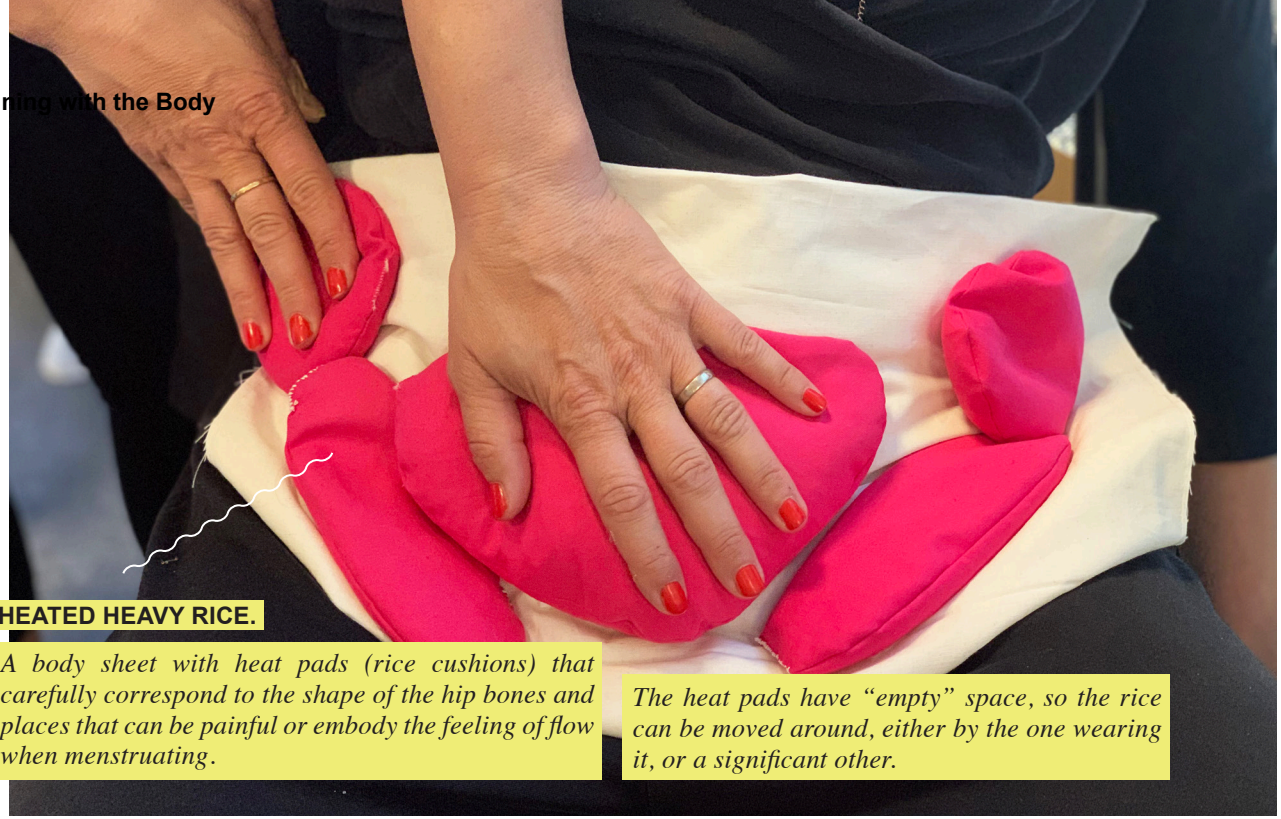
The soma connaisseuse emphasized that knowledge of the body is created through movement. The movements we engaged with during the workshop expressed experiential qualities of *trust* and *taking space*. Embodying the soma connaisseuse's mantra of "cyclical beings in cyclical worlds" asked us to disregard the focus on productivity that is often part of Western societies, and just be present in the movements and in our bodies. The movements facilitated a dialogue between listening to the body, trusting what it tells, and using movement to express what one wants to become. This inspired us to continue designing in line with soma design, focusing on the concepts of trust and making space, with the aim of giving body literacy through deeply engaging with the body.

UTERUS

body literacy through movement



blurring the boundary of the body inside/outside



HEATED HEAVY RICE.

A body sheet with heat pads (rice cushions) that carefully correspond to the shape of the hip bones and places that can be painful or embody the feeling of flow when menstruating.

The heat pads have "empty" space, so the rice can be moved around, either by the one wearing it, or a significant other.

TILTING PELVIS.

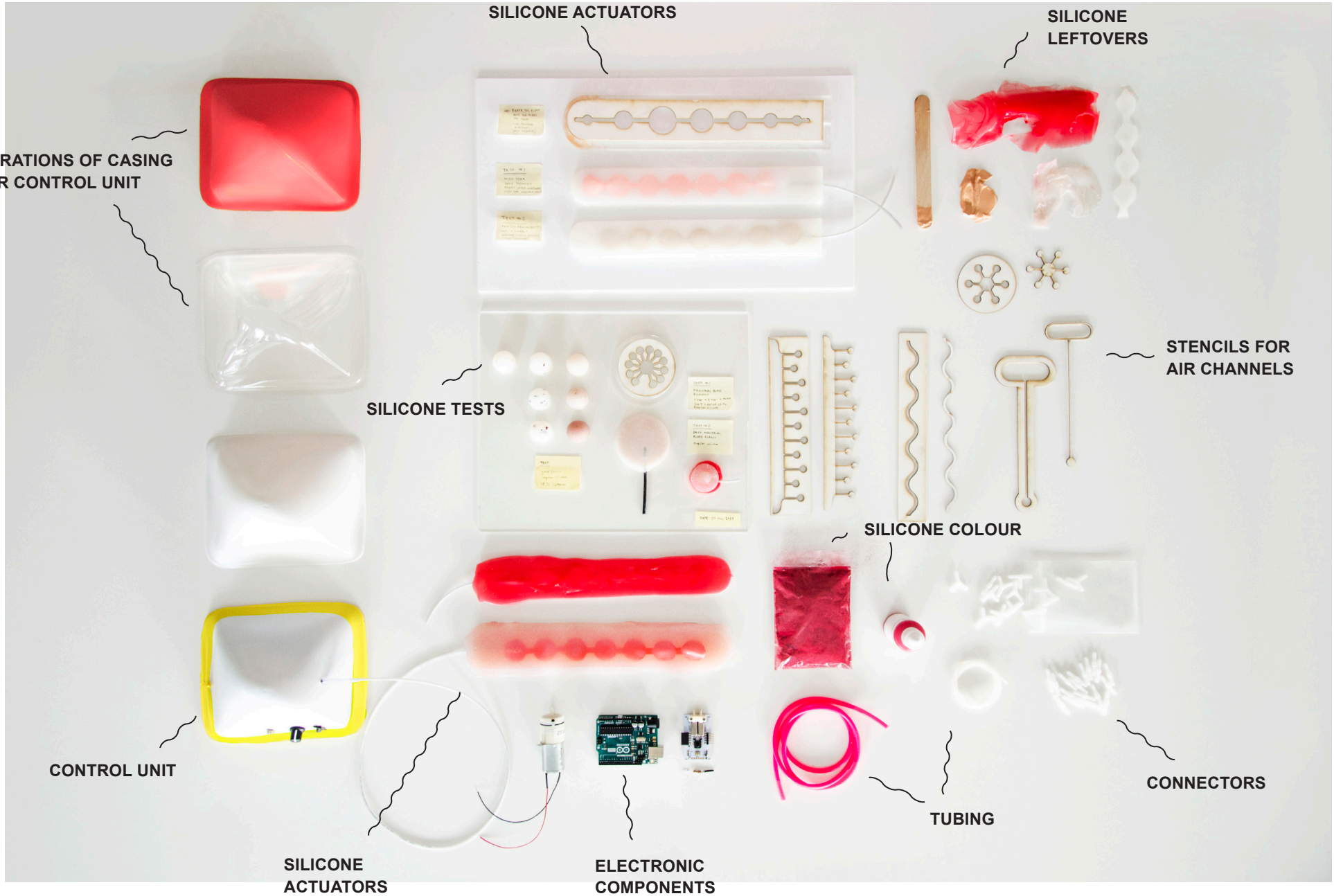
A soft, flat surface, which is placed under the back while laying down, affording circular movements in the pelvis.

Imagine a future scenario where the person experiencing their first bleedings lives with objects that inspire bodily movements that allow them to develop knowledge, meaning and appreciation of their changing body.

3. Prototyping New Menarche Movements

Through a three-day design workshop, using soma design methods [15] and embodied design ideation [31] to design for the broader topic of somatic transitions, we explored and built artefacts and interactions that address the unique experiences of menarche. A Feldenkrais lesson sensitised us to the touching of hip bones and the lower back area, which in line with previous design insights, inspired us to design two design concepts.

Designing these concepts made us see an opportunity to work with weight- and shape-changing materials in the application area of menarche, since these materials can inspire movements, stimuli and massage, and allow new behaviour to emerge. We realized how important it is to ground the design concepts in the bodily practices and their qualities in ways that make the interactions we build make sense as we move. The materials we use in this process are crucial, as how we move and (come to) understand our bodies are intimately shaped by and shaping the materials surrounding us [10].


ITERATIONS OF SILICONE ACTUATORS
SILICONE LEFTOVERS
ITERATIONS OF CASING FOR CONTROL UNIT
SILICONE TESTS
STENCILS FOR AIR CHANNELS
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CONNECTORS
TUBING
SILICONE ACTUATORS
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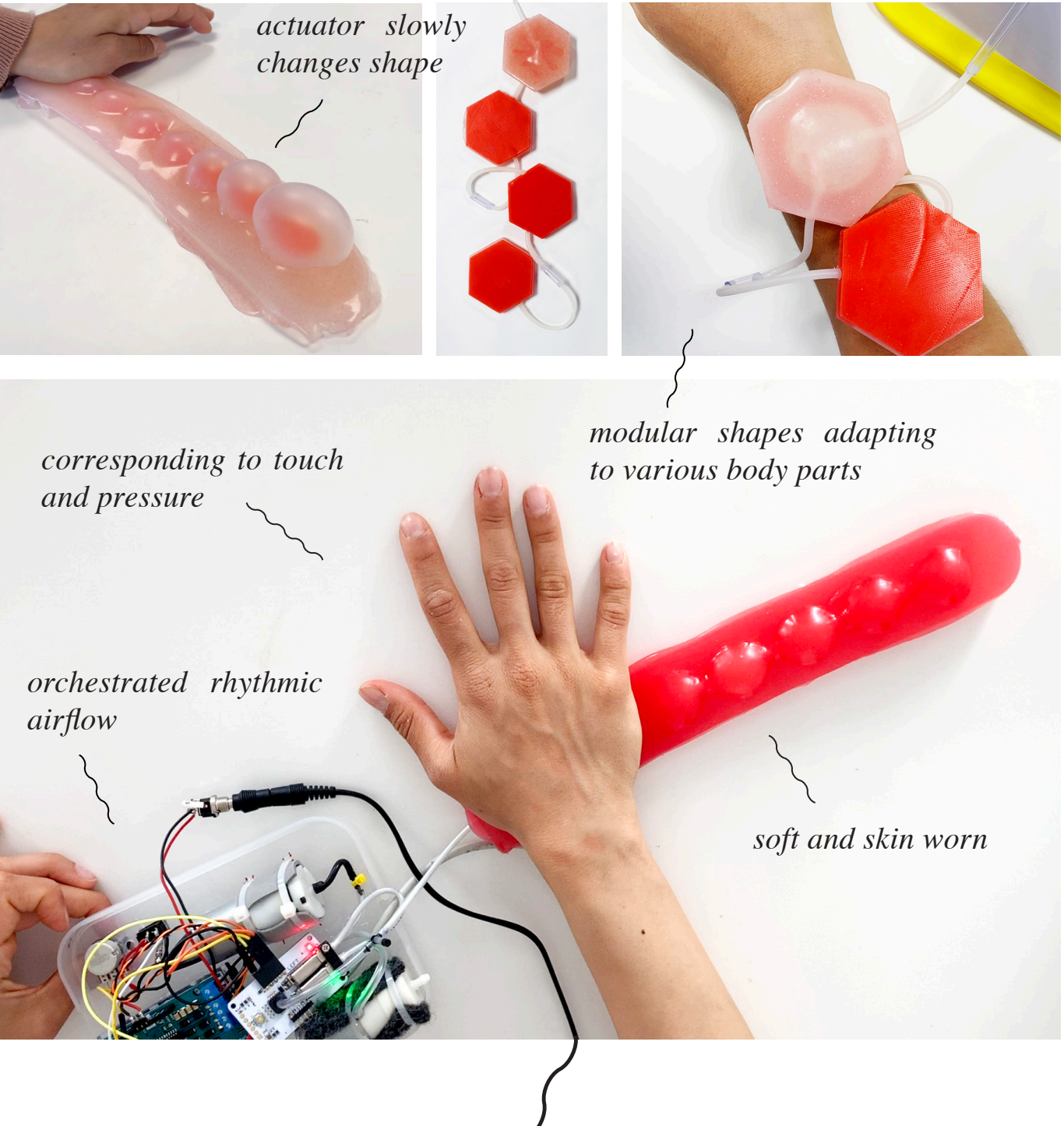


DESIGNING MENARCHE BITS

Through first-person engagement with our menstruating bodies, we elicited movement qualities that informed our hands-on design process. **Fluidity** was an overarching theme both in the exercises that guided us, e.g. yoga, Feldenkrais, breathing, but also in the body's materiality and longer-term somatic transitions. Another evocative and inspiring movement quality was the **cyclical** patterns of the pelvic floor exercises, which also came through as a temporal quality while sharing our experiences of changes in our cycles throughout life. We came to understand better that cyclical behaviours are so abundant in human experience yet so unique to each individual. These qualities guided the process of forming Menarche Bits' shape, movement and integrated design.

In the first prototypes, we mainly focused on harmonizing human-material interactions. We explored low-cost materials that are safe and compliant to use for on-body applications. Compliancy was an important material quality to allow for the **fluidity** of the body's movement. Inspired by the ongoing research in shape-changing interfaces [21] and soft robotics [6,7], we built a set of soft pneumatic actuators made of silicone with multiple degrees of freedom in movement; expansion, bending and wrapping around by twisting.

Based on our initial explorations with the soft silicone actuators, we iterated on our design to be appropriated to different parts of the body. Actuators with larger inflation areas were intended for less sensitive areas of the body such as the pelvis, which require larger forces "to be moved". More sensitive parts could be sensitized with smaller inflatable parts to orchestrate a **cyclical** movement of point-like tactile sensations. We explored pressure-sensing to provide direct feedback when pressing the actuators with our bodies. The immediate inflation response inspired a strong **connection** with the material. We noted down these qualities as requirements for our design iterations.

The next prototypes were built more elaborate in shape and compliancy with the skin, and with embedded sensing capability. We used input signals coming from

the body (such as touch or diaphragm breathing) to adapt the shape and movement of the bits, in order to keep the tight feedback loop between action and response (by both the body and the material). We found the immediate feedback from the actuator to express an intimate relation with the material; one that follows and encourages subtle bodily movements, forming a deeper engagement between the soft robotic material and the body, so that the interface nearly becomes perceived as an extension of the body.

Fabrication Process

The fabrication process of Menarche Bits can be divided into the following four steps:

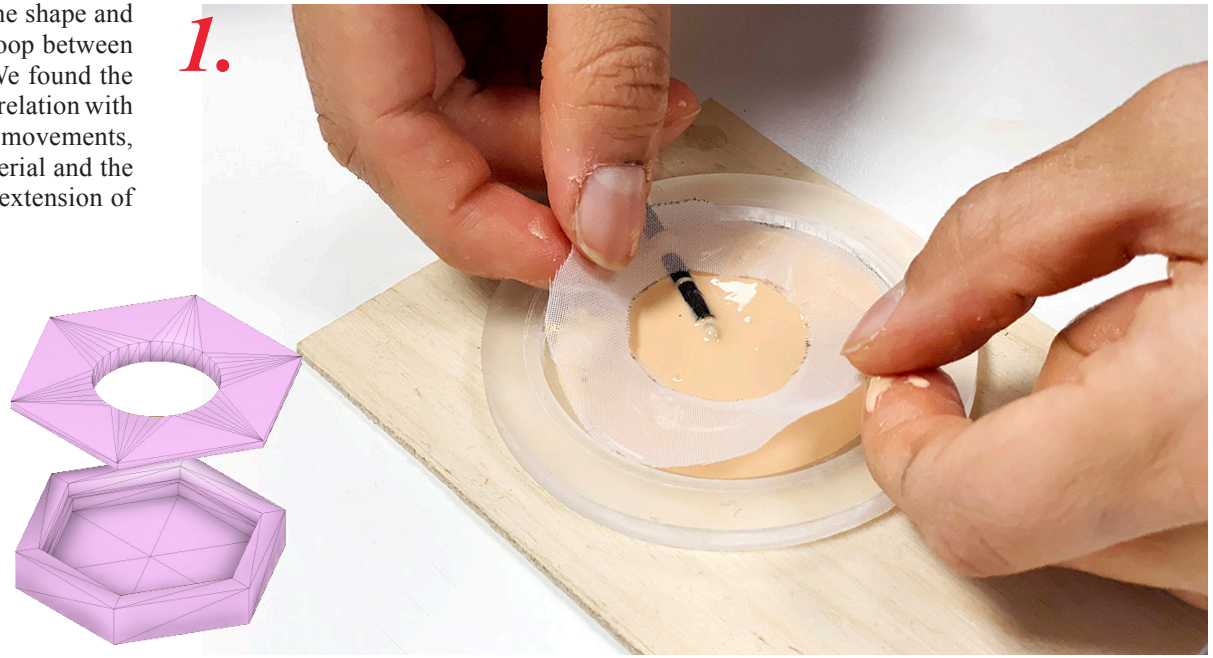
1. Molds and Stencils

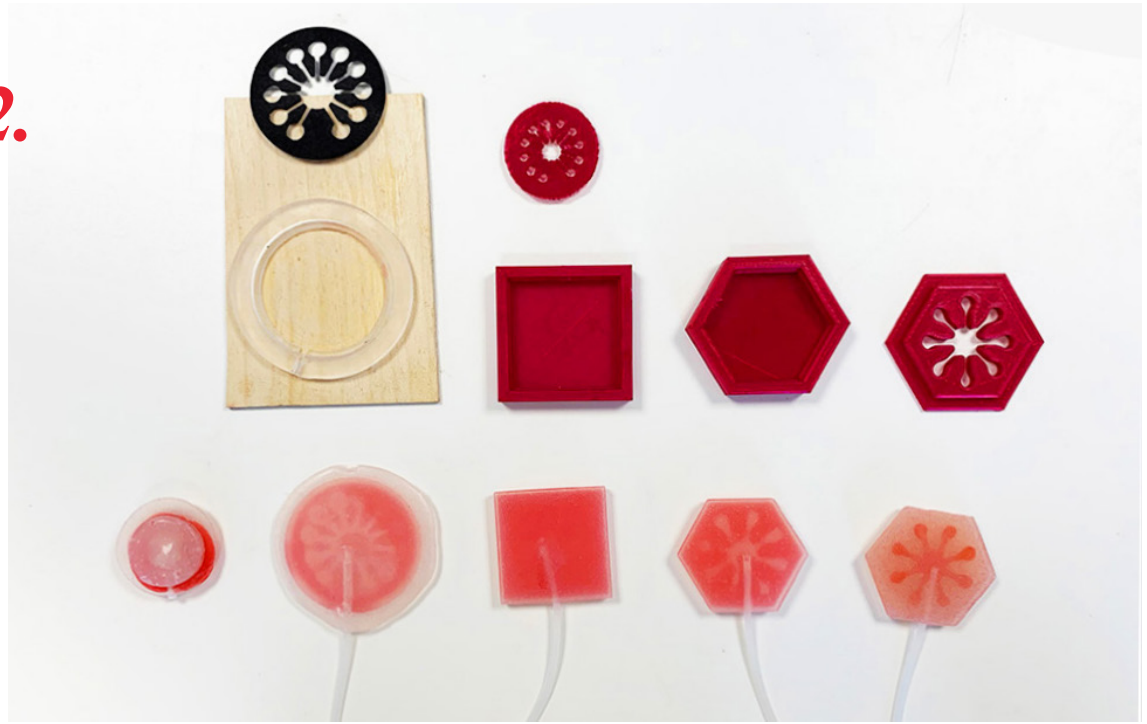
We used AutoCAD to design the initial laser-cut patterns of the molds and stencils, in order to then fabricate the silicone actuator. The thickness of the actuator was supposed to be a minimum of 4mm due to the thickness of the plastic tubing material that would allow us to minimize resistance and power consumption. For fluid channels, the minimum width was to be no smaller than 2 mm, or the air might not be able to pass through. Once the sizes were optimized, we designed 3D molds and stencils for our actuators in Rhinoceros for 3D printing.

2. Silicone Actuator

Our criteria for the choice of materials and rapid fabrication methods were cost, accessibility, and scalability of the processes. The material we used as the substrate is a versatile platinum-catalyzed silicone (Smooth-On Ecoflex 00-30) which is used in many soft robotics applications and allows us to follow existing protocols for mixing and molding.

In order to achieve different form factors, we laser cut a number of stencil patterns to be used as patterns of the "actuated forms". After curing the first layer of the silicone in the mold, we placed the stencils on its surface to apply the release agent on the cut-pattern area that we would like to not adhere to the base layer and create the inflated pattern. Once our designs were precise enough, we modelled and printed the molds with their stencil parts for rapid production of the bits.

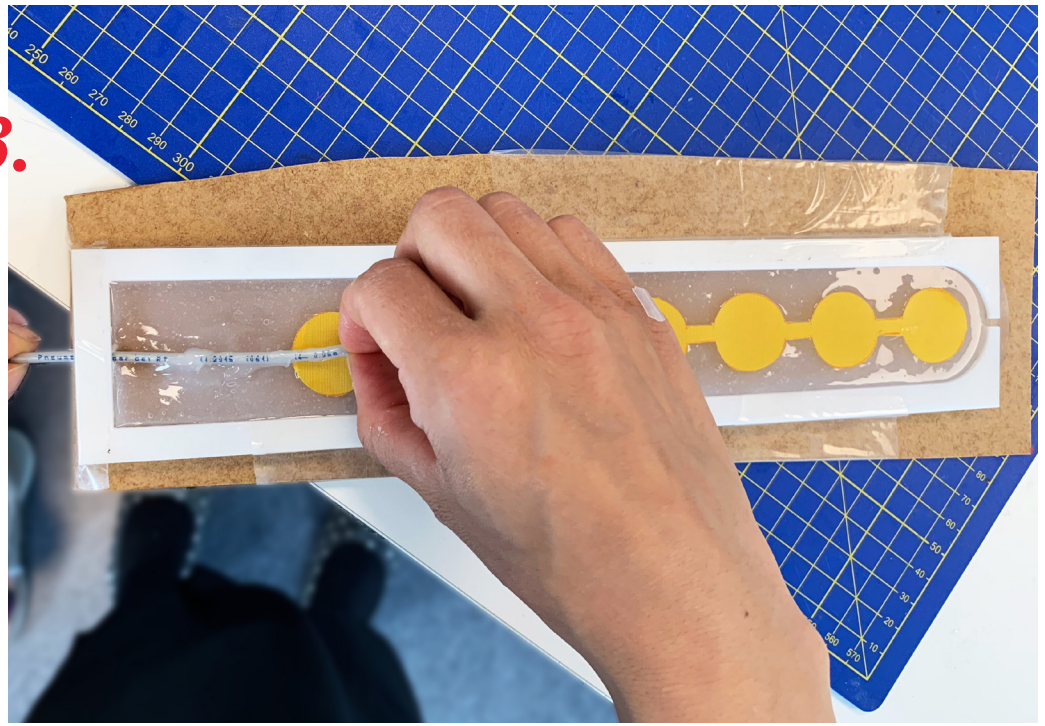




3. Tubing and Connections

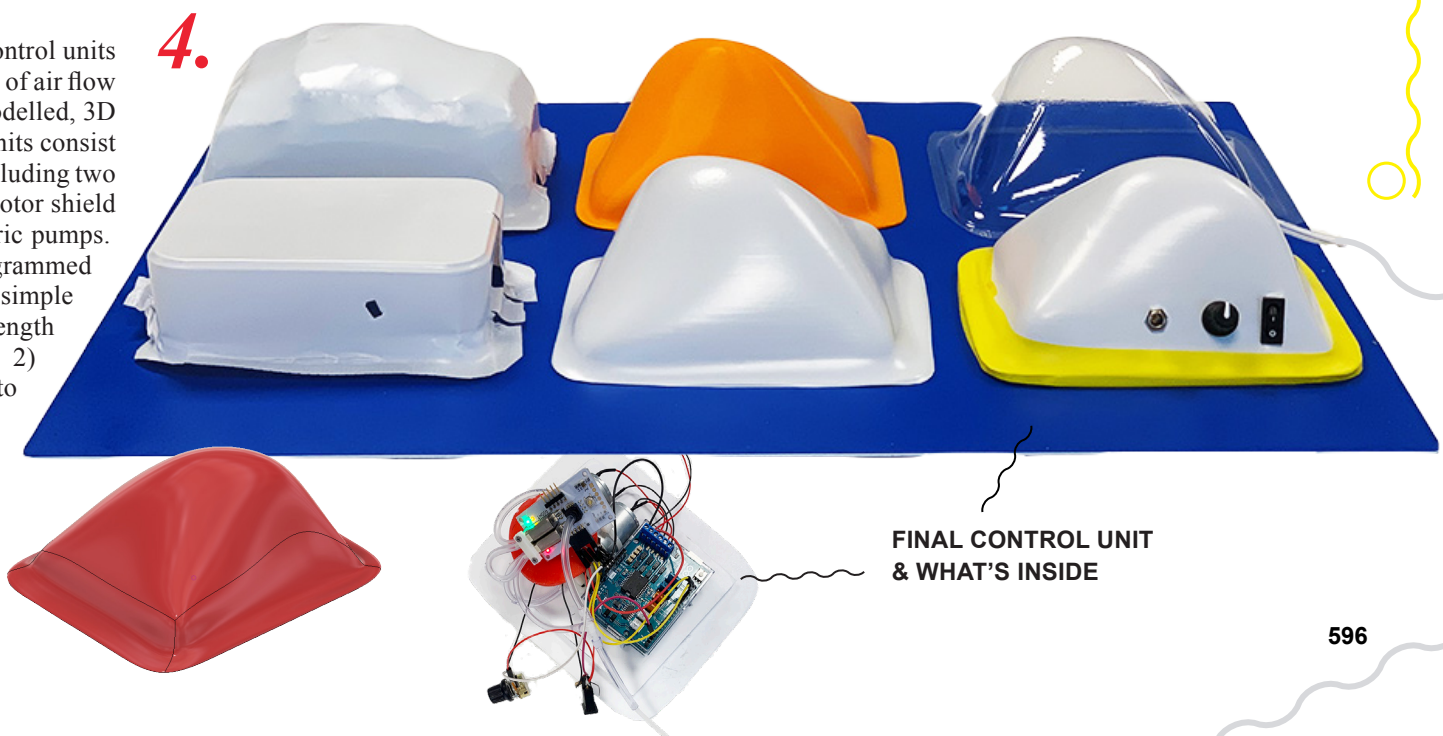
For the bits with pre-designed movement patterns, the tubings were inserted before pouring the top and final layer of the structure. To avoid blockage by liquid silicone in the tubing, we inserted a wax-coated metal wire along the tubing towards the center of the shape and removed once the layer was cured. We used plastic barbed connectors for a robust connection between the silicone body’s tubing and that of the electric pump.

For the modular bits, we designed a spiralling inner channel to lay and fit the tubing in. This decision was mainly to avoid any potential risk of tubing removal from the silicone actuator during plug-in and -out. We used I, T and Y shaped non-barbed connectors with various sizes of tubing to broaden the variety of orchestrated actuations.



4. Control Unit

We designed, built and programmed two control units which orchestrate the inflation and deflation of air flow in the silicone actuators. The shape was modelled, 3D printed, and vacuum formed. The control units consist of an Arduino Uno, a Pneuduino module including two valves and a pressure sensor, an Arduino motor shield that controls the power and two 12V electric pumps. Each control unit runs a different pre-programmed interactive behaviour, 1) one unit drives a simple interaction where one can adjust the length of inflation/deflation on a potentiometer, 2) another unit utilizes the pressure sensor to adjust the inflation/deflation based on the applied pressure on the silicone body.



TOWARDS DESIGNING SHAPE-CHANGING TECHNOLOGIES FOR MENARCHE

Menarche Bits explore the novel opportunity of bringing shape-changing technologies into close contact with the (hormonal) changing body. We found shape-changing technologies to be a curious and evocative material in connection with the menstruating body, due to their ability to continuously change form, state and behaviour [21]. As we began to reflect on where to put them on the body, how strong and fast inflation we would like, and how we would like them to interact with the body, we started to make sense of our bodies in new ways. Through touching [8,23] and breathing [2,24] with the rhythms of the silicone bits, we experienced an intimate and organic contact that continuously suggested and supported new movements and meanings. These qualities of the interactions connect with our intentions of making space for menarche experiences and trusting the body and the uncertainty implied in its changes. Menarche Bits, then, constitute a collection of shape-changing technologies that open a design space and are open for interpretation, while embodying a somaesthetic way of thinking about values and experiences of menarche.

1. Designing for Movement through Actuation

Massive amounts of data about the menstrual cycle are currently being produced through manual tracking and sensing [9,13]. As a counternarrative to the data-driven construction of the menstruating body, we propose that actuation can make a person attend to specific internally felt experiences of their menstruating body, creating body literacy through movement.

In Menarche Bits, we used shape-changing technologies to motivate body movement: We aimed to go beyond and challenge the restrictive and constrained

movements that a person might experience when starting to menstruate. Movements such as how one sits on a chair, lie in bed or hold their lower back when having menstrual cramps, how one restrains their movements when doing sports in fear of leakage, or how one hides their menstrual products in their sleeves when walking.

2. Changing Shape with the Changing Body

Menarche marks the beginning of changes to the body in relation to menstruation and hormones; changes throughout the menstrual cycle, changes from cycle to cycle, changes in cycles if one gets pregnant, or when one starts experiencing signs of menopause. Menarche Bits take advantage of how shape-changing technologies have temporal forms [30], and aim to incorporate this quality to adapt to these body changes. Menarche Bits, thus, speculate on using shape-changing to facilitate noticing, appreciating, and staying with body changes. In order to design with the temporality of the changing body, we must aim for slow and long-term interactions [11,20]. Besides designing for short time frames and fixed interactions that can be experienced over and over again, we could take advantage of the conformity and transformability [17] of shape-changing technologies and design for interactions that slowly evolve and change in time; throughout monthly cycles and years.

3. Corresponding to the Materiality of the Body

Menarche Bits use shape-changing technologies to sensitize the wearer of the materiality of the menstruating body. By adhering to the skin or being inserted into stretchable pockets as part of a garment, Menarche Bits come close to the membrane of the body, that is the skin. Menarche Bits bring attention to a specific area of the body, such as the pelvic area or lower back. Through rhythmic patterns of airflow, Menarche Bits extend this attention to experiences that feel like passing through to the inside of the body. It is our intention that Menarche Bits can inspire shape-changing technologies that sensitise the wearer's body to internally felt experiences of change happening inside the body, such as feelings of menstrual cramps, throbbing pains, or physical experiences of anxiety during PMS (premenstrual syndrome). In such way, shape-changing technologies could more intimately correspond to not only the membrane but also the inner materiality of the body.

As Menarche Bits open up for such possible interactions, we can speculate on how such correspondence could be achieved, including the use of bodily fluids (the body's biological material) [8,12], as input or trigger for interaction. We could, for instance, speculate on using hormone tracking via wearable microfluidic devices to inform and activate specific movement patterns; or using menstrual blood that the body naturally flushes out to actuate the system. Such prototypes would be energy efficient, as they would operate without electrical power and instead use a natural input from the body.

LIMITATIONS AND FUTURE WORK

Menarche Bits are part of an ongoing research project exploring young adolescents' experiences of menarche in sports. Future work involves organising workshops with young athletes who recently started to menstruate. In the workshops, we will use Menarche Bits to explore and express their specific experiences of menarche in sports contexts and build concepts of body-worn technologies that engage these experiences.

We are currently developing the material qualities of Menarche Bits, building on the PDMS-based fluidic actuators in milli-scale and the possibility of utilizing the natural flow of menstrual blood to activate them. Adding sensing ability to the actuators is crucial for interactivity, so we are considering to couple them with on-skin or textile-integrated flexible microfluidic chips to track and inform the menstruator of hormonal changes via haptic feedback.

While the fabrication approaches introduced in this pictorial are cheap and accessible with off-the-shelf material, it remains a challenge to fabricate actuators that are wearable directly on the skin with adherence and compliance from the silicone we used. Therefore, an iteration that uses flat sheets of PDMS to build thinner and skin-grade flat actuators seems promising. One limitation of working with pre-cured PDMS sheets is the lack of self-adherence which necessitates an extra step of surface treatment and use of expensive equipment (e.g. oxygen plasma) to achieve accurate, robust designs.

With our findings from the workshops with young athletes and our continuous material research, we will develop Menarche Bits into tailored and robust body-worn shape-changing technologies. These prototypes will be deployed in a long-term study with the same participants from the workshops to explore how the participants will use them as part of their everyday life and sports practice.

CONCLUSION

Menarche Bits contribute to designing with intimate materials and movements of the menstruating body. We call for the DIS community to nurture bodily intimacy in sensitive and taboo topics; to stay with the materiality and fluidity of our bodies, in order to make space and create new movements for being human in times of change.

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