

Design of a Swimming Rescue System for People with Chronic Diseases in the Event of Acute Loss of Consciousness

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***Design of a Swimming Rescue System
for People with Chronic Diseases
in the Event of Acute Loss of Consciousness***

***Entwurf eines Rettungssystems beim Schwimmen
für Menschen mit chronischer Erkrankung
bei akutem Bewusstseinsverlust***



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Design of a Swimming Rescue System for People with Chronic Diseases in the Event of Acute Loss of Consciousness

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Abstract

English Version

People living with epilepsy, heart disease or diabetes mellitus are not only facing limitations in their everyday lives, but also a higher risk of mortality due to their condition. In addition to falling due to spontaneous loss of consciousness caused by chronic diseases, drowning is the most common cause of death for this group of people. This project aims to create a participatory design for swimwear that triggers a rescue system in the event of a medical emergency to prevent the person from drowning. In addition, outsiders should be alerted to the emergency situation via a smartwatch application and guided through the appropriate rescue procedure with the help of instructions.

Deutsche Version

Menschen, die mit Epilepsie, Herzerkrankungen oder Diabetes mellitus leben, haben neben den Einschränkungen im Alltag ein höheres Sterberisiko durch ihre Erkrankung. Neben Stürzen durch eine spontane Bewusstlosigkeit ausgelöst durch die chronische Erkrankung, zählt Ertrinken als die häufigste Todesursache für die genannte Personengruppe. Mit dieser Arbeit soll ein partizipatives Design für eine Schwimmbekleidung gestaltet werden, die im Falle eines medizinischen Notfalls ein Rettungssystem auslöst, das die Person vor dem Ertrinken bewahren soll. Darüber hinaus sollen Außenstehende durch eine Smartwatch-Anwendung auf die Notsituation hingewiesen und mit Hilfe von Anweisungen durch das weitere sachgemäße Rettungsvorgehen geleitet werden.

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TRIGGER WARNING



This thesis explains and shows information and visual representations of medical emergencies, especially about drowning persons, people with epileptic seizures, heart attacks or glycaemic shocks.

If you are sensible about any of these topics, please skip the first two chapters ("Motivation" and "Medical Research").

1. Motivation

People with chronic diseases are restricted in their everyday lives – often in situations that appear harmless to outsiders. Alongside falls, drowning is one of the most common causes of sudden death, at least among people with epilepsy [MBS+19]. People living with other chronic diseases, such as heart diseases or diabetes mellitus, are also exposed to this constant danger. Swimming, competitive sports, water polo, aqua fitness, canoeing, or simply taking a bath are particularly risky and cause uncertainty for the person affected and any relatives. Furthermore, rescuing someone from the water is made significantly more difficult, especially in the case of people with tonic-clonic epilepsy, due to the immense tension in their muscles, which also puts the rescuer at risk.

The aim of this thesis is to find a potential product solution dealing with this issue. More specifically, the main goals of this work are to

- improve the safety-feeling of people affected by a chronic disease in activities involving swimming (e.g. visiting a public pool),
- simplifying the rescue manoever of the life guard or other observers while simultaneously enhancing their own safety and
- to bring more awareness to the entire topic of chronic diseases and restrictions, enabeling a better life quality of affected people.

After a medical and technical research concerning existing solutions, the target group and the concrete task will be defined. This includes focussing on special groups of chronic diseases to be covered in this work. The main part of this thesis will then be the development of a self-designed product solution. Finally, the aforementioned solution will be evaluated with the defined target group using a survey.



Fig. 1: Person having an epileptic seizure.



Fig. 2: Drowned person.

2. Medical Research

There are various types of chronic diseases. This huge variety makes it hard to cover all possible diseases with just one product solution. Therefore, this work focusses on three types of diseases which are relatively common: Epilepsy, heart diseases and diabetes mellitus. In particular, all these diseases cause fainting.

2.1 Epilepsy

Epilepsy is a neurological disease of the brain, which causes seizures. Each individual who lives with epilepsy has a very unique form of it, depending on which part of the brain is affected. Moreover, it can be said that there are three different groups of forms of epilepsy: Focal aware seizures (FAS), Focal Impaired Awareness Seizures (FIAS) and bilateral tonic-clonic seizures (BTCS) [TSG+21]. FAS and FIAS only affect a specific part of the brain, while BTCS affects the whole brain [GG88]. While persons with FAS still have consciousness during a seizure, persons with FIAS or BTSC may lose their consciousness. Additionally, persons with BTCS also may have muscle contractions. Especially, the last group has a chance of receiving a status epilepticus. The latter is an epileptical seizure involving muscle spasms lasting for at least five minutes together with unconsciousness with the risk of permanent brain damage [TSG+21].

One of the key problems of living with epilepsy is to properly forecast a seizure. It is already known that some dogs are able to detect seizures a couple of minutes before they actually happen, probably by detecting a lower blood oxygen level [@DL25]. However, the precise mechanism remains unknown.

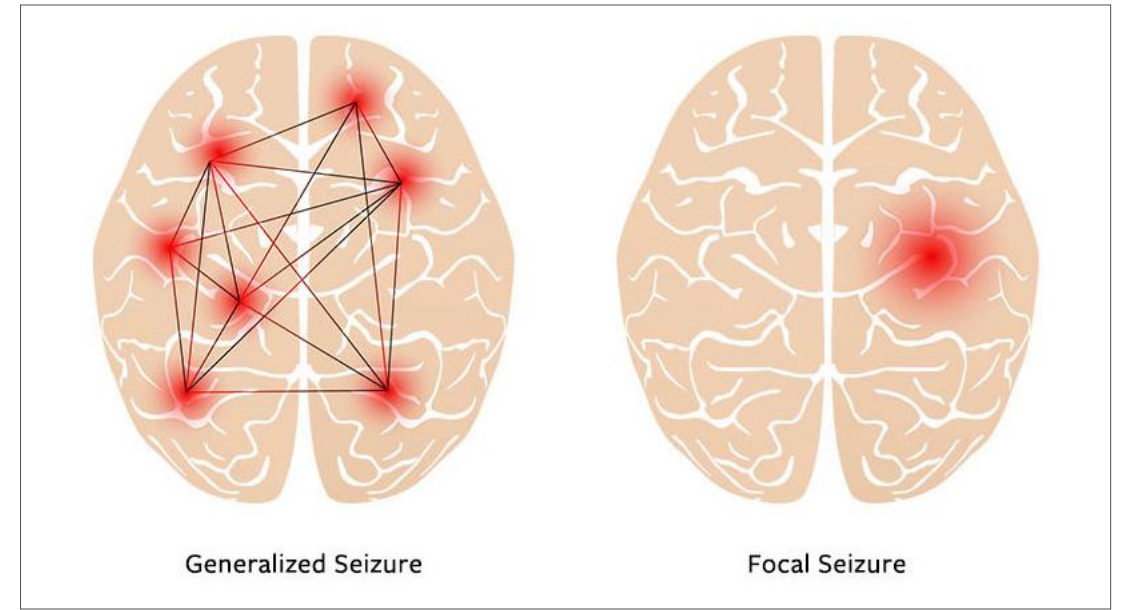


Fig. 3: Areas affected by the different types of epilepsy.

[@DL25]. Additionally, dogs can't be trained to detect seizures: those dogs who can already have this skill when they are born [@DL25]. Also, not many dogs have this skill, moreover, dogs cannot assist people while swimming, and some people are allergic to dog hair.

Studies have shown that epileptic seizures can also be predicted using the wrist-worn device Embrace. This device tracks the movement of the owner using an accelerometer, as well as the electrodermal activity. During their study, a sensitivity of about 97 % and a false alarm rate of only 0.4 % could be achieved [OCG+18].

Other studies have shown that tracking the heart rate and the blood-oxygen level can help to enhance a precise seizure detection [CBN+16].



Fig. 4: Epilepsy can be detected by an electroencephalogram (EEG).



Fig. 5: Garmin Vivosmart fitness tracker.

However, for this detection to work, a sufficiently large set of data is required and the device has to be adjusted individually. This has especially been confirmed by measurements using long-time EEG [CMG11]. In their study, the authors concluded that it is not possible to have a precise seizure detection without using any individual health data.

There was especially a study about seizure detection with commercial smartwatches using the model Garmin Vivosmart 4 [TSG+21]. A person with FAS, having sometimes no seizures at all, sometimes multiple ones per week, wore this smartwatch model, which was able to detect the blood-oxygen level, heart rate and movement. In addition, they compared their results with those of a person without epilepsy as a control subject. The study has shown that the smart watch was able to detect a lower blood-oxygen level, as well as a spontaneously higher heart rate, caused by the epileptic seizures. The authors themselves did however point out, that there is need to conduct more studies about how precisely commercial smart watches can detect epileptic seizures, regarding that their study involved only one patient and one control subject [TSG+21].

Overall, it has been shown, that epileptic seizures are detectable through a lower blood-oxygen level, a different motion detected by an accelerometer and a rapidly increasing heart rate. All these parameters can be detected by modern smart watches like Apple watch [App25a] [App25b] [App24]. It would also be possible to use a more precise seizure detection like Embrace, but the focus of this work will be set on commercial smart watches. An additional tracking of the stress level could also help to set an alert to the wearing person, because stress can cause seizures as well [TSG+21].

2.2 Heart Diseases

The cardiovascular system is a complex and one of the most important organs for the vital functions of the human body. It consists of the heart and the blood vessels [LBJ25]. There are four main groups of heart diseases [LBJ25] [@Lor24]:

Coronary artery disease (CAD)

- blockage or narrowing in the coronary arteries (the arteries which transport the oxygen-rich blood through the body)
- lack of oxygen-rich blood in the heart muscles, causing chest pain
- dying of heart-muscle tissues caused by low blood flow
- inability of the heart to pump enough blood through the human body, leading to heart attacks

Cerebrovascular disease (CVD)

- affects the flow of the blood to the brain
- can cause strokes or the prestep, a so called ischemic attack

Peripheral artery disease (PAD)

- blockage or narrowing in the peripheral arteries
- arterial disease of the limbs
- can cause muscle pain, especially claudication

Aortic atherosclerosis

- blockage or narrowing in the aorta
- can cause chest and abdomen aneurysms



Fig. 6: Heart attacks can be caused by heart diseases.

CAD and CVD have a higher chance of heart attacks and/or strokes, which can be a severe risk for a person to go swimming alone.

Smartwatches are able to track the heart rate [@App24]. There has been a study confirming that smartwatches are also able to detect a cardiac arrhythmia (an uneven rate of the heart) [NLD+21]. The latter can cause heart attacks, as well as strokes [NLD+21]. Due to its episodic nature, it is not easy to track with short-time ECG [NLD+21]. One key result of the aforementioned study was that smart watches can detect cardiac arrhythmia with a substantially higher accuracy because of the long-term supervision of the heart rate [NLD+21].

2.3 Diabetes mellitus

Diabetes mellitus is one of the most common chronic diseases worldwide [SSK+21]. It is a glucose-intolerance disease first classified as different types in the 1980s [AZ98]. A distinction is made between IDDM (insulin-dependent diabetes mellitus) [@N89] alias type 1, and NIDDM (noninsulin-dependent diabetes mellitus) [@N89], also known as type 2 [AZ98]. Additionally to the two commonly known types of diabetes, a third type was clarified, named MRDM (malnutrition-related diabetes mellitus). All of the above should be differed from IGT (impaired glucose intolerance), as well as GDM (gestational diabetes mellitus) as a cause of pregnancy [AZ98]. The latter will not be treated within this thesis.

IDDM is caused by an autoimmune disease, leading to a beta-cell destruction which normally ends in a low or high insulin deficiency [AZ98]. By contrast, NIDDM as well as MRDM are often caused if nutrition is too high or too low, respectively [AZ98] [@N89].

While IGT often develops prior to diabetes mellitus type 2 [RDM04], GDM is merely a temporary type of diabetes while having a change in metabolism during pregnancy.

Diabetes is typically diagnosed by analysing the blood-sugar value: if the person often has hyperglycaemia (increased blood-sugar value) or hypoglycaemia (decreased blood-sugar value), it can easily be tracked by finger picking or wearing a CGMS (continuous glucose monitoring system) [MMB+25].

Studies have shown that hyperglycaemia and hypoglycaemia influence the heart rate, detectable by an electrocardiogram (ECG) [OKD+19].



Fig. 7: Insulin pumps are tracking the blood-sugar level and regulating the insulin value.

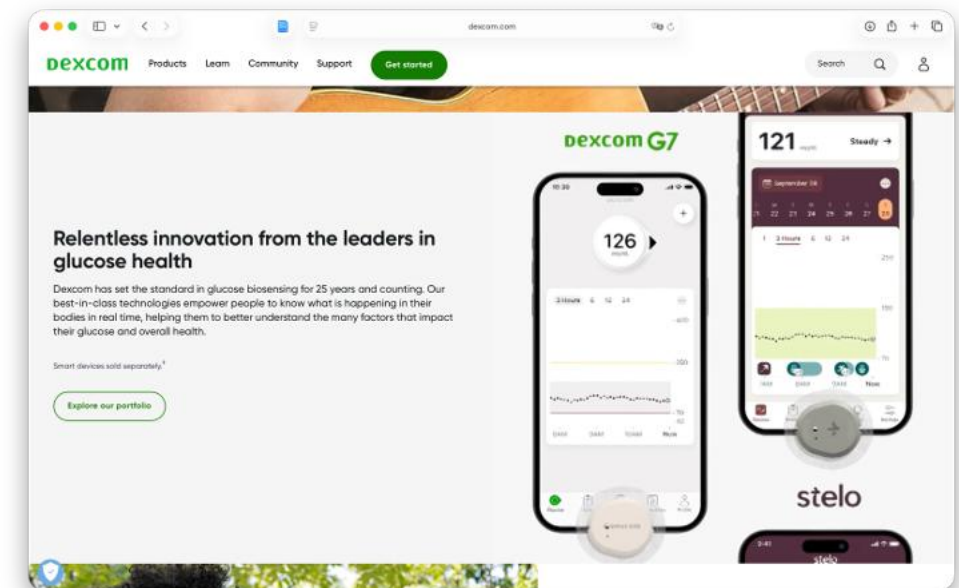


Fig. 8: Third-party applications can warn the CGMS owner about critical blood-sugar levels.

A study at the Lucerne Cantonal Hospital tried to find out, whether changes of the blood-sugar value can be detected by tracking the following vital signs in real time using a smartwatch: heart rate, heart-rate variability, step count, energy expenditure, blood-oxygen saturation, and respiratory rate [MMB+25]. For comparison, the participants also had to measure their blood-sugar values manually. As a result, the smartwatch was able to predict blood-sugar changes according to a different heart rate and in relation with the day time (with a specific focus on dining times). One has to consider that the above-mentioned studies only included a small group of participants (11 persons) and also, that smartwatches are not always tracking vital data with an accuracy of 100 %. Thus, more research is needed here, as well as usage of medical devices which can track vital data more efficiently.

All in all, it has been shown that a technical basis exists, so that for this work, the model will reference to the technical features already available for market-ready smartwatches.

2.4 Behaviour of Outsiders

Heart attacks as well as their treatment (doing CPR) are well known to society. Conversely, many people are not aware of epileptic seizures, neither what epilepsy actually is, nor what different kinds of seizures exist, not even talking about how to help a person having a seizure [MMR+21].

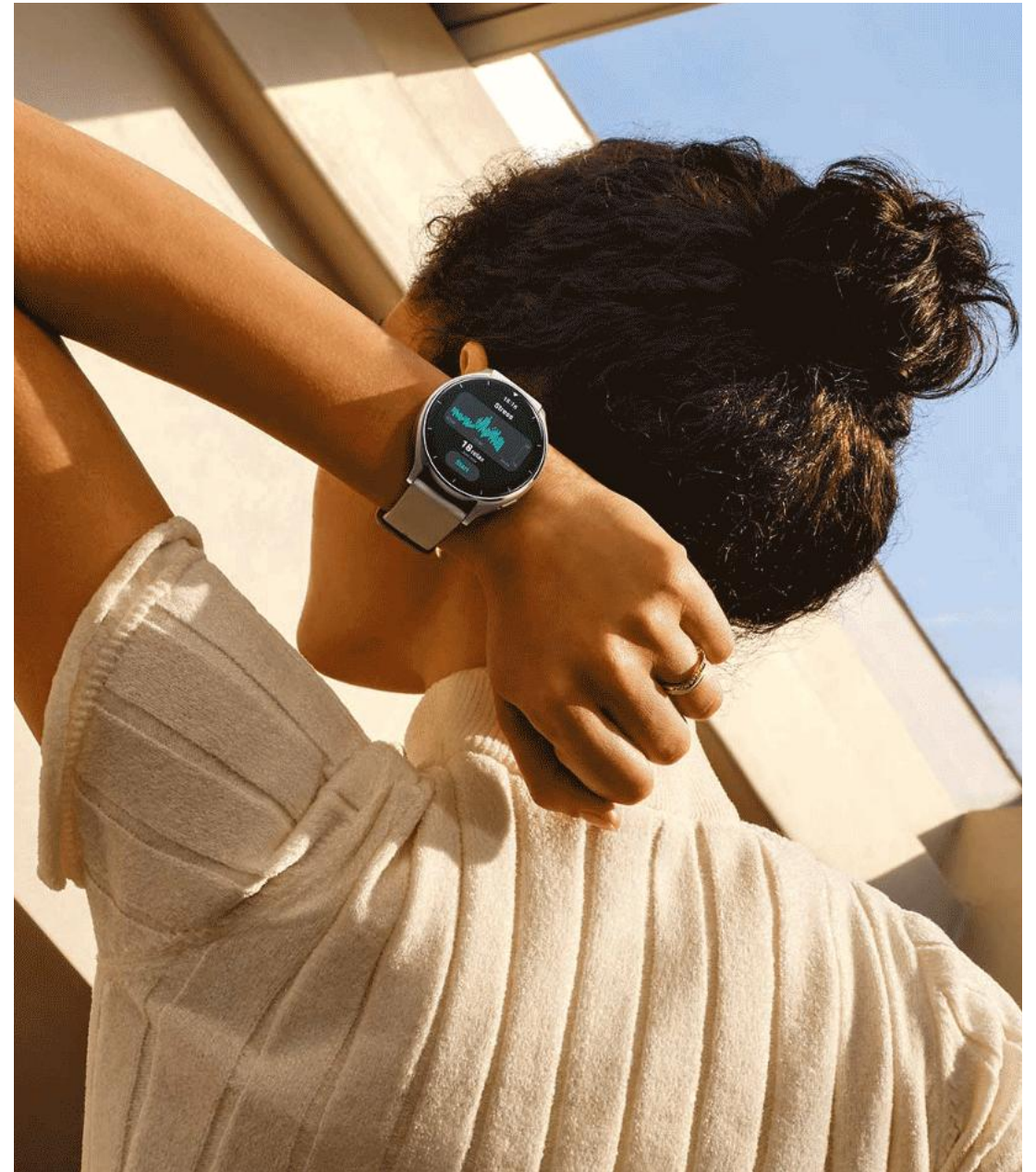


Fig. 9: The Xiaomi Watch 2 can also track vital values and is compatible with Android.



Fig. 10: Specific information about chronic diseases is not always known to outsiders.



Fig. 11: The existence of medical ID's is often not known for outsiders.

Medical ID cards – whether in physical or digital form – also often don't help. This is because, outsiders often don't search for such an ID card either due to the lack of knowledge about the existence of such an ID or because of the shock situation caused by the medical emergency [MMR+21]. For the case of glyceamic shocks, no studies seem to exist about how outside persons behave.

A reason why large parts of society are not as aware about epilepsy and glyceamic shocks as is the case for heart attacks might be the typical schedule of first-aid courses. During the past decades, proper treatment of heart attacks has been absolutely mandatory in such courses while glyceamic shocks and epilepsy were often not taught. Nowadays, this begins to change: since 2020, epileptic seizures as well as glycaemic shocks are included in the First Aid, Resuscitation and Education Guidelines of the International Federation of the Red Cross and Red Crescent Societies [MI21]. This will hopefully increase awareness of both medical emergencies in society, although it will take a couple of years, until a sufficiently larger part of society will adapt the knowledge internationally.

In general, it is important to provide people in an emergency situation with clear information and instructions to ensure safety of both outsiders and affected persons [OHK+17]. It is desirable to have an alarm at first that appeals to different senses in order to achieve the highest possible success rate (visual, acoustic or tactile, e.g. via vibration). Therefore, the alarm should have a wide catchment area. The alarm must be followed by a clear warning message of what is happening and what the outsiders are supposed to do [OHK+17]. The message should also be provided in a visual and acoustic version, if possible, to enable a higher accessibility.

3. Technical Fundamentals

3.1 Design of Life Jackets

Life jackets are a common piece of clothing, used in sailing, airplanes and other circumstances to ensure the survival of passengers in a critical situation and to prevent them from drowning. A life jacket can be an inspirational clothing design to consider for this work.

Additionally, a life jacket – or something similar – should be constructed such that it is impossible to wear it in a wrong way in order to counteract the risk of wrong usage [Pas61]. Furthermore, “It shall provide support to the head so that the face of an unconscious person is held above the water with the body inclined backwards from its vertical position.” and “It shall be capable of turning the body, on entering the water, to a safe floating position with the body inclined backwards from its vertical position.” [Pas61].

For designing a life jacket or similar clothings, it is necessary to know, how much the different parts of the human body weigh and how much buoyancy the human body already has on its own.

There exist a lot of different measurement tables about the weight of human body parts, like in the work of Pask [Pas61]. Most of them are similar to each other. One of the only papers found during the research, which had body masses for both men and women, is the work of Nikolova and Toshev [NT7].

For the most parts of the body, the relative weight distribution is very similar for both men and women. The largest deviations are found for torso and tighs where the relative weight is higher for men than for women.

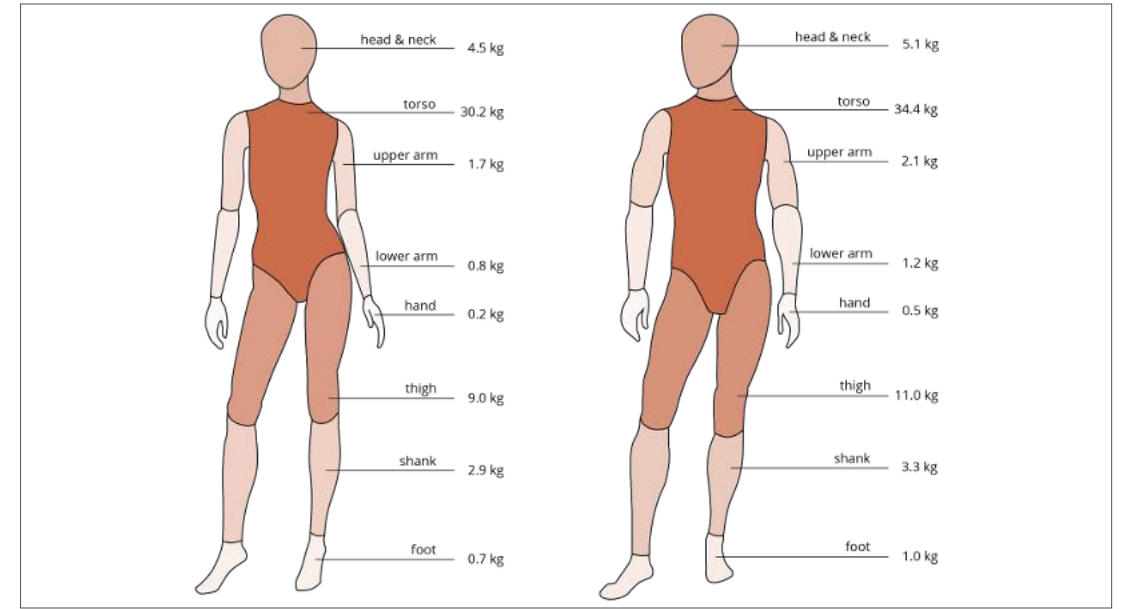


Fig. 12: Weight distribution of the different body parts, women vs. men [NT7].

G.S. Nikolova, Y.E. Toshev / Journal of Biomechanics 40 (2007) 3700–3707 3705

Table 3
The mass of the segments of the body (kg) for males and females

Segment	Males					Females	
	Drillis and Contini (1966)	Clauser et al. (1969)	Chandler et al. (1975) ^a	Zatsiorsky and Seluyanov (1983, 1985)	Our data	Zatsiorsky (2002)	Our data
Entire body	73.4	65.6	65.2	73.0	77.7	61.9	65.3
Head + Neck	–	–	–	5.0	5.1	4.2	4.5
Torso	–	33.3	34.0	31.8	34.4	26.4	30.2
Upper arm	2.6	1.7	1.9	2.0	2.1	1.6	1.7
Lower arm	1.3	1.0	1.1	1.2	1.2	0.9	0.8
Hand	0.4	0.4	0.4	0.5	0.5	0.4	0.2
Thigh	6.9	6.7	6.6	10.4	11.0	9.2	9.0
Shank	3.1	2.8	2.7	3.2	3.3	3.0	2.9
Foot	1.0	1.0	0.8	1.0	1.0	0.9	0.7

^aThe mean values from the left-and right-hand side of the body are given.

Fig. 13: Body-mass percentage of the body parts of men and women from different studies [NT7].



Fig. 14: The step-by-step inflating of a life jacket [Svb20].

In general, it is not easy to test life jackets in realistic situations, considering unconscious persons, heavy waves in the sea or other natural conditions. Additionally, different body proportions, distribution of body weight as well as different body shapes amongst men, women and children, makes it even more difficult to find an overall product solution [Pas61].

In this work, it is not required that the person wearing the life jacket can swim easily, since the situation to be covered is an unconscious person. Instead, it will be important for the rescuing person to easily transport the unconscious person out of the water.

Inflatable life jackets are often made out of nylon or polyester because of its light-weighted and robust characteristics [Spo24]. Additionally, these materials only absorb a minimum of water, nylon e.g. only absorbs about 2 % water which makes it suitable for swimming clothes [Tor26]. There are four different kinds of life jackets: 50 N, 100 N, 150 N and 275 N buoyancy. [MER25]. While the first two kinds of life jackets only offer support while swimming, life jackets with 150 N and more buoyancy ensure that the head will be held over the water surface even in the case of unconsciousness [Svb20]. Life jackets are using carbon dioxide cartridges to inflate themselves, mostly through a manual action like pulling on a rope, or automatically through a hydrostatic or chemical mechanism when the life jackets gets in contact with water [Spo24].

For emergency situation in water, a green fluorescent colour called uranin is sometimes used [Kla26]. It is an environmentally-friendly colour and not toxic for animals, humans or plants and can show from far, where an emergency situation is [Kla26].

3.2 Functionality of Carbon Dioxide Cartridges

There are two different sizes of carbon dioxide cartridges: 24 or 33 grams, depending on how much buoyancy the life jacket delivers [Sea20].

Life jackets with an automatic sensor need a water-soluble bobbin, which dissolves upon contact with water. This then triggers a mechanism which punctures the carbon dioxide cartridge and inflates the bladder of the life jacket immediately [Blu25]. Additionally, a replacement green indicator clip is needed, which signals, when the cartridge needs to be changed [Sea20]. A change is necessary after every usage or after about three years of storage [Blu25].

A manually-pullable inflator arm should be considered for the design of life jackets, to also cover cases in which the automatic mechanism doesn't work.



Fig. 15: Left to right: Green indicator clip, water soluble bobbin and carbon dioxide cartridge.

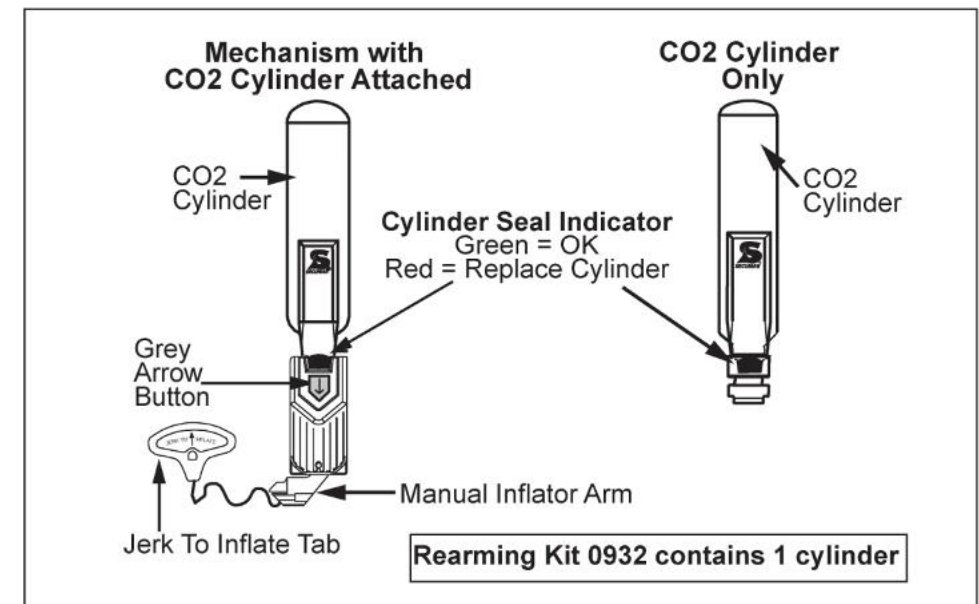


Fig. 16: Design and function of the carbon dioxide valve in life jackets.

3.3 Classification of Recent Work

The following product solutions dealing with similar approaches to the topic of this thesis will be presented in brief.

They are intended to serve as inspiration for the thesis.

SWÖM

The Danish Company SWÖM ApS developed a swimming shirt for children. With the non-inflated product, a normal swimming and diving of the child is possible, the product inflates itself only in a certain emergency: only if the child reaches a sufficiently deep diving depth, the swimming shirt's sensor triggers a carbon dioxide cartridge. The cartridge can be changed after usage and the shirt itself is washable [Swo25].

Hexoray

The startup Hexoray based in Belgium designed a product solution called "SwimVest" – a product that can be inflated by pulling a cord, which activates a carbon dioxide cartridge [Kic24].

Plouf

The French company Greystone SAS developed a product solution called "Plouf". It represents classic swim wear for male and female consumers. It is made out of "Fibreair", which is a synthetic fibre injected with air. This ensures a constant buoyancy while swimming, but makes diving less possible [Bel25].

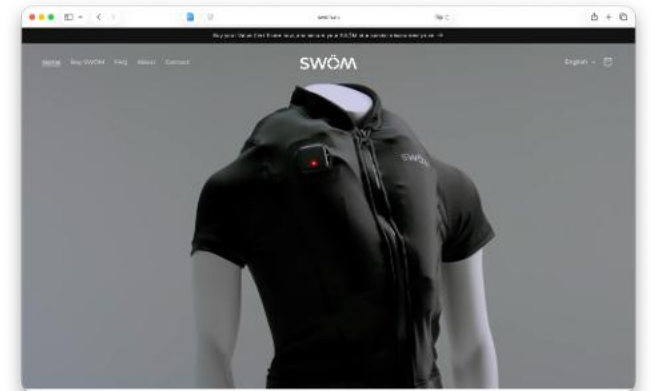


Fig. 17: SWÖM [Swo25].

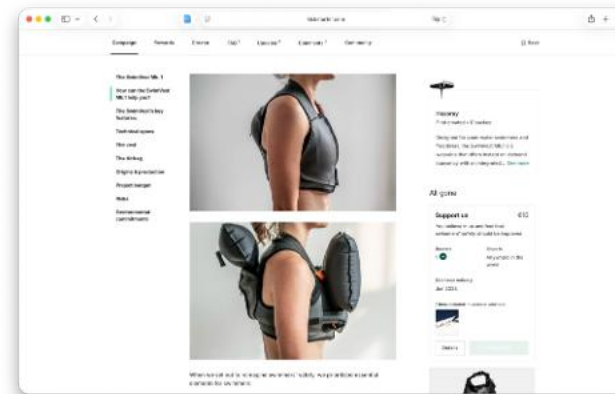


Fig. 18: Hexoray [Kic24].



Fig. 19: Plouf [Bel25].

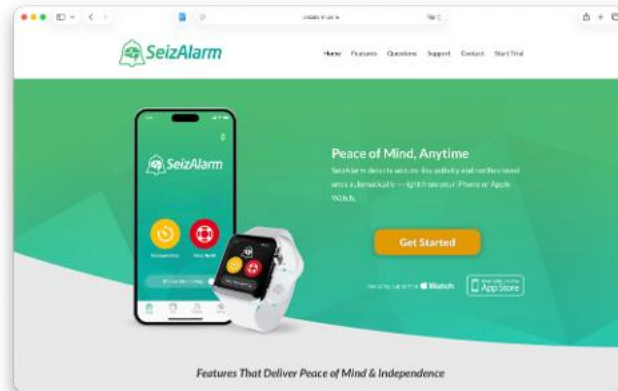


Fig. 20: SeizAlarm [Sei25].

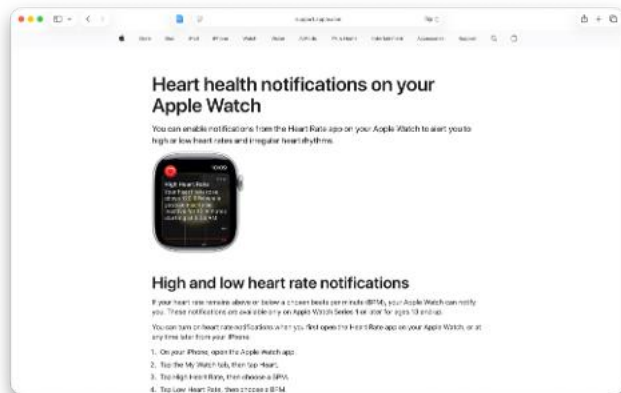


Fig. 21: Apple Watch [App25c].

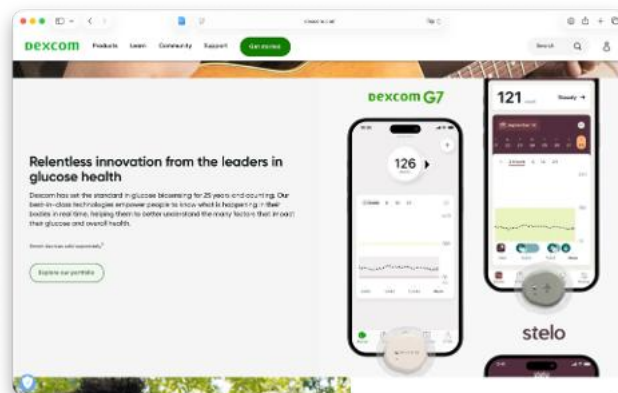


Fig. 22: Dexcom [BMS25].

SeizAlarm

The application SeizAlarm for Apple Watch can detect epileptic seizures by constantly tracking the pulse and movement of the wearing person [Sei25].

Apple Watch

The Apple Watch provides the feature to detect irregular rhythms of the wearer's heart, which can cause heart attacks. A notification can be set up before using the watch [App25c].

Dexcom G7 CGM-System

The company Dexcom Deutschland GmbH offers a Third-Party solution for smartphones and smartwatches: The application can be connected to a CMS (continuous glucose monitoring) device, which is placed under the skin of the consumer and contains a sensor which constantly checks the glucose level of the blood. It can additionally be connected to an insulin pump [BMS25].

4. Analysis of Swimming

4.1 Swimming Movements

To have an approximate analysis of the movement while swimming, the four most common swimming styles will be analysed: breaststroke, front crawl, butterfly and backstroke [UG21].

When studying the swimming movement, the human body can be treated as a rigid body. This approximation is allowed, because most of the time, the torso is tended to ensure an even buoyancy. This also applies to most of the joints. The entire movement is mostly executed by arms and legs [NSM07].

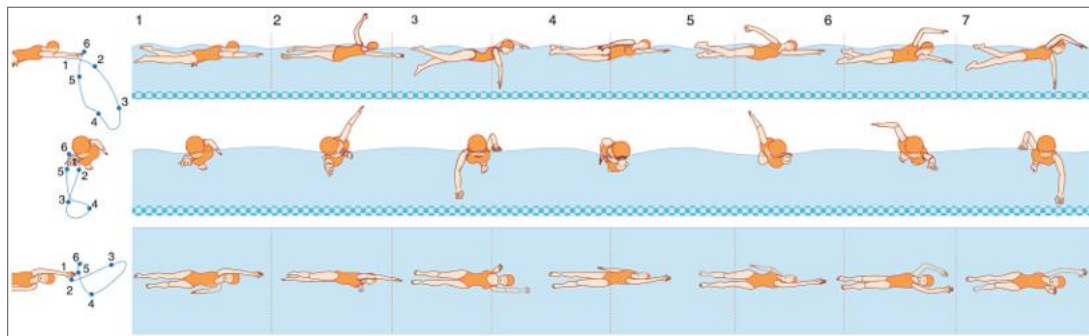


Fig. 23: Front-crawl body movement [UG21].

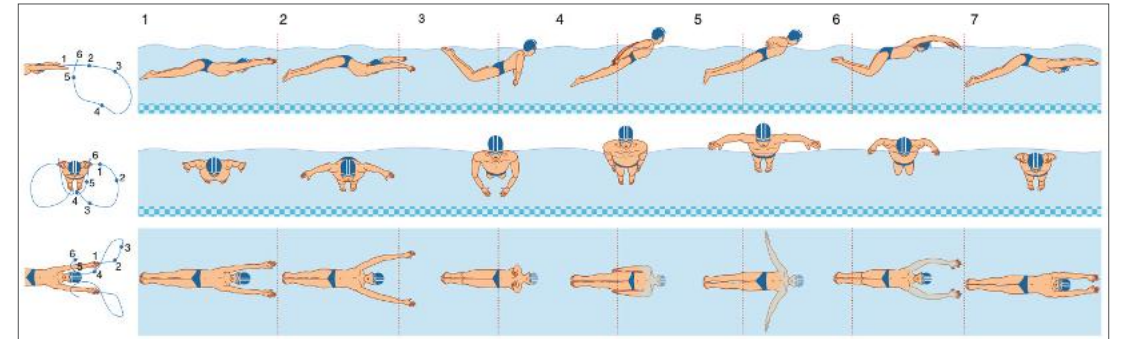


Fig. 24: Butterfly-stroke body movement [UG21].

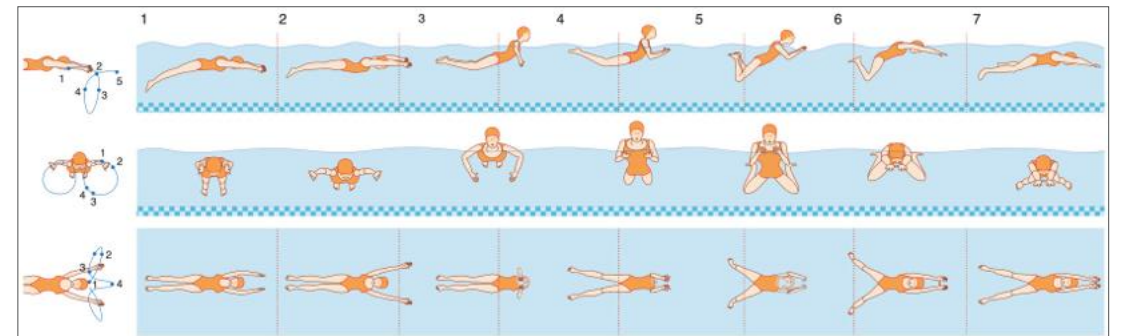


Fig. 25: Breaststroke body movement [UG21].

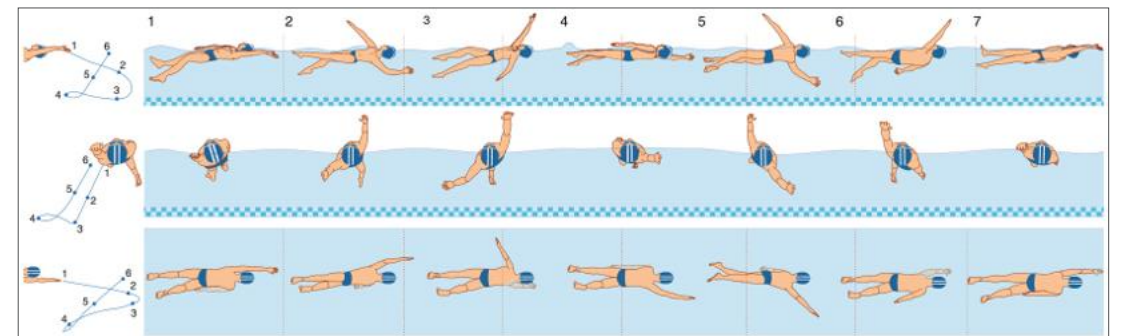


Fig. 26: Backstroke body movement [UG21].

4.2 Rescue Manoeuvres

The three main rescue grips taught in the German life-guard training for the mandatory silver rescue swimming licence are the underarm-carry handle, the head-drag handle, as well as the towing handle [Lip25].

All of them are performed in the supine position with a leg-kick movement, while the person being rescued is stabilised with both hands.

The supine position comforts with the position of the person being rescued wearing an inflated life jacket.

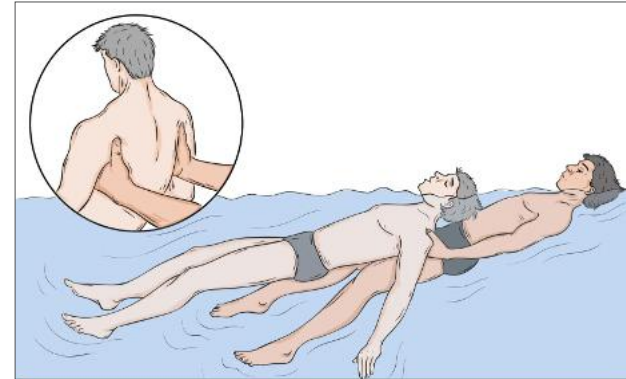


Fig. 27: Underarm-carry handle [Lip25].



Fig. 28: Head-drag handle [Lip25].



Fig. 29: Towing handle [Lip25].

5. Target Group Definition

5.1 Chronical Disease Focus

It is necessary to clarify, which chronic disease(s) should be covered in this work. Regarding that, it is important that the focus can only be set on chronic diseases, which are detectable by tracking specific vital values. After the medical research and checking the technical fundamentals, the focus for the product solution of this work should be set on the following chronic diseases:

- **BTSC** (generalised epilepsy – with bilateral tonic-clonic seizures which cause immediate fainting),
- **CAD** (coronary artery disease – with blockage in the coronary arteries which transport the oxygen-rich blood causing heart attacks),
- **CVD** (cerebrovascular disease – affecting the flow of blood towards the brain causing strokes),
- **IDDM** (insulin-dependent diabetes mellitus, alias type 1 – causing glycaemic shocks) and
- **NIDDM** (noninsulin-dependent diabetes mellitus, alias type 2 – causing glycaemic shocks).

Approximately 50 million people worldwide live with epilepsy [SSS+14], 160 million with heart diseases [LZL+25], and approximately 463 million with type 1, 2, or another form of diabetes [SPS+19]. Here, it is not easy to say, how many people actually count to the defined target group, because of the various forms of each disease as well as potentially many undetected or not precisely-defined diseases of each individual.

Moreover, it can be said, the target group is around 600 million people worldwide with an unknown uncertainty.



Fig. 30: Some chronic diseases can be treated by medicine, but they are often not curable.



Fig. 31: People with chronic diseases feel restricted through the disease in their everyday life.

5.2 Demographic Focus

Since it is often common practice in the development of medical products to first design products for adults and then adapt them to the body proportions of children [LR19], this study will focus on adults (aged 18–80) in western countries.

The resulting product can be adapted to other ethnic body measurements and religious and/or social world views in the clothing sector. The focus of the work will be on clothing size M for women and L for men. Other clothing sizes will be taken into account but, due to time constraints, will not be given their own design.

Furthermore, only swimming sports that can be practised indoors will be considered initially. The choice of target group depends on the everyday environment in which this work is carried out, as well as the average measures of the human body.

Additionally, the function of the swim wear should be practicable for the common rescue manoeuvres of trained lifeguards.



Fig. 32: Classic swimwear for women.

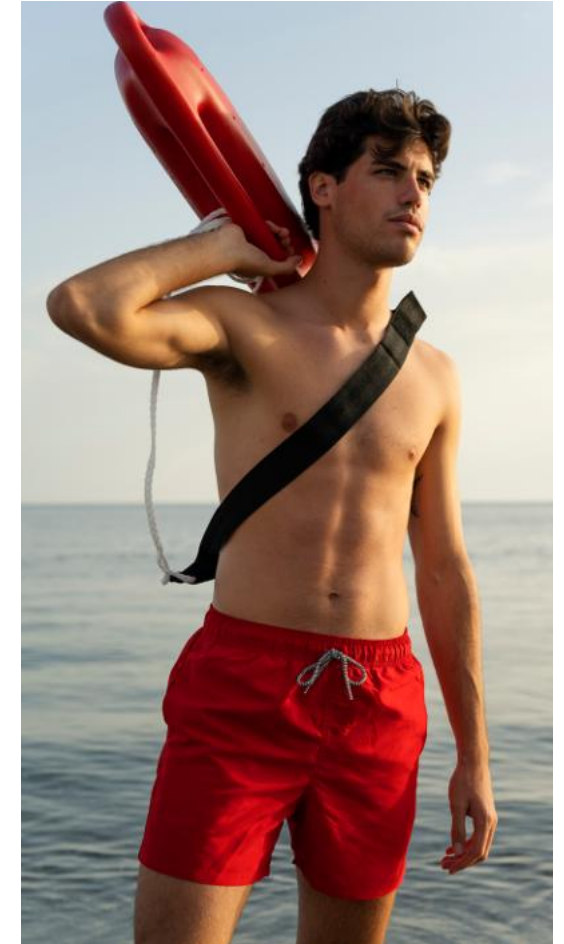


Fig. 33: The swimwear of the potentially drowning person should be practicable for the lifeguard as well.

6. Task Definition and Potentials

The aim is to develop a product solution consisting of swimwear together with an application for a smartwatch: the swimwear can be worn like normal swimwear and should ensure a high degree of freedom of movement. The application must be installed on the smartwatch prior to swimming. A smartwatch is used to detect and recognise critical situations. In addition to triggering an acoustic signal, the swimwear, which is linked to the smartwatch, inflates and brings the user to the surface of the water. The product is therefore designed to give the user and their relatives a greater sense of security. It also aims to achieve greater independence. Rescue in a critical situation should be simplified and, in the best case scenario, the risk of death for the user can be reduced.

With this work, a swimwear – one for men, one for women – made out of Nylon will be designed. It will consist of two layers, containing an inflatable bladder in between those layers. A carbon dioxide cartridge can be placed inside the swimwear. Instead of a water-soluble bobbin, a small piece will be added to the cartridge: a water-resistant piece with a small sensor inside of it, which is able to send and receive a Bluetooth signal. Through this, the piece is able to connect to a smartwatch. When the smartwatch detects a medical emergency, it sends a signal to the piece. This will activate the same mechanism like a water-soluble bobbin does and thus punctures the carbon dioxide cartridge to inflate the bladder of the life jacket immediately. It will be clarified, how the visual and acoustic signal of the smartwatch will look like, but the main focus will be set on the swimwear. Uranin will not be used, it can be considered as an outlook for a subsequent product solution used for outdoors swimming activities.

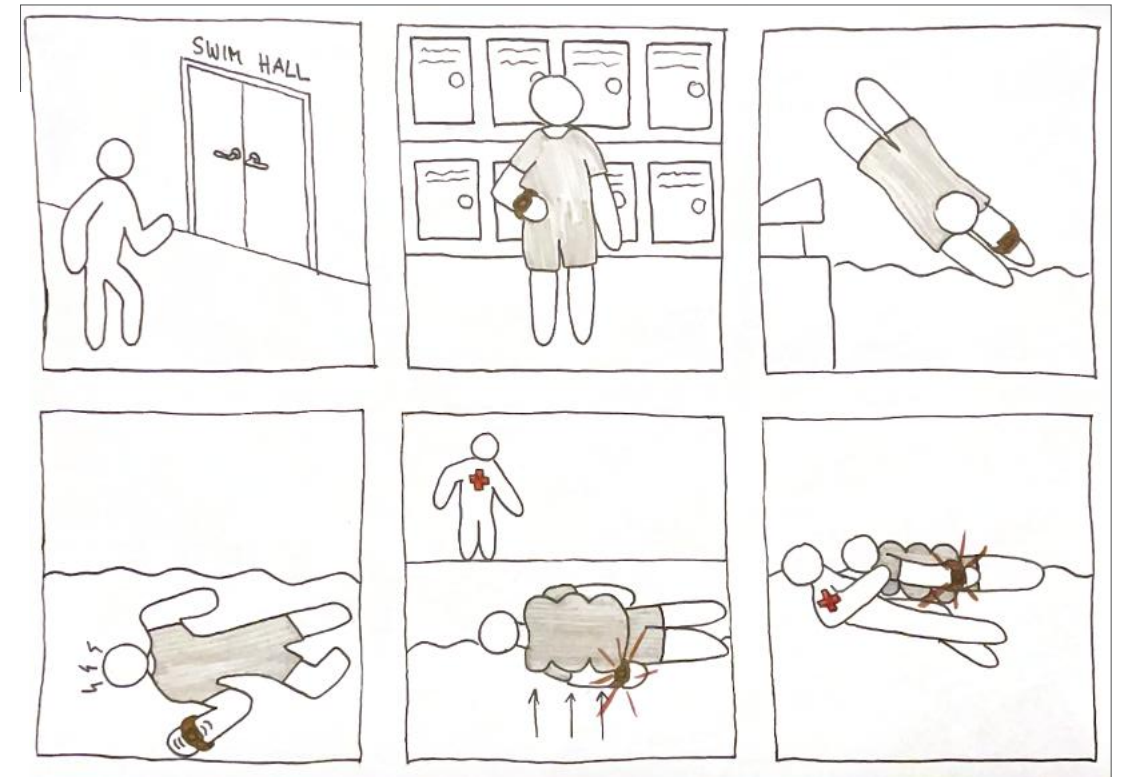


Fig. 34: Possible application scenario for the product solution: Before swimming, the smartwatch and swimwear are put on and paired with each other. The user can go swimming normally. If a medical emergency occurs, the smartwatch can detect this by constantly tracking vital signs and sends a signal to the swimwear. This inflates with the help of an integrated vital carbon dioxide cartridge, while the smartwatch triggers an acoustic and visual alarm. The person floats to the surface of the water and can be transported away in a supine position.

7. First Survey

The aim is to design a user-centered product design solution. Although I am not part of the target group, it is important to get some information directly from people who are part of the target group, unless the design will not suit the target group. This design field is also called “participatory design”, which has the aim to work directly with the potential users [MK93].

To this end, prior to the draft phase, I started a brief survey, in which I only asked people who are part of the target group. The complete survey with all answers can be found in anonymised form in the Appendix A of this thesis.

7.1 Demographic Data

Three participants of the survey are male, eight are female. Ten of them are between the ages 18 - 34, only one person is older than 65. Almost half the participants said that their highest education is A-levels, the rest replied that they received a university degree. Eight participants are students, two are working full-time, and one person checked the answer “other” for their employment relationship.

7.2 Questions about the Disease

Six of the participants are living with epilepsy, two of them even stated the concrete definition: juvenile epilepsy and generalized epilepsy, grand mal. Two participants are living with diabetes mellitus type 1, one of them additionally with hypothyroidism, which is a disease, where the thyroid gland does not produce enough of the thyroid hormone, which can cause – among other things – fatigue and heart problems [@May22].

Two participants are living with heart diseases, one of them with recurrent ventricular tachycardia, which is a type of irregular heart beat, called an arrhythmia [@May24a].

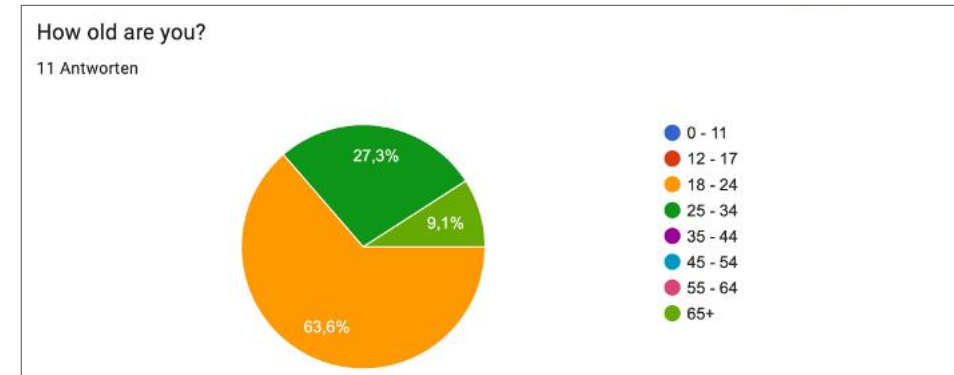


Fig. 35: Age of the participants.

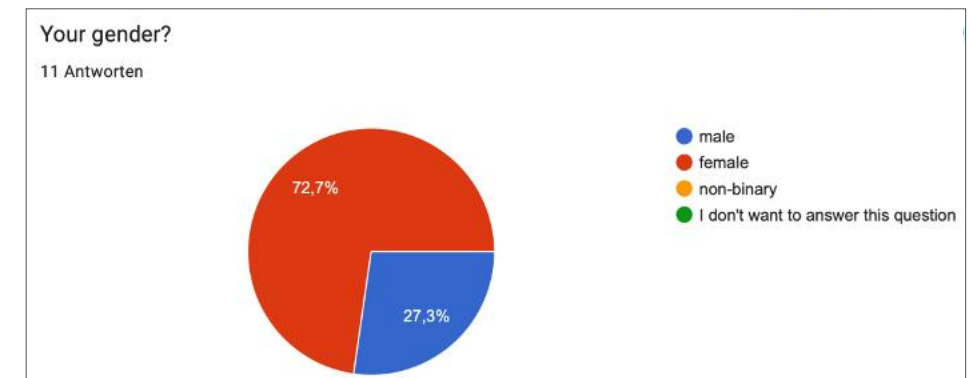


Fig. 36: Gender of the participants.

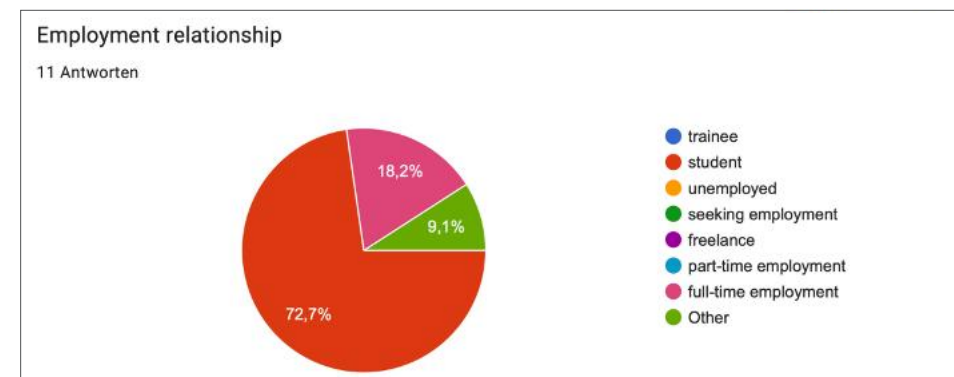


Fig. 37: Employment relationship of the participants.

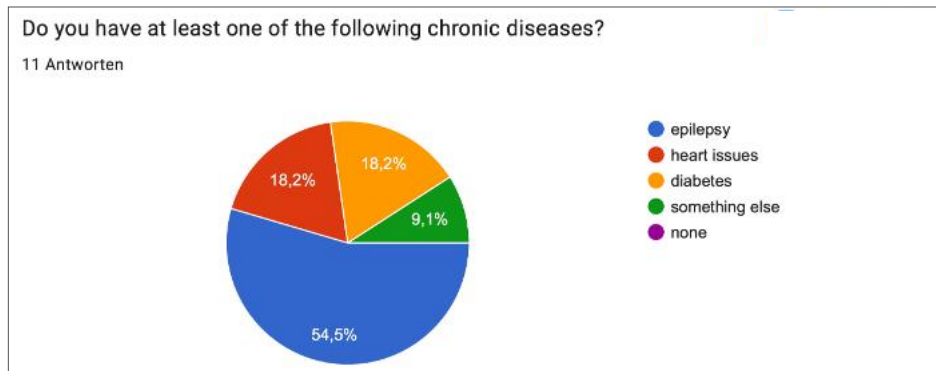


Fig. 38: Chronic diseases of the participants.

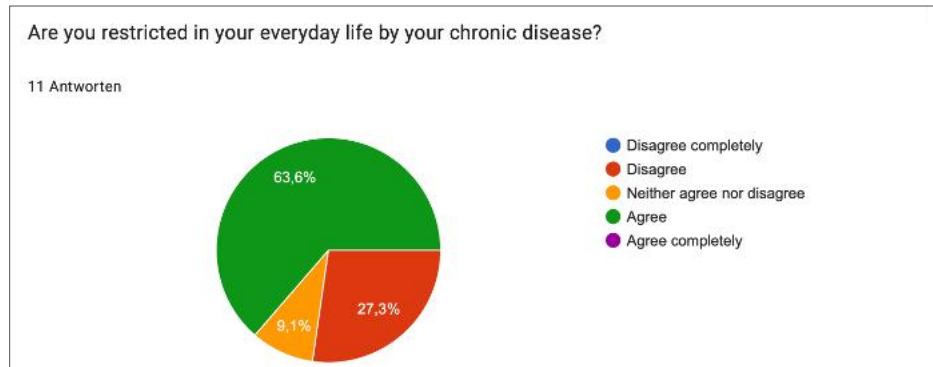


Fig. 39: Evaluation, whether the participants feel restricted because of their disease.

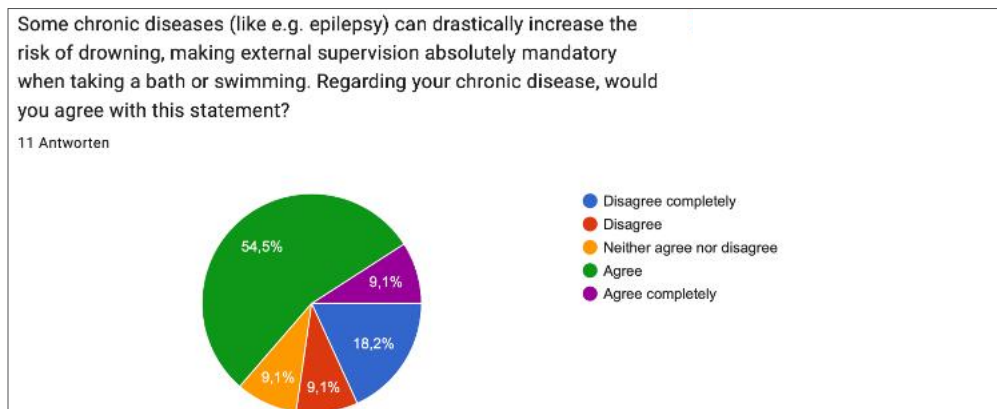


Fig. 40: Evaluation, whether the participants feel restricted while swimming.

The other one is living with POTS, which “[...] affects the autonomic nervous system, which controls involuntary body functions such as heart rate and blood pressure.”, and thus “[...] can lead to lightheadedness, dizziness and fainting.” [Tor25]. One was answering, living with an eye migraine. Unfortunately, the participant didn’t specify whether she is living with a migraine with aura or retinal migraine. Both diseases can change vision for a couple of minutes [May24b].

About two thirds agreed, that their chronic disease is restricting them in their everyday life, as well as it restricts them while swimming. Upcoming worries while swimming – especially for the ones with epilepsy – are that they could receive a seizure with nobody outstanding noticing it, or a rescue could be difficult because of the muscle spasms. This causes them to prefer to go swimming with someone who knows about the chronic disease, even if they are under medication for their chronic disease. Additionally, the less common knowledge in our society makes them worry that even if people try to help them in an emergency, they may not know how to manage a seizure. Another struggle – mainly by the participants with heart diseases or diabetes mellitus – is fainting or having less energy to get safely out of the water or falling and getting injured while falling on land.

7.3 Questions about the Potential Product Solution

Eighth out of eleven participants are interested in buying such a product. On average, they would be willing to pay about 100 € for it (the smartwatch not included).

The majority prefers a product, which resembles already existing swim wear. The asked female participants agreed on wearing swimwear, which resembles a swimsuit, whereas the male participants disagree on that. Instead, they would prefer a swimming shirt, similar to a surf shirt.

Seven participants agreed on wearing an additional tool with their usual swimwear; four disagreed on that.

The majority of the participants would be willing to wear a smartwatch for the usage of the product. Two were saying that they would prefer wearing a wristband solely for this purpose, because of less usage of a smartwatch or data protection reasons. Additionally, according to the research about the accuracy of smartwatches, a wristband specialized on epilepsy, heart diseases or diabetes mellitus could work more precisely and can be regarded as an outlook.

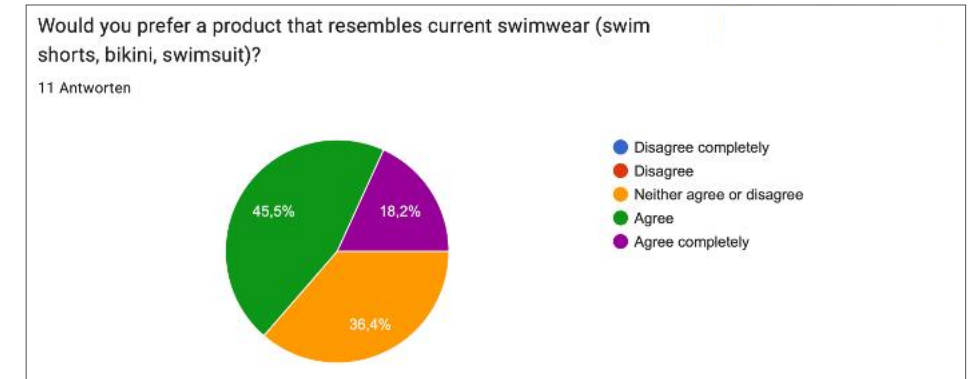


Fig. 41: Evaluation, whether the participants prefer a product resembling current swimwear.

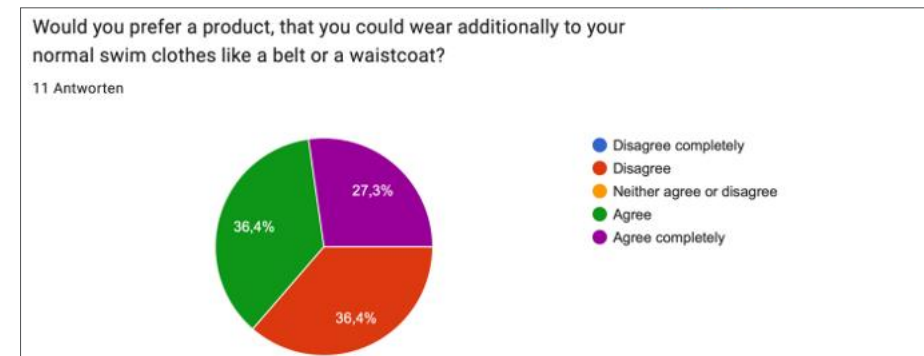


Fig. 42: Evaluation, whether the participants prefer a product additionally worn to their actual swimwear.

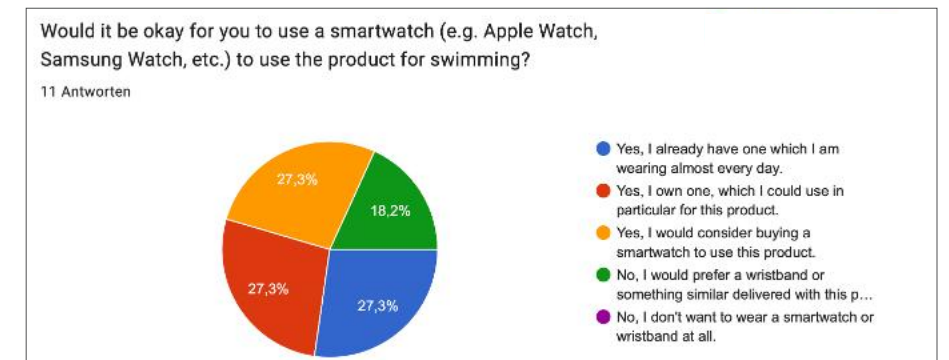


Fig. 43: Evaluation, whether the participants agree on wearing a smartwatch.

8. Drafts

The draft phase started based on the information obtained from both the research work and the survey.

After brainstorming possible ideas for product solutions, body areas of both genders for the potential placement have been identified.

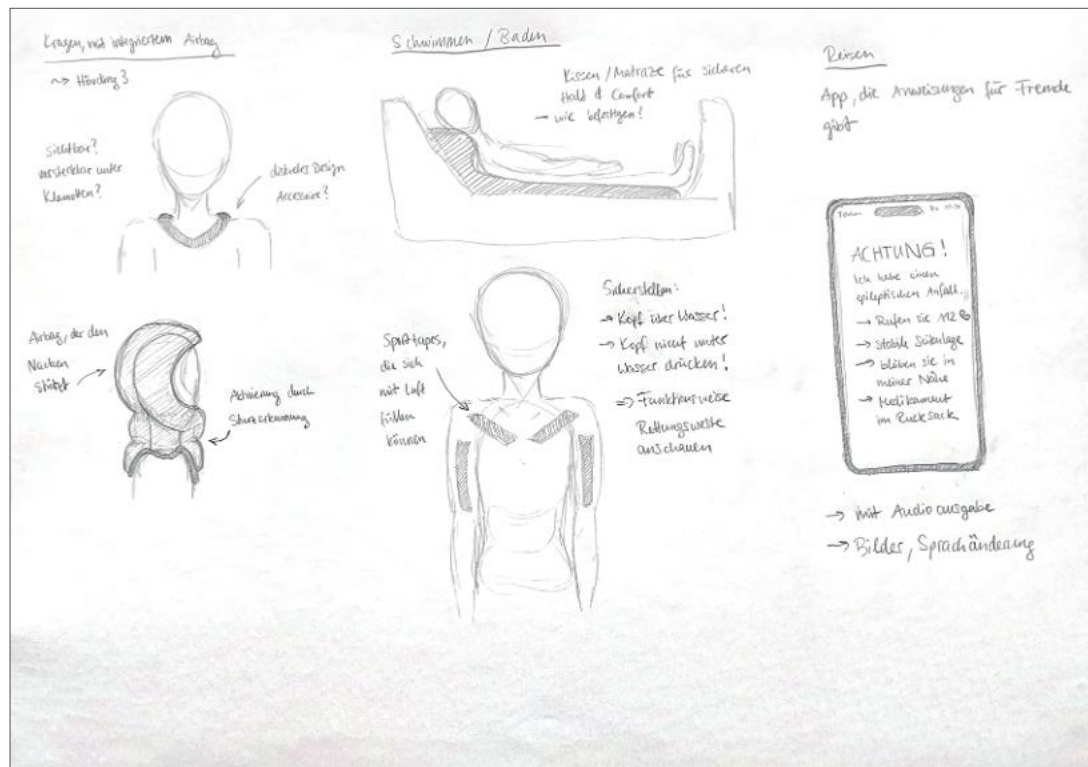


Fig. 44: First brainstorming.



Fig. 45: Drafts of potentially covered body parts.

9. Variants

Regarding the existing swimwear, the result of the survey and technical limitations of the life jacket aspect, I quickly came to the conclusion that two different versions should be considered: Version 1 consists of a swimsuit for women as a stand-alone solution, together with a swimming shirt for men, which are intended to be worn in combination with swimming trunks. By contrast, version 2 represents a swimming shirt with a zipper at the front, which can be worn additionally to the normally-worn swimwear for both men and women.

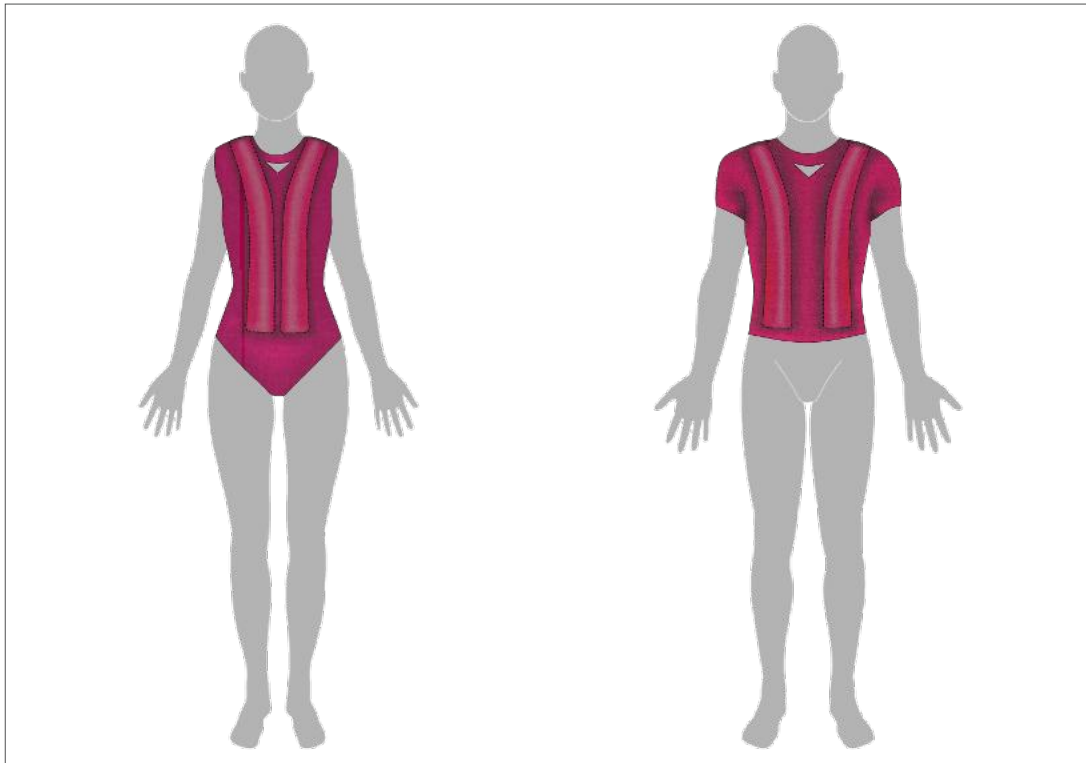


Fig. 46: Version 1: a swimsuit for women and a swimming shirt for men

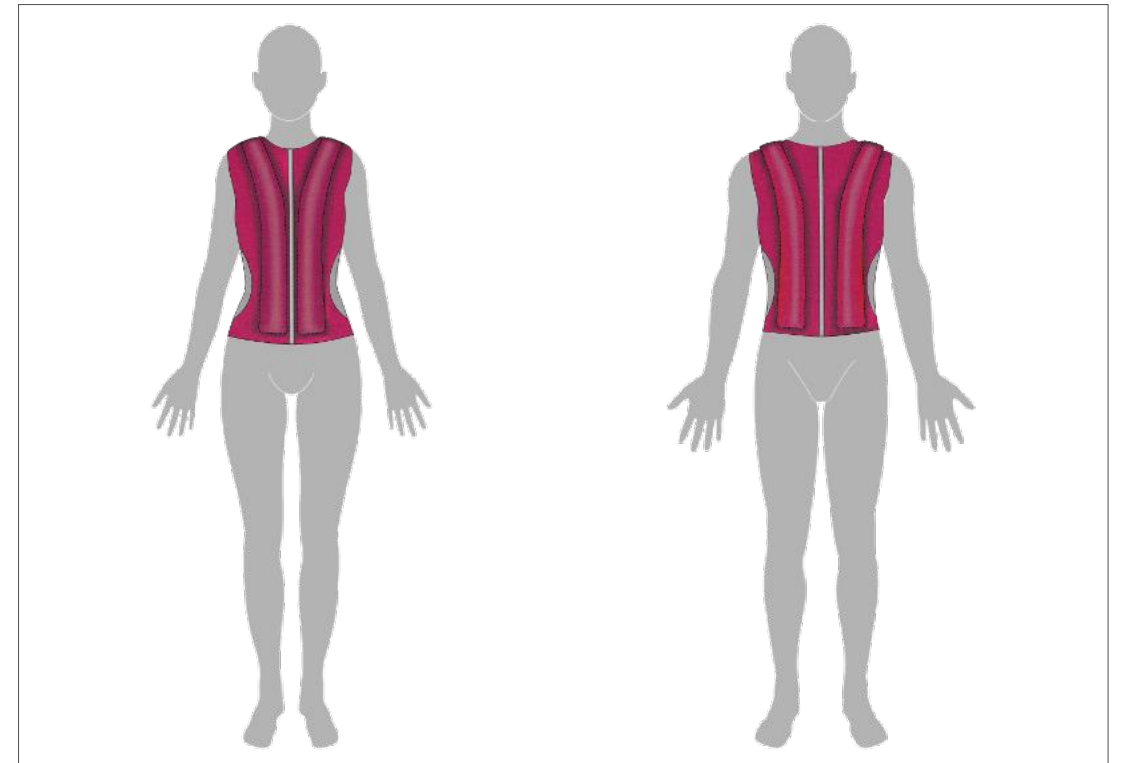


Fig. 47: Version 2: a swimming shirt for both women and men

10. Refinement

10.1 Technical Refinement

The resulting product is supposed to hold the wearer's head above the water surface in case of unconsciousness. Like life jackets with 150 N and more buoyancy, a carbon dioxide cartridge of 24 or 33 g is necessary [Sea20]. To ensure the most unconsciousness-proof product solution, a 33 g cartridge is used.

Life jackets which work automatically upon contact with water typically use a water-soluble bobbin to puncture the carbon dioxide cartridge. For the emergency system presented in this thesis, a different mechanism is required, that is sensitive only to medical emergencies. Additionally, there is need of a technical interface between the smartwatch, which tracks the vital values of the wearer and the swimming shirt itself. To this end, a wireless Bluetooth module can be used: it only needs 3 V of voltage, which can be provided by a normal 10-year battery.

Additionally, it is a really small technical component (about 25 x 35 mm) and light-weighted. With this component, Bluetooth signals can be sent and received. With the integrated 32-Bit processor and 16 kB RAM, an electromagnetic actuator can be controlled to punctuate the carbon dioxide cartridge.

This was the first technical idea, which became also part of the evaluation. It slightly changed afterwards.

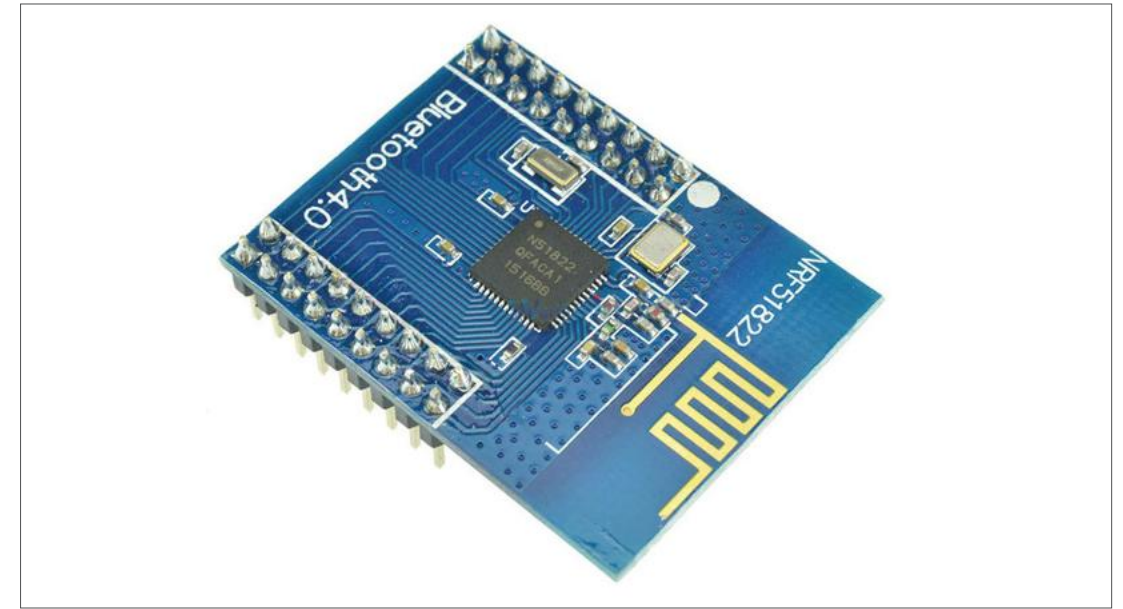


Fig. 48: Wireless Bluetooth module by Hailege.

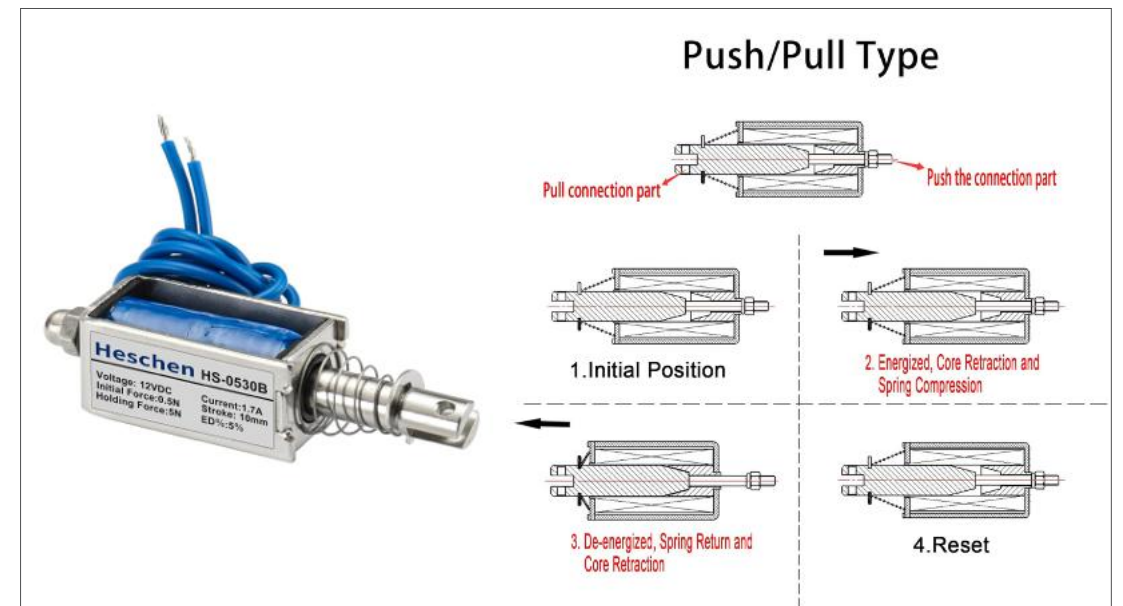


Fig. 49: Electromagnetic actuator by Heschen.

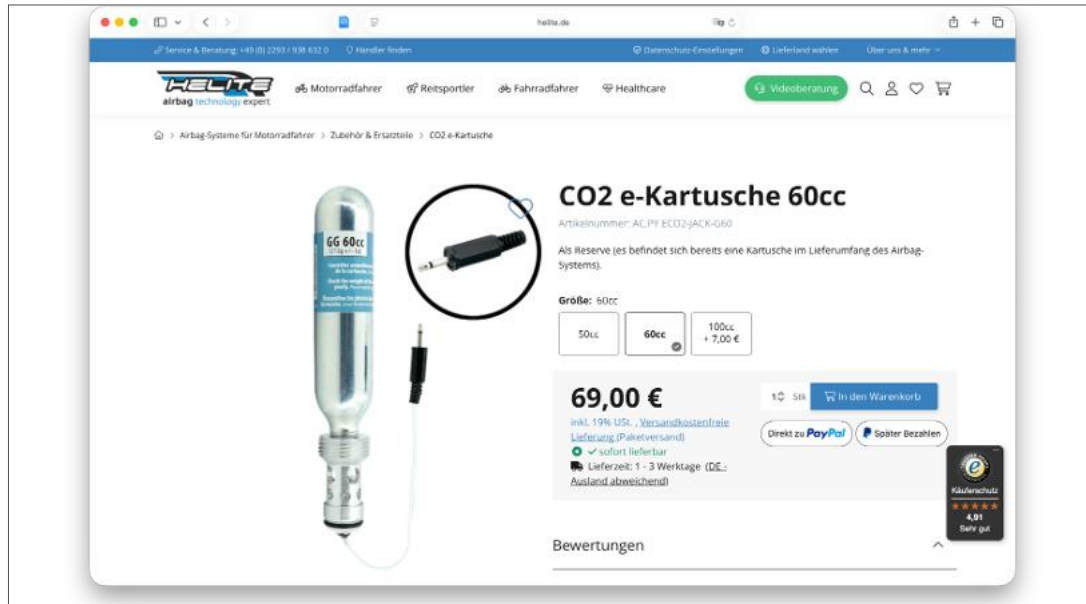


Fig. 50: E-carbon dioxide cartridges from the German company Helite.

During the design-refinement phase, another kind of carbon dioxide cartridges has been found through research: e-carbon dioxide cartridges. Those are typically used in motorcycle airbag vests. E-carbon dioxide cartridges come along with a jack plug. Comparable products need about 5 V of voltage [Hel23].

An e-cartridge will eliminate the need for an electromagnetic actuator. The cartridge itself needs to be attached in the inside of the swimming shirt at the inflatable part. Because of the limited space between the swimming shirt and the skin, the rest of the technical parts will be outsourced to a box attached at the outside of the jacket. This will be shown in the following section.

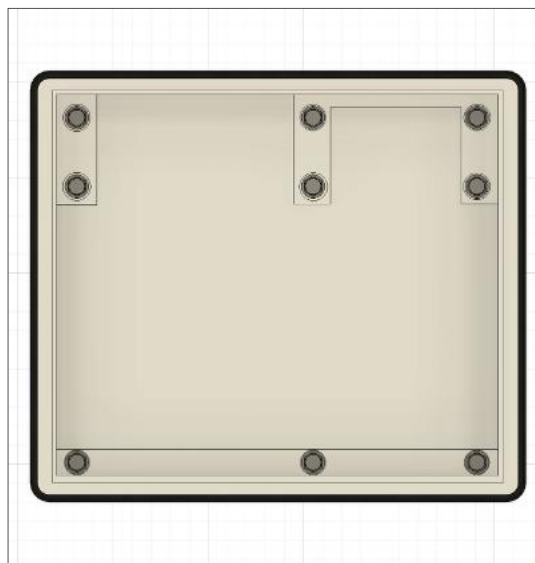


Fig. 51: Empty box (top view).

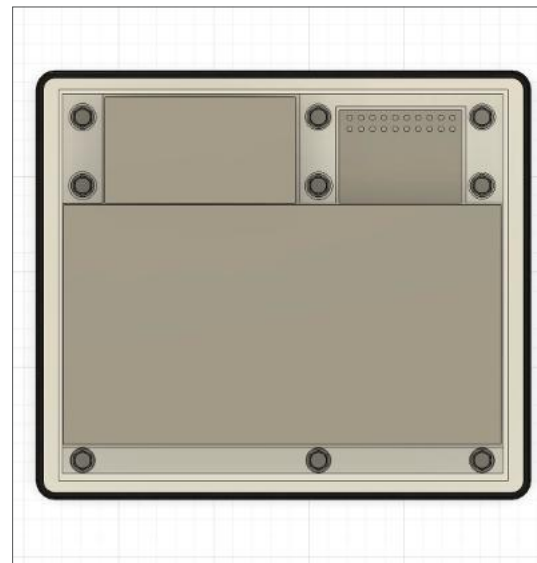


Fig. 52: Box with technical components (top view).

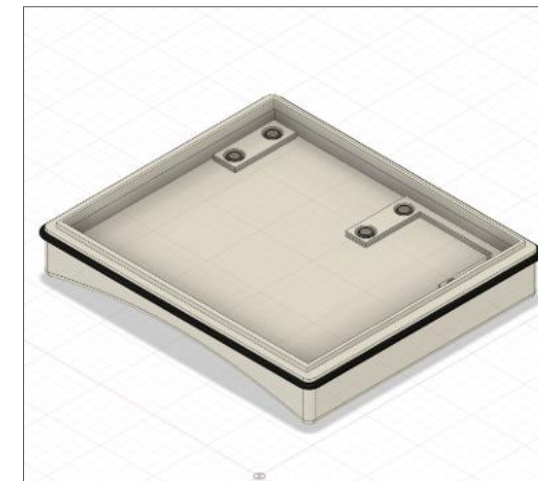


Fig. 53: Empty box (oblique view).

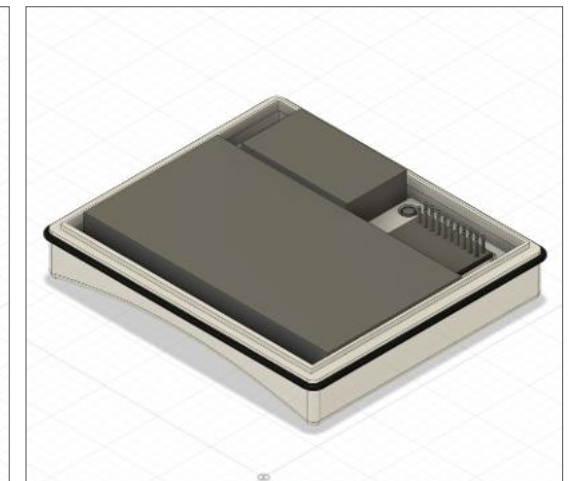


Fig. 54: Box with technical components (oblique view).

The box will be made out of ABS plastic (Acrylonitrile butadiene styrene) and it will be isolated by a rubber layer in the middle part to make it waterproof. The lid shown in Fig. 58 is only necessary for the model to include the technical elements. In the product, the lid will not be removable to ensure the waterproofness as well.

To attach the box to the outside of the swimming shirt, an additional magnetic piece shown in Fig. 59 will be placed on the inside of the swimming shirt.

The box and the additional piece will be slightly concave to have a better fit on the moving body.

The box will have the following dimensions and weight:

→ 126 x 110 x 36 mm (length x width x height) and

→ 310 g.



Fig. 55: Carbon dioxide cartridge inside the bracket.

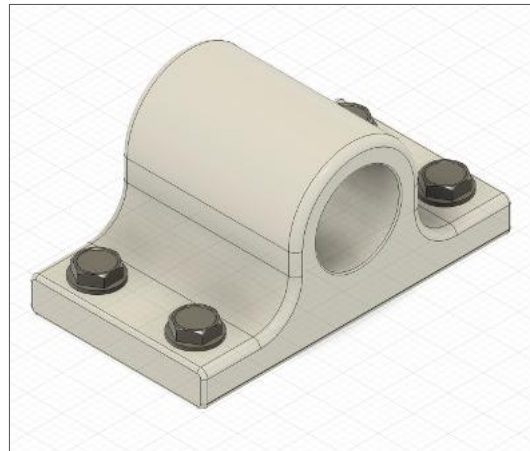


Fig. 56: Bracket from the other side. The bottom contains a hole to connect it to the inflatable part of the swimming shirt.

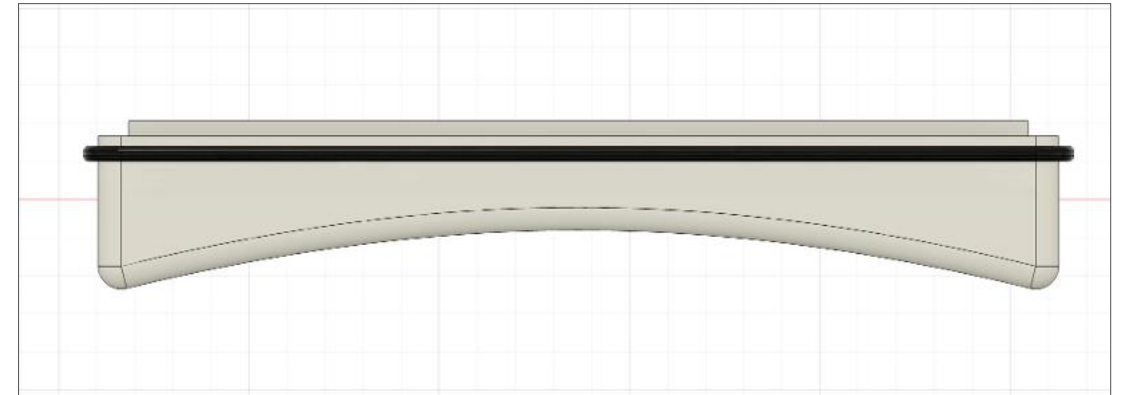


Fig. 57: Box with its concave shape (side view).

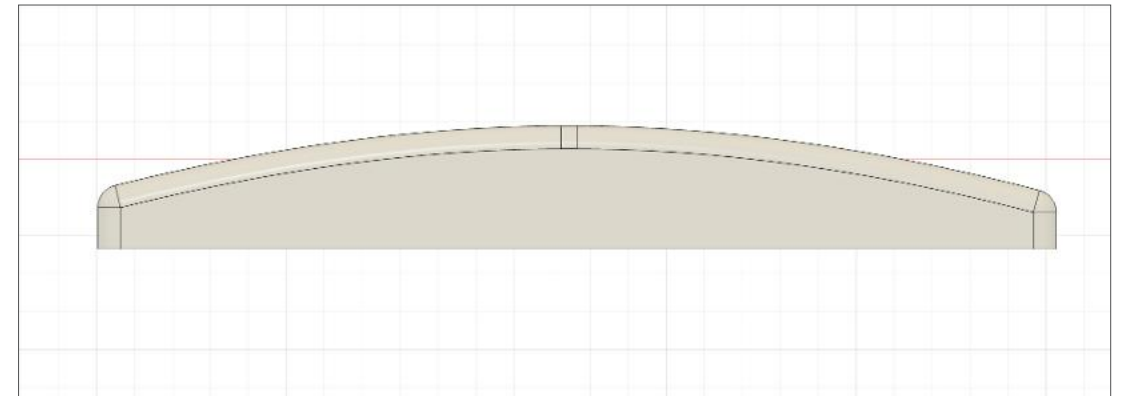


Fig. 58: Lid (side view).

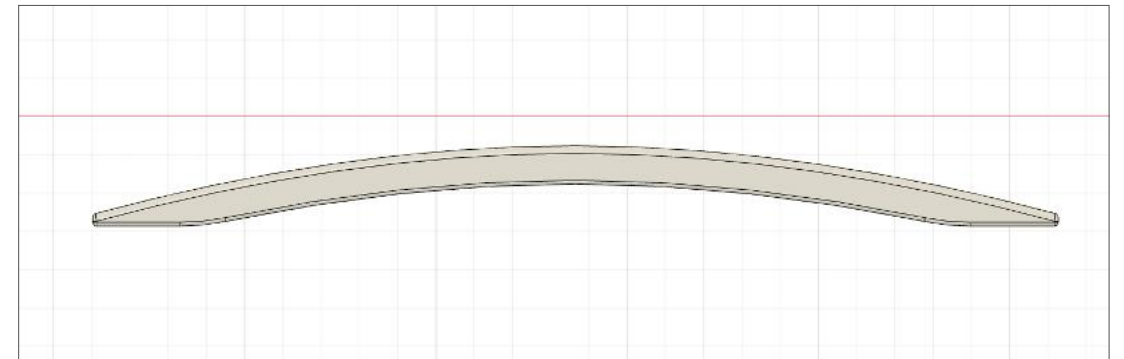


Fig. 59: Interior piece with its concave shape (side view).

10.2 Design Refinement

The aim of this thesis is to create a visual model on a scale 1:1, one model in European size M for women and one model in European size L for men.



Fig. 60: EU-size M for women.



Refinement

To this end, a paper model was created based on classic clothing size pattern creation.

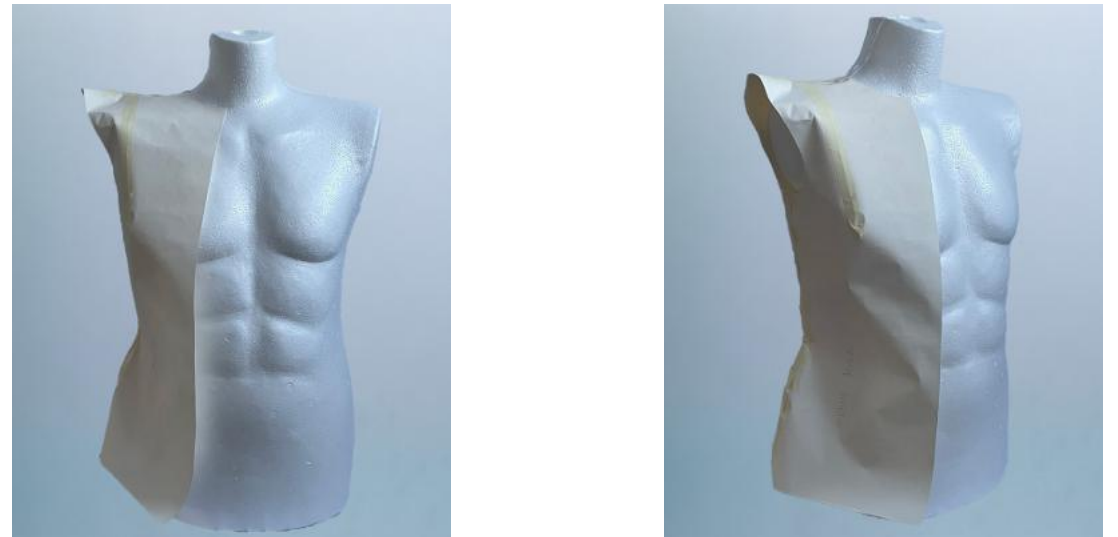
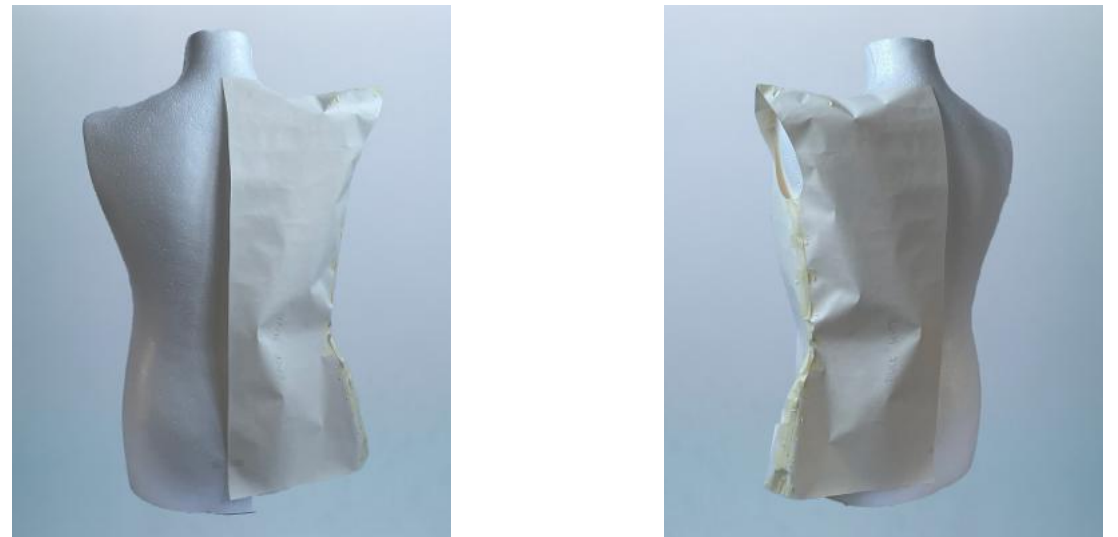


Fig. 61: EU-size L for men.



Refinement

After determining the approximate size of the two clothing sizes with the help of the measurements, a model was made out of foam rubber.



Fig. 62: Classic clothing size pattern for women EU-size M in black rubber foam.



Fig. 63: Classic clothing size pattern for men EU-size L in black rubber foam.

Originally, a slim-fit size with a material like nylon or polyester was intended. However, the rubber foam was more rigid than expected, so the resulting model didn't fit as desired.



Fig. 64: Women, rubber foam model.



Refinement



Fig. 65: Men, rubber foam model.



Refinement

To obtain a better fit, a method used by Cosplayers was applied: The styro-foam models got covered with clear film and sewing patterns were drawn on them.

This time, the main focus was set on the additional layer which will be inflated. A final version was not achieved at this point though.

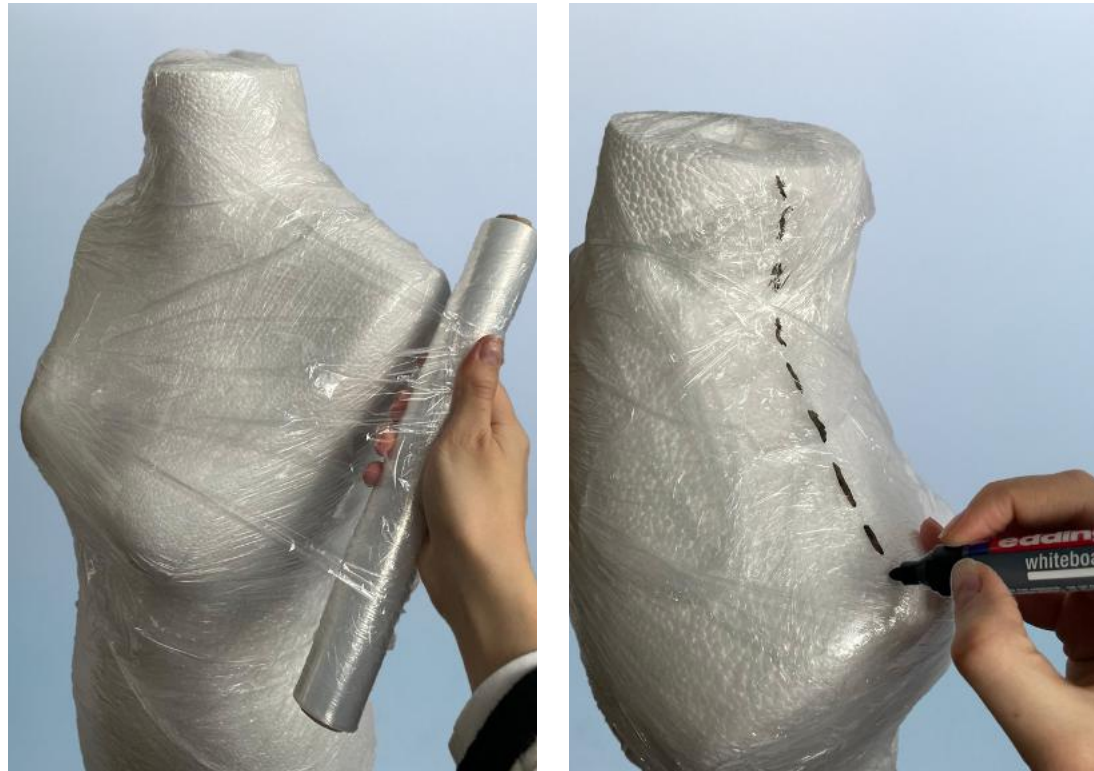


Fig. 66: Modelling of the sewing pattern.

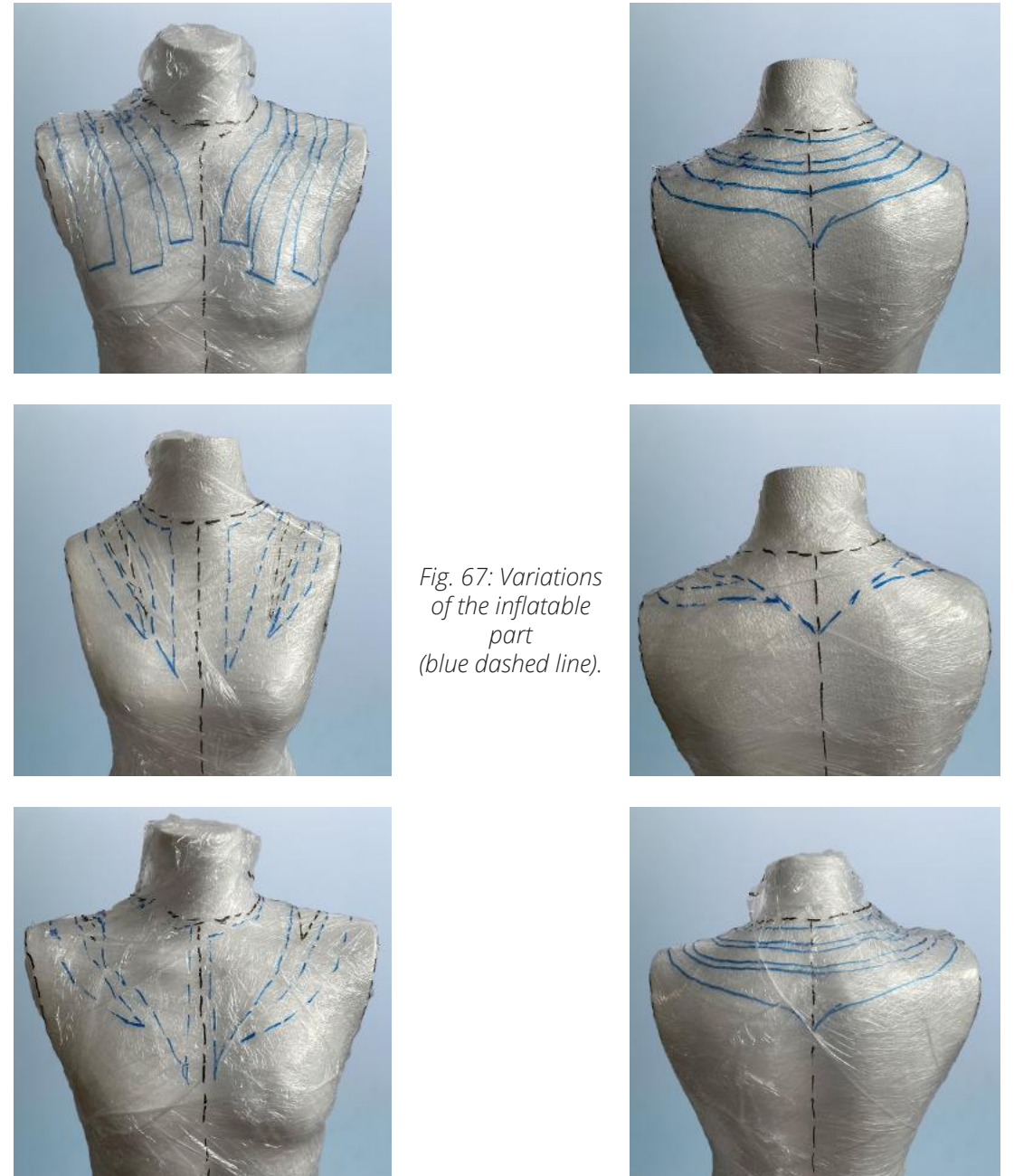


Fig. 67: Variations of the inflatable part (blue dashed line).

The overall shape of the swimming shirt had to be finalised prior to the inflation part.



Fig. 68: Transferring the sewing pattern from foil to paper and fabric.



The basic shape drawn on the foil was transferred to paper, and finally to fabric.

For the first model, a Jersey fabric was used.



Fig. 69: Sewing the first fabric model.

The paper sewing patterns can then also be used for the final model. They are not very accurate, but they will serve as a basis for the final model of the product design.



Fig. 70: Sewing pattern, women, front side.



Fig. 71: Sewing pattern, women, back side.

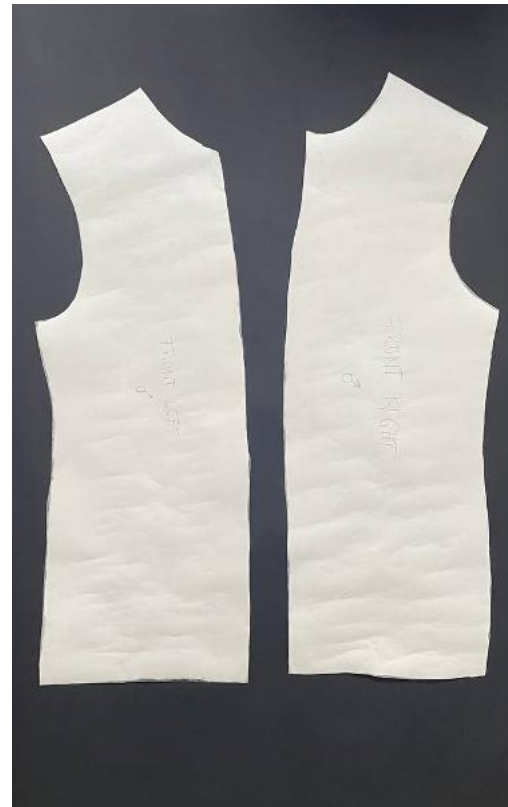


Fig. 72: Sewing pattern, men, front side.



Fig. 73: Sewing pattern, men, back side.

The first basic shape of the swimming shirt for women and men was created. To comply with sustainability, fabric remnants were used for this phase of model building.



Fig. 74: Women, fabric model.



Fig. 75: Men, fabric model.



With the basic layer, a rough shape for the inflating layer was found on a paper sketch. The last, larger image at the bottom of the next page shows the final decision.

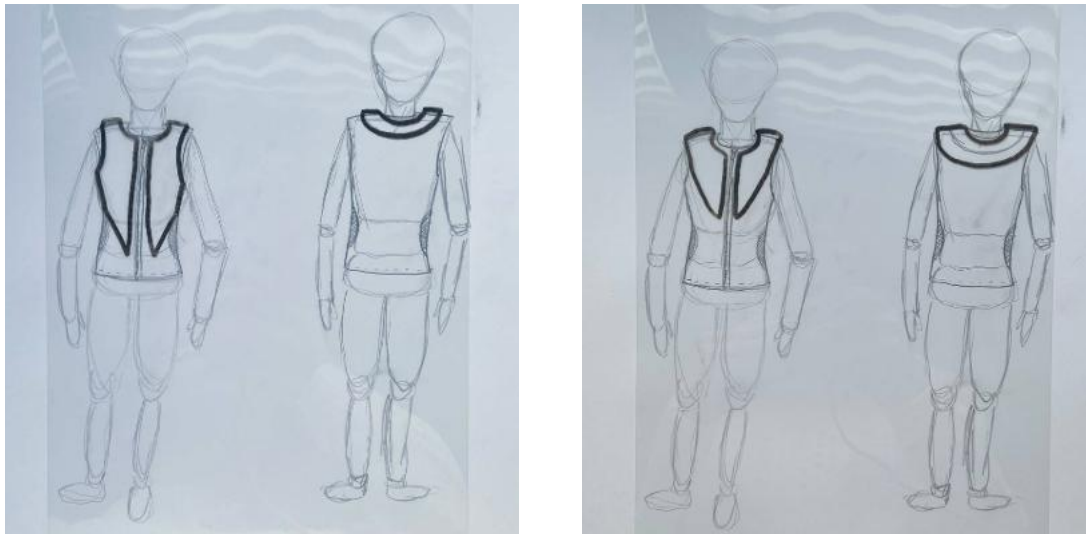


Fig. 76: Drafts of the inflatable part, front and back view.

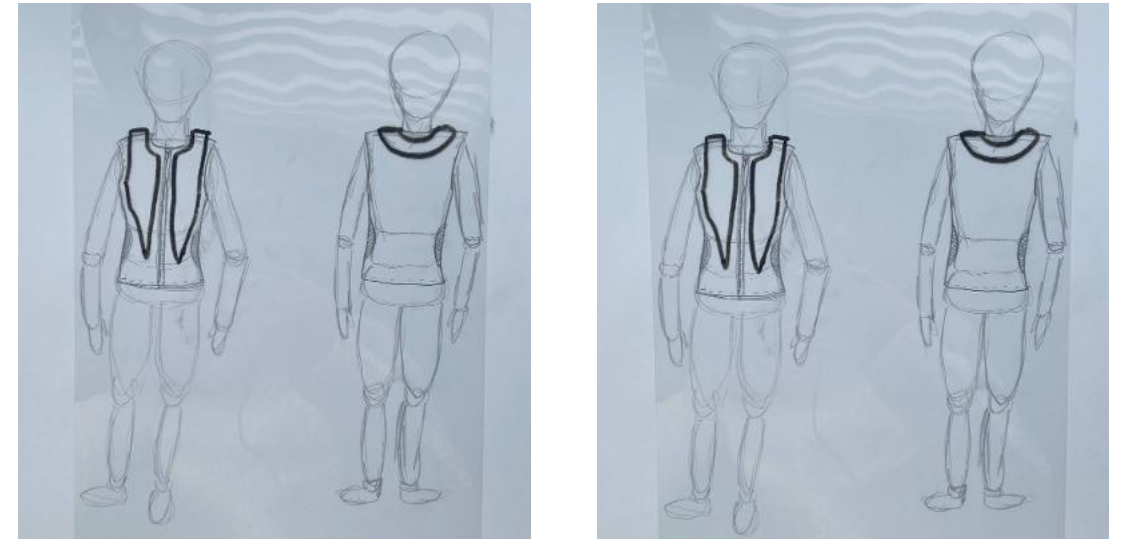
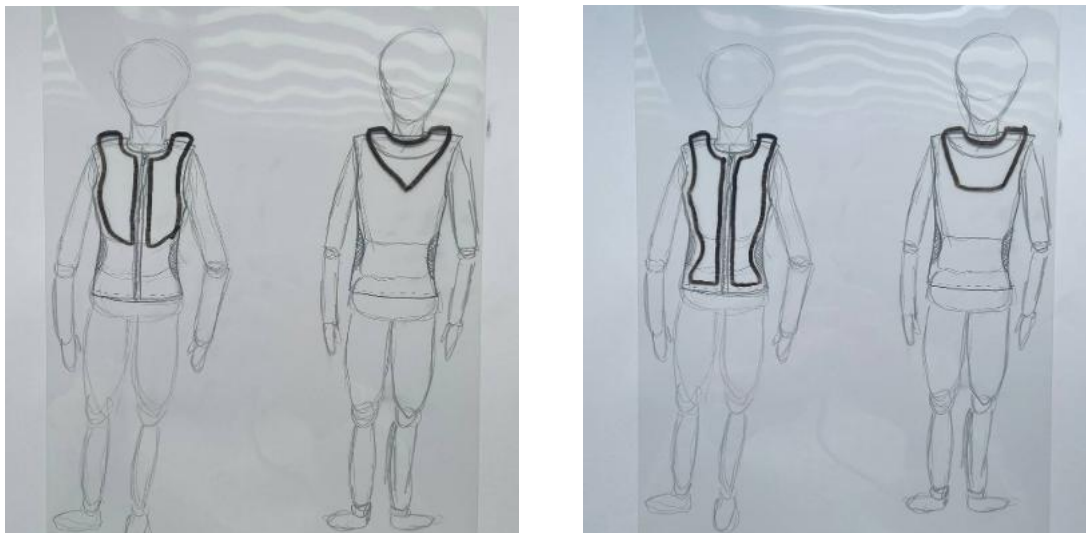
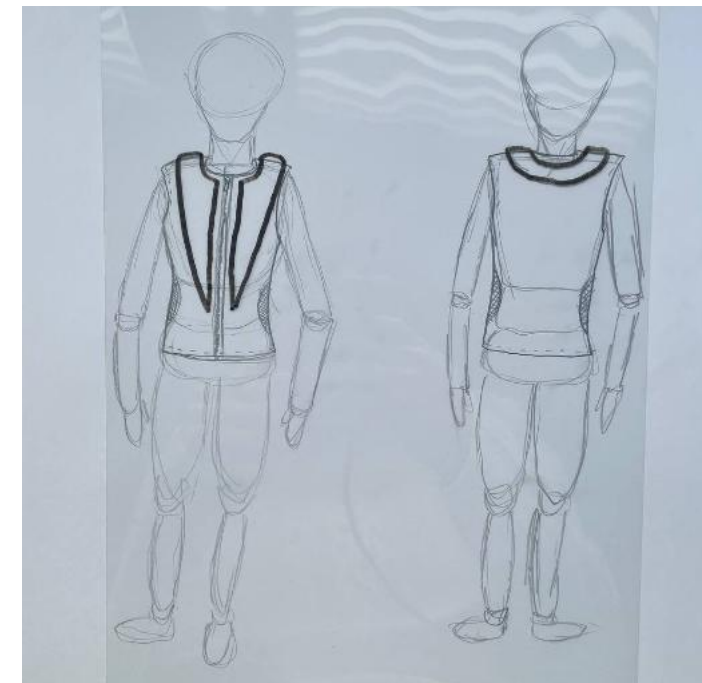


Fig. 77: Drafts of the inflatable part, front and back view, final variation at the bottom.



Colour and Typography

The aim was to use vibrant colours which give a sportive appearance, but mainly serve as signal colours.

In order to give the swimming shirt the classical swimwear aesthetics, a plain colour was added.

I decided for a dark anthracite version with red-orange for men, and a white version with cyan for women.

The product name is written in a bold sportive font. Here I have chosen Acumin Variable Concept ExtraCondensed Bold Italic.

Additionally, lines will be added as graphic elements.

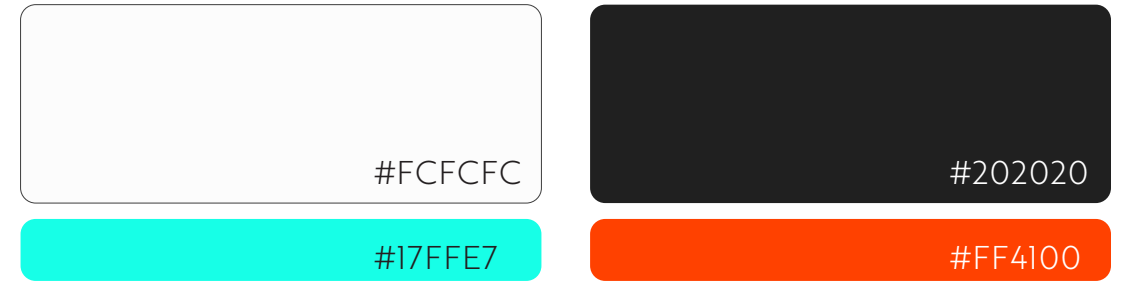


Fig. 78: Defined colours: white and cyan for women (left), dark anthracite and red-orange for men (right) with hex values in RGB.



Fig. 79: Graphic elements consist of lines with different line width.

Aa Bb Cc Dd Ee Ff Gg Hh Ii Jj Kk Ll Mm Nn
Oo Pp Qq Rr Ss Tt Uu Vv Ww Xx Yy Zz
0 1 2 3 4 5 6 7 8 9
. , ! ? # " \$ % & / () = ' + * - ° < >

Fig. 80: Acumin Variable Concept ExtraCondensed Black Italic as product font.

Renderings

With the defined colours, font and graphic elements, a rendering of the sketch was created for the evaluation.

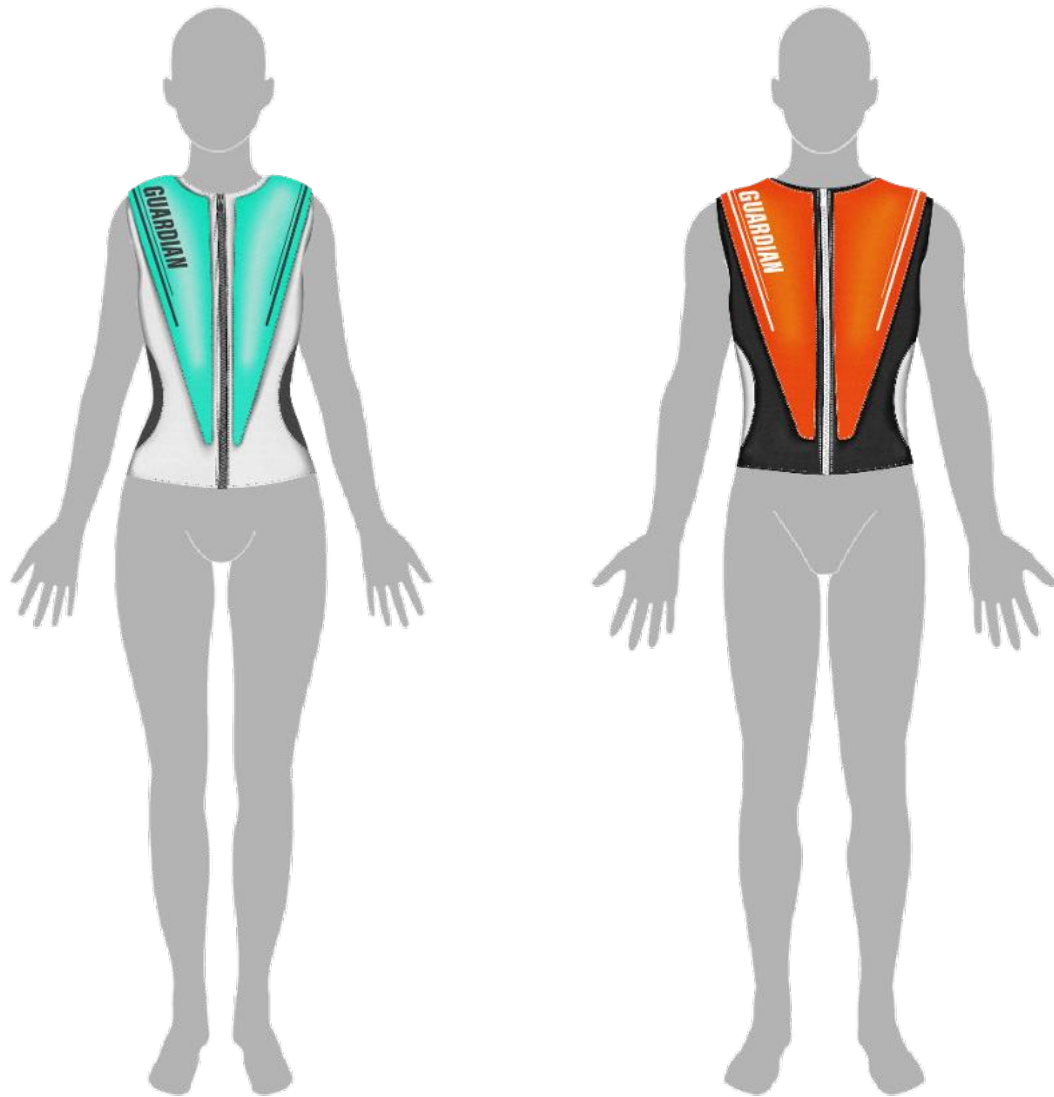


Fig. 81: Rendering of the swimming shirt (left: women | right: men) front view.

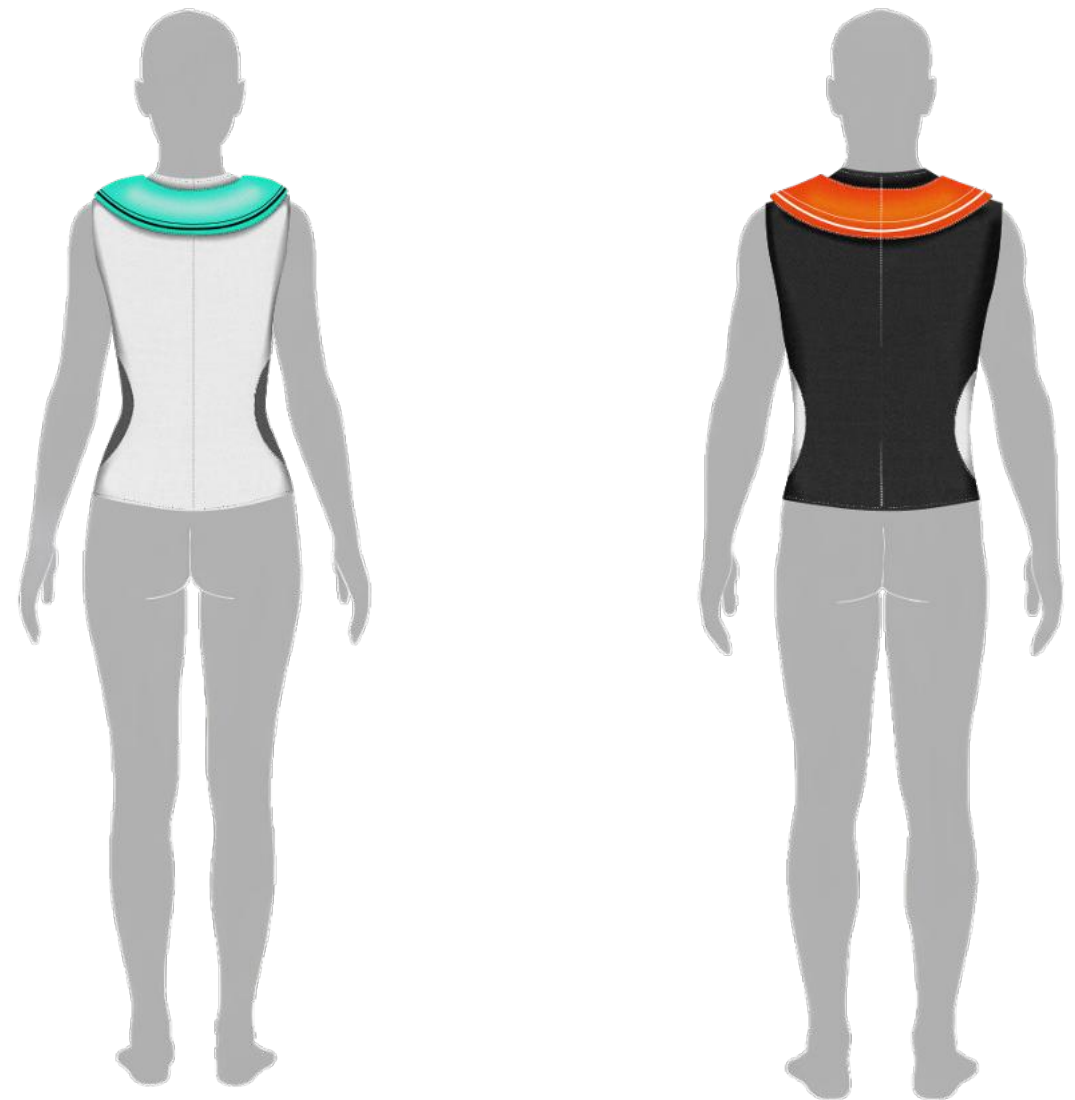


Fig. 82: Rendering of the swimming shirt (left: women | right: men), back view.

For the evaluation, an additional rendering was added, showing where the technical parts will be placed.

The technical components were changed during the evaluation and will be shown in *chapter 14*.

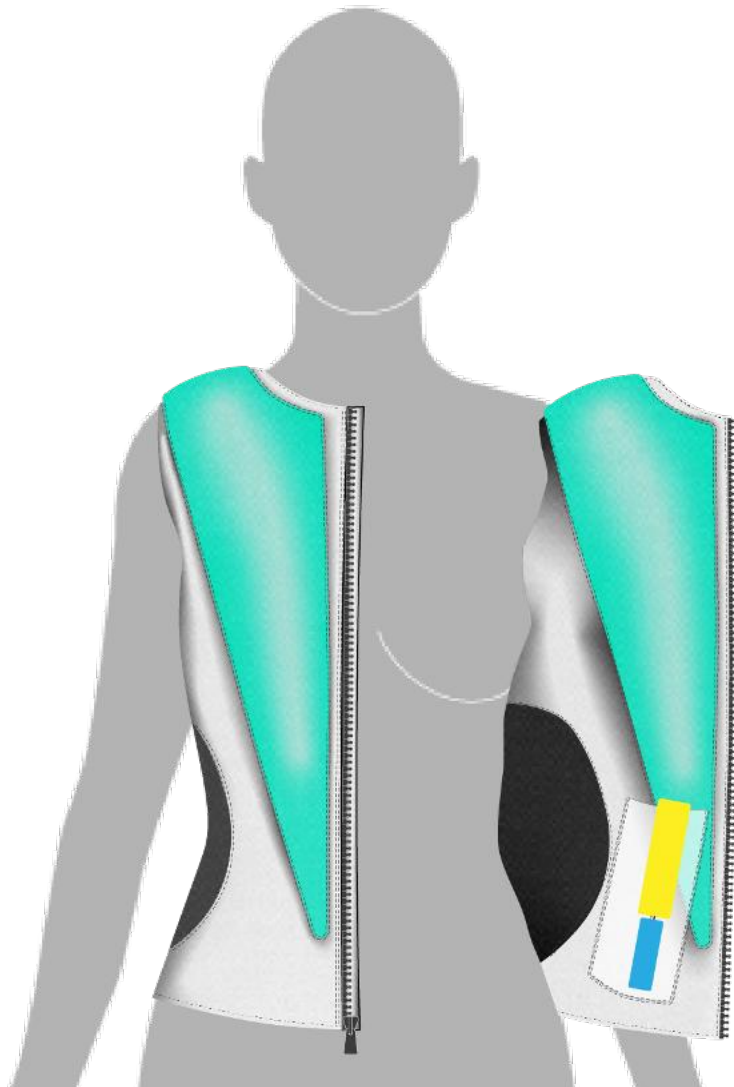


Fig. 83: Rendering of the inside pocket with the first designed technical components, women.



Fig. 84: Rendering of the inside pocket with the first designed technical components, men.

Another layer of clear film was added on the basic swimming shirt shape to apply the inflating layer.



Fig. 85: Inflatable part foil-sewing pattern, women.



Fig. 86: Inflatable part foil-sewing pattern, men.



The resulting paper sewing patterns for the inflatable part are shown here. For less material usage and efficiency reasons, they will only be added in the final model.



Fig. 87: Sewing pattern inflatable part, women, back and front side.

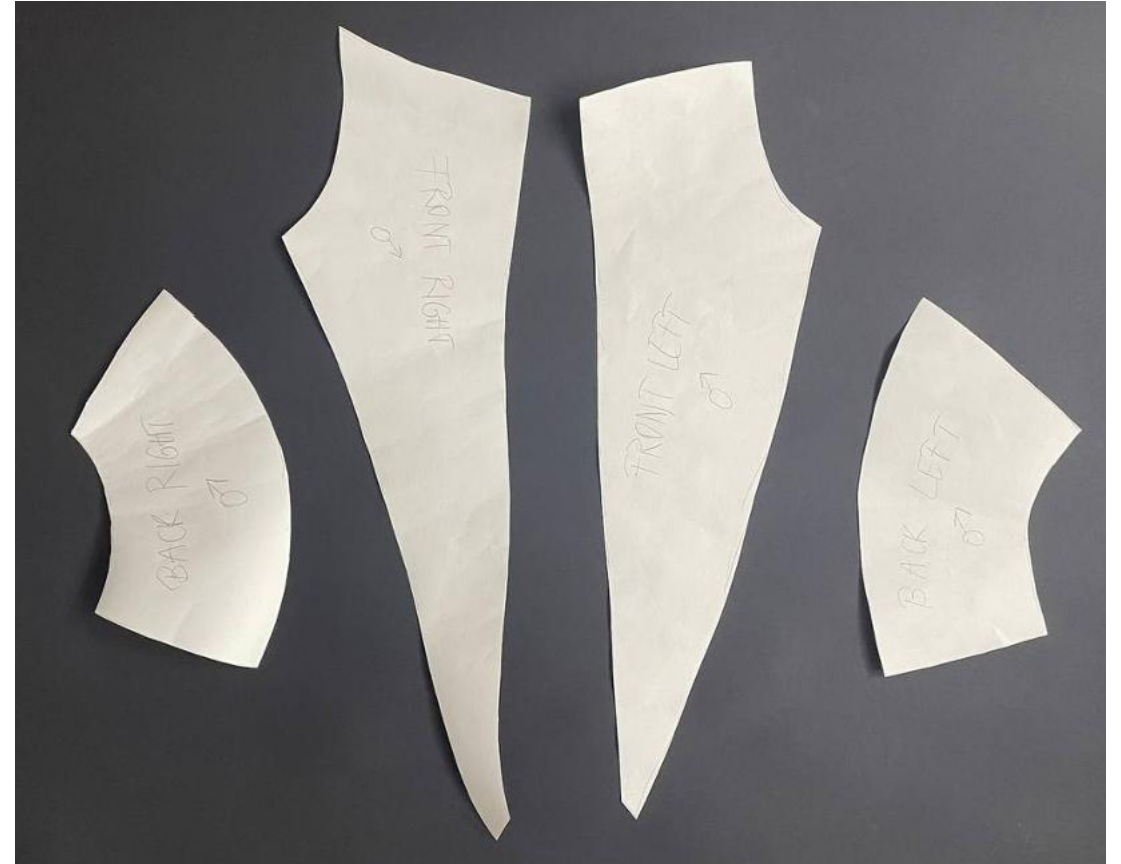


Fig. 88: Sewing pattern inflatable part, men, back and front side.

10.3 Design of the Smartwatch Application

For the UX/UI, the surface of the Apple Watch series 11 was chosen, because it can track the necessary vital values for the defined target group (heart rate, blood oxygen, movement). Additionally, third-party applications exist to connect with e.g. a CGMS.

Following the behaviour of outsiders during a critical situation, the smartwatch should provide an alert followed by a clear and brief instruction about what the outsider is supposed to do to help the person being in an emergency situation. Following the Protective Action Decision Model (PADM), it has to be differed between the pre-decisional and the decisional process [OHK+17]. During the pre-decisional process, the outsider should receive a signal alerting him or her about a critical situation, paying attention to the situation and preparing the outsider to receive necessary information about the situation [OHK+17]. The subsequent decisional process then shows the outsider, that the following information is critically important for the situation, making clear, that his or her actions are necessary to help the person in the emergency situation and making the outsider start acting [OHK+17].

A UX/UI design was created for a persona of a female user living with a generalised Epilepsy. The application was divided in the pre-decisional phase and the decisional phase. In the pre-decisional phase, the application shows an alert screen at the beginning, with a blinking background in red or cyan. The only instruction is to press the button (“digital crown” called by Apple watch). Additionally, an alert sound with the highest possible volume will be played, until the button is pressed. On the next screen, a brief

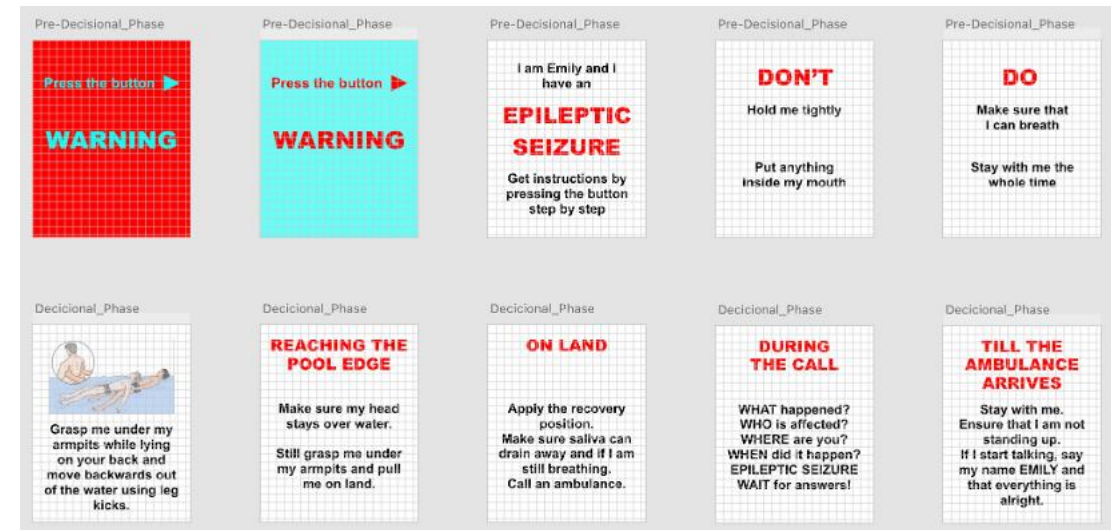


Fig. 89: First UI/UX of an application for Apple Watch series 11, 42 mm. Red and cyan are contrast rich colours which are accessible for colour blind people as well. The navigation works through clicking the digital crown step by step. The grid will be not visible in the application.

instruction is displayed that the person has an emergency and that more instructions will follow step-by-step upon pressing the button. The following two screens briefly summarise what the outsider should and shouldn't do. After the attention of the outsider has been caught, the decisional phase starts: an image shows to the outsider, how the person can be transported through and out of the water. The following screens explain, what should be considered on land and summarises what should be said during the call to the ambulance. At the end, instructions are given about what the outsider is supposed to do, until the ambulance arrives.

The smartwatch application will not be evaluated because of time constraints and because the main focus is set on the product design.

11. Cost Calculation

It should be ensured, that the target group is able and willed to pay the potential price of the final product.

A rough cost calculation can be found in the table on the next page.
An overall price has been calculated for both versions, women and men.

The prices are approximate values based on prices for the model of this work, the current minimum income in Germany and estimated prices for trading margin and turnover for selling in Germany as well as a relatively rough summary of the application development and maintenance.

What	Amount per Shirt	Price per Unit	Total Price
fabric basic shirt 100 x 150 mm	2	5,00 €	10,00 €
fabric inflatable 100 x 150 mm	1	6,00 €	6,00 €
zipper	1	8,00 €	8,00 €
Bluetooth module	1	5,00 €	5,00 €
electromagnetic actuator	1	6,00 €	6,00 €
wiring	4	0,05 €	0,20 €
yellow box	1	1,50 €	1,50 €
blue box	1	1,00 €	1,00 €
water proofness	1	2,70 €	2,70 €
carbon dioxide cartridge 33 g	1	18,00 €	18,00 €
3 V 10-year- battery	4	0,40 €	1,60 €
sewing work per hour	8	15,00	120,00 €
trading margin	1	30,00 €	30,00 €
turnover	1	30,00 €	30,00 €
app development	1	30,00 €	30,00 €
app maintenance	1	30,00 €	30,00 €
			300,00 €

Tab. 1: Approximate cost calculation of the resulting product solution.

12. Evaluation

Another survey should investigate, whether the target group likes the design and can manage the technical components.

To reach as many people as possible of the defined target group, a contact with a doctor working at the Epilepsiezentrum Kleinwachau (Epilepsy Center Kleinwachau) in Germany was established. A survey about the final design of this work was created in collaboration with him. The digital survey was shared on-site with the patients of the Epilepsy Center. The complete survey can be found in Appendix B of this thesis. The survey had to be in German for the patients of the Epilepsy center.

Unfortunately only four people took part in this evaluation.

It was also the aim to ask rescue swimmers about their experiences with rescuing people, especially people with a chronic disease. Therefore, the Deutsche Lebens-Rettungs-Gemeinschaft Dresden (DLRG Dresden) was contacted multiple times. However, no response was received and the survey wasn't filled in by anybody. Because of this, the survey will not be part of the Appendix.

12.1 Demographic Data

Two of the four participants are male, one is female and one answered with "I don't want to answer this question". The participants are in the age between 25 and 64 years. Two of them have a university degree, one completed a training course and one finished secondary school. Three participants do a salaried employment, one is retired.

All participants live with a form of epilepsy, which restricts them in their everyday life and especially makes swimming a riskful activity.

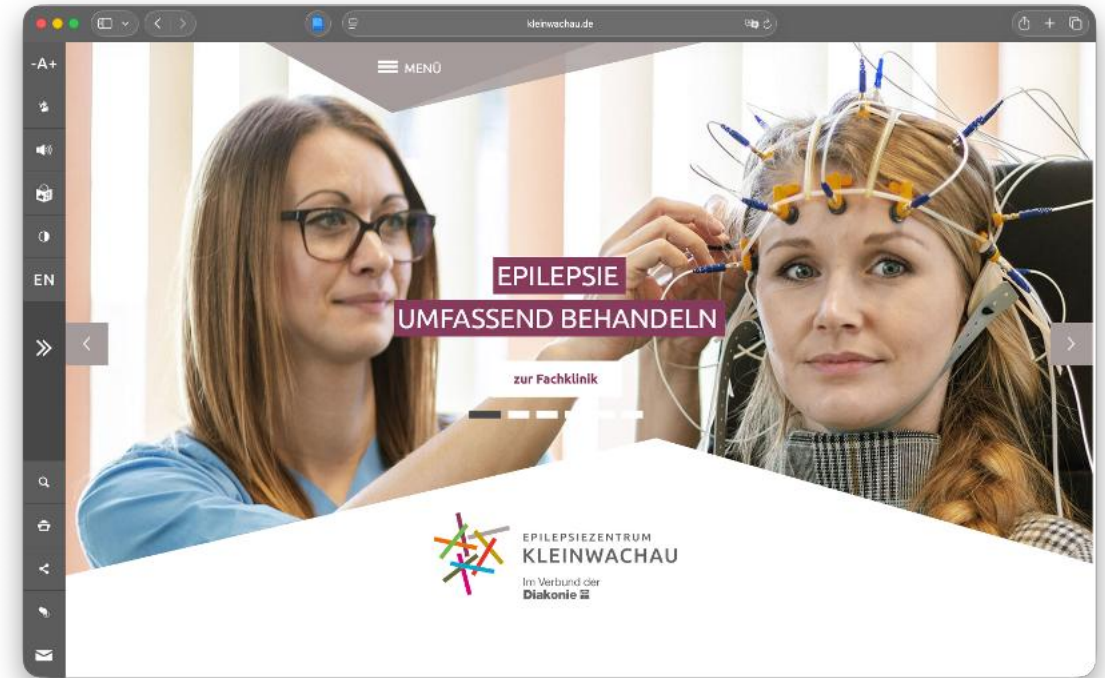


Fig. 90: The hospital in Kleinwachau (Eastern Germany) specialises in patients with epilepsy.

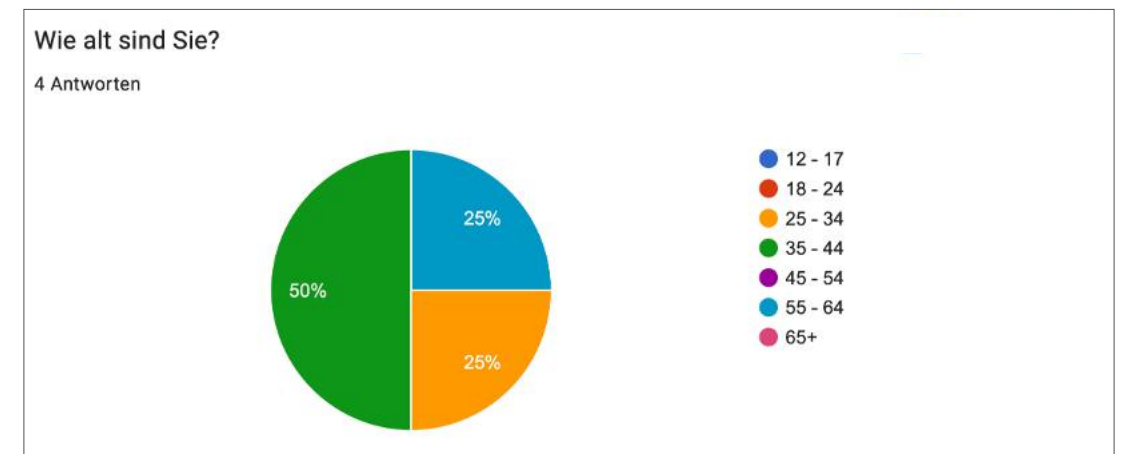


Fig. 91: The age of the participants.

12.2 Questions about Aesthetics

After explaining the application scenario of the product solution, the renderings of the swimming shirt were shown.

Three of the participants like the colours of the product design, one answered “Neither agree nor disagree”. The one, who didn’t agreed to the colour mentioned, that he would prefer a brighter colour. The overall aesthetics was accepted. Three of the participants would buy the designed product solution, regardless the price, one disagreed on that.

After the participants received the information, that the product will cost around 300 € (without the smartwatch), two of the participants changed their opinion from “Agree” to “Neither agree nor disagree”.

Two participants would prefer to buy a product, which includes a wrist-worn device, so that the purchase and usage of an additional smartwatch would be unnecessary. One participant would prefer to use a smartwatch with the swimming shirt. One didn’t agree on either of these statements.

One participant commented, that on the one hand he likes the product not looking too much like a life jacket when its not inflated, but on the other hand that it will probably catch attention in the inflated state as it then more resembles a life jacket.



Fig. 92: Evaluation, whether the participants like the overall aesthetics of the design.

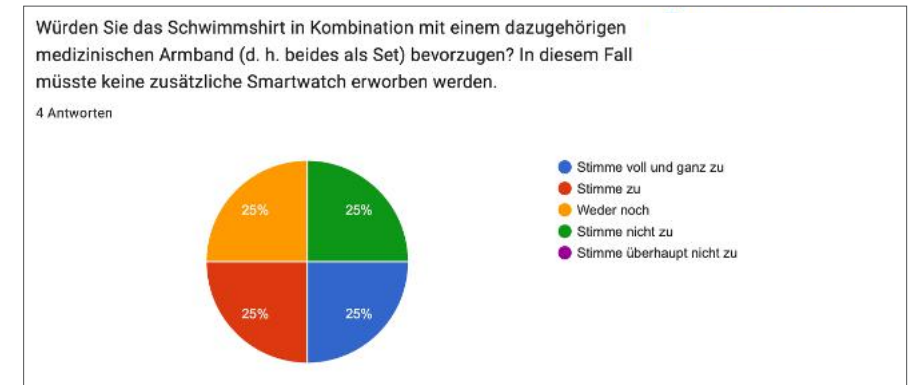


Fig. 93: Evaluation, whether the participants prefer a medical wrist-worn device.

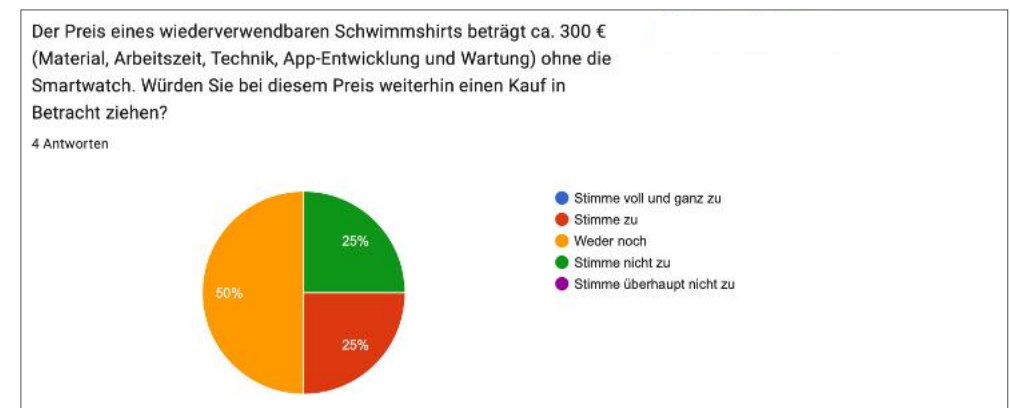


Fig. 94: Evaluation, whether the participants would pay the calculated price.

12.3 Questions about Practicability

During the evaluation, the exchange of both the carbon dioxide cartridge and the batteries was shown to the participants.

Three of the participants would be able to change the carbon dioxide cartridge on their own and find it moreover unnecessary to hand this task to a proven expert. One participant would prefer a proven expert exchanging the carbon dioxide cartridge.

Also, the exchange of the battery doesn't seem like a problem to the participants; all prefer exchanging them on their own.

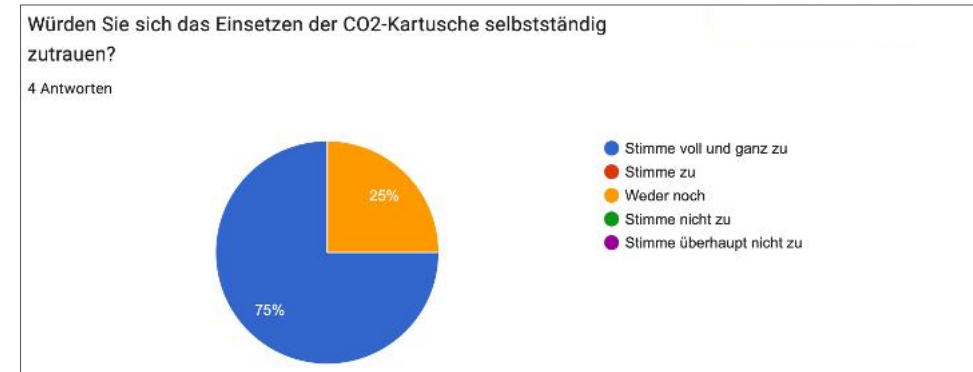


Fig. 95: Evaluation, whether the participants would exchange the cartridge themselves.

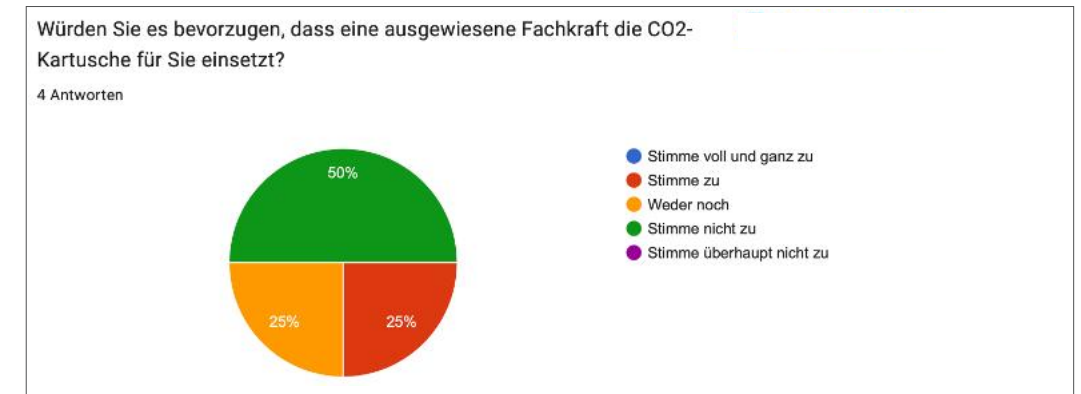


Fig. 96: Evaluation, whether the participants would prefer an expert exchanging the cartridge.

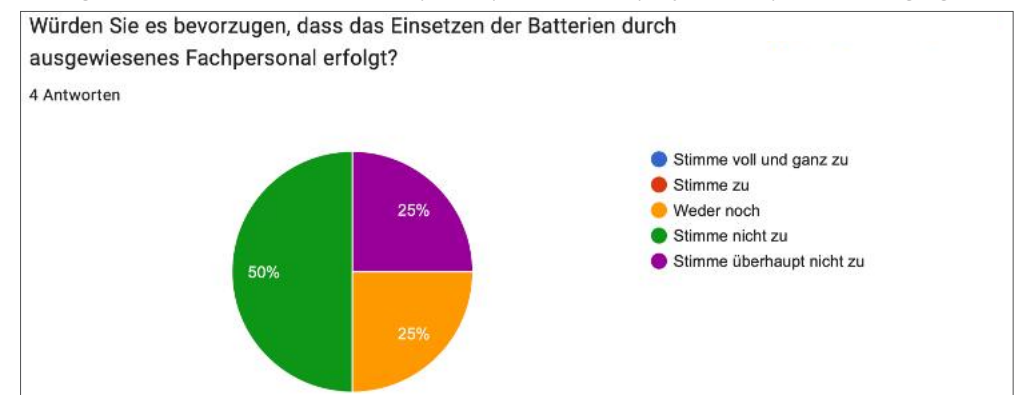


Fig. 97: Evaluation, whether the participants would have the batteries exchanged by an expert.

13. Model Building

The aim was to create a 1:1 physical model for both women and men, such that design decisions can be better assessed. The physical model will not be a working prototype and will miss the final details. Additionally, there will be only one non-inflated version for women and one inflated version for men, because of the limited time for this thesis.

To get an authentic look, nylon fabric and zippers were used.



Fig. 98: The nylon fabrics and zippers.

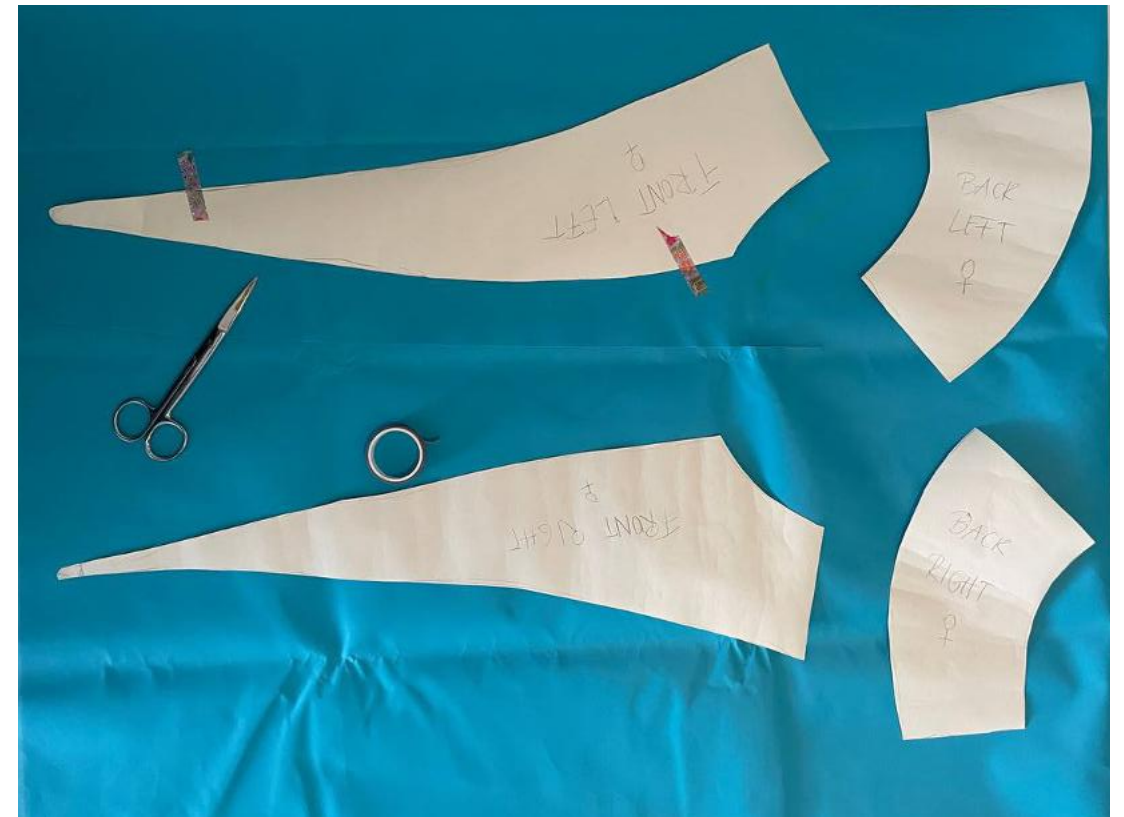


Fig. 99: Transferring the sewing pattern from the first fabric model to the nylon.

The model for women is supposed to show, how the swimming shirt will look from the outside and inside, as well as how the technical components will be placed.

Due to the high transparency of the white nylon fabric, a double layer of the latter was used. This was then combined with an inside and outside layer of the cyan inflatable part. A pocket was added to one inside layer to provide space for the technical components.



Fig. 100: Two layers sewn together, back parts.



Fig. 101: The two back parts sewn together.



Fig. 102: Notches were added to enable sewing the convex and concave shapes together.



Fig. 103: The added inside pocket.

The model for men is supposed to show, how the swimming shirt will look like, when its inflated. To this end, foam was added for the inflating parts. For this purpose, the sewing pattern of the inflating parts needed to be adjusted. This again happend using the foil technique.



Fig. 104: Model without inflating part, men.



Fig. 105: Foam for the inflating part.



Fig. 106: Adjusted sewing pattern for the inflating part, front side.



Fig. 107: Adjusted sewing pattern for the inflating part, back side.

The parts of the box as well as the bracket and the carbon dioxide cartridge were printed out as white and black versions with recyclable PLA 3D-printing material.

The branding was added afterwards with spray paint.

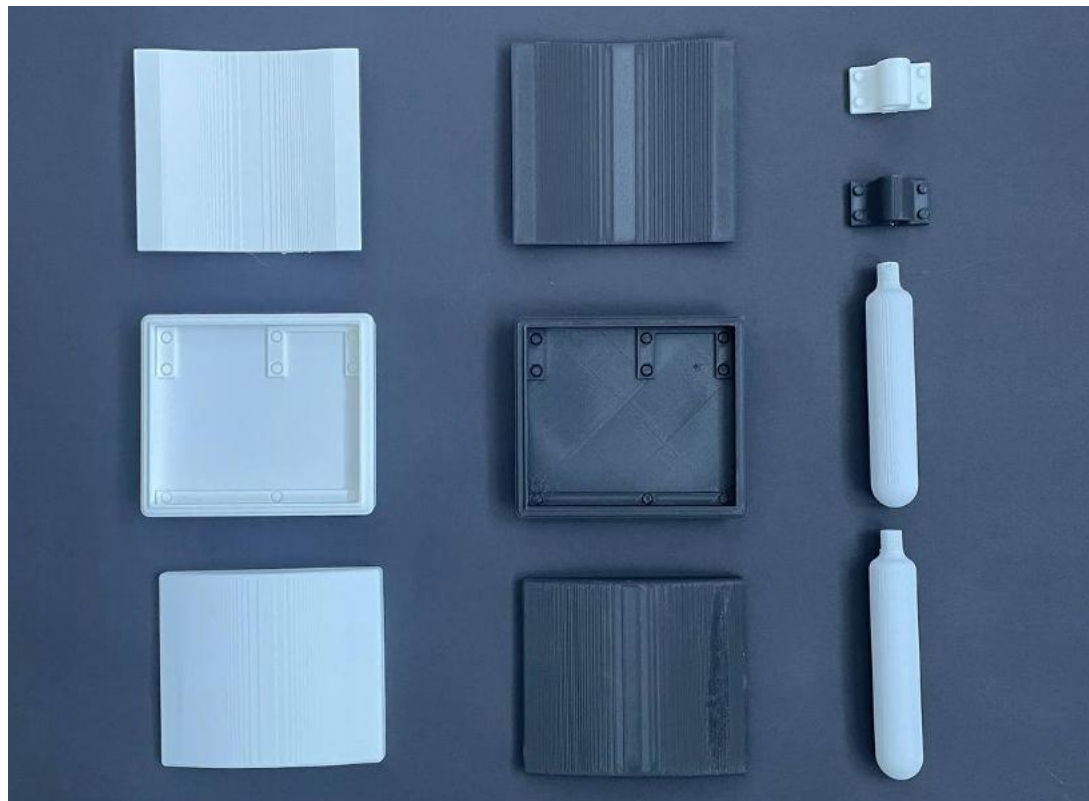


Fig. 108: The technical components and the 33 g carbon dioxide cartridges, printed with PLA.



Fig. 109: Carbon dioxide cartridge in bracket, connected to the technical components.



Fig. 110: Final model, non-inflated, front side, women



Fig. 111: Final model, non-inflated, back side and inside, women





Fig. 112: Final model, inflated, front side, men



Fig. 113: Final model, back side and box close-up, inflated, men



14. Result

The refined technical components were changed in the renderings. Additionally, the following changes were added as well:

- The patches on the left and right sides in the lumbar region got expanded to the arms. They consist of a flexible, bendable fabric called polyester lycra blend, which is often used for swim wear. The same kind of fabric was added in the neck region, to ensure a better movement while swimming. The colour of the patches was changed to black in the version for men.
- The inside pocket for the technical components got bigger to provide a higher comfort while swimming.
- A matching pair of swimming shorts was added for both women and men. It is possible to wear any kind of swimming shorts to the swimming shirt, but thereby, a uniform design language is created.
- The box is considered to be smaller as the one at the physical model. This can probably be ensured by a smaller battery and an overall refinement of the technical components.

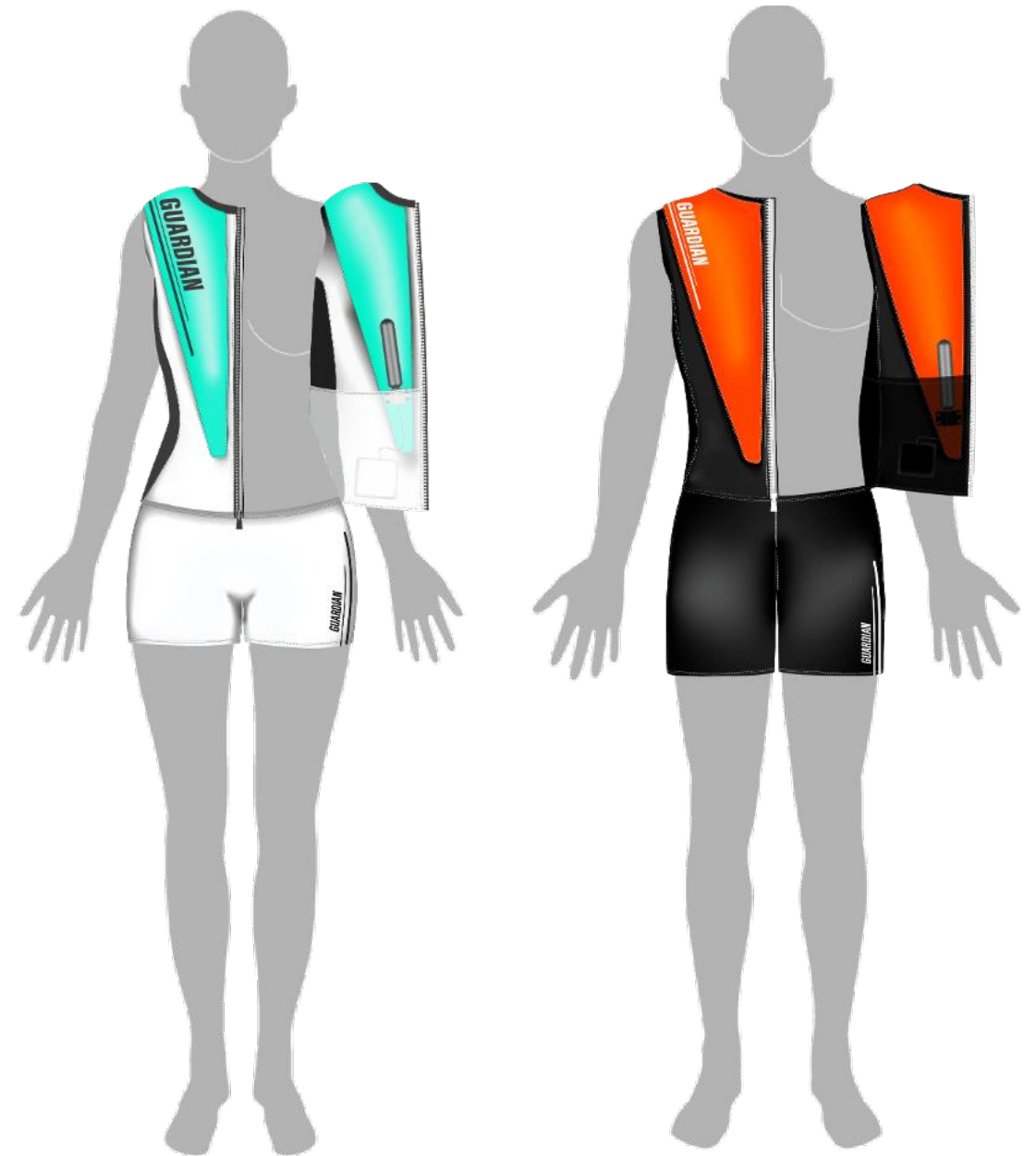


Fig. 114: Final rendering with inside pocket and technical components, women (left), men (right).

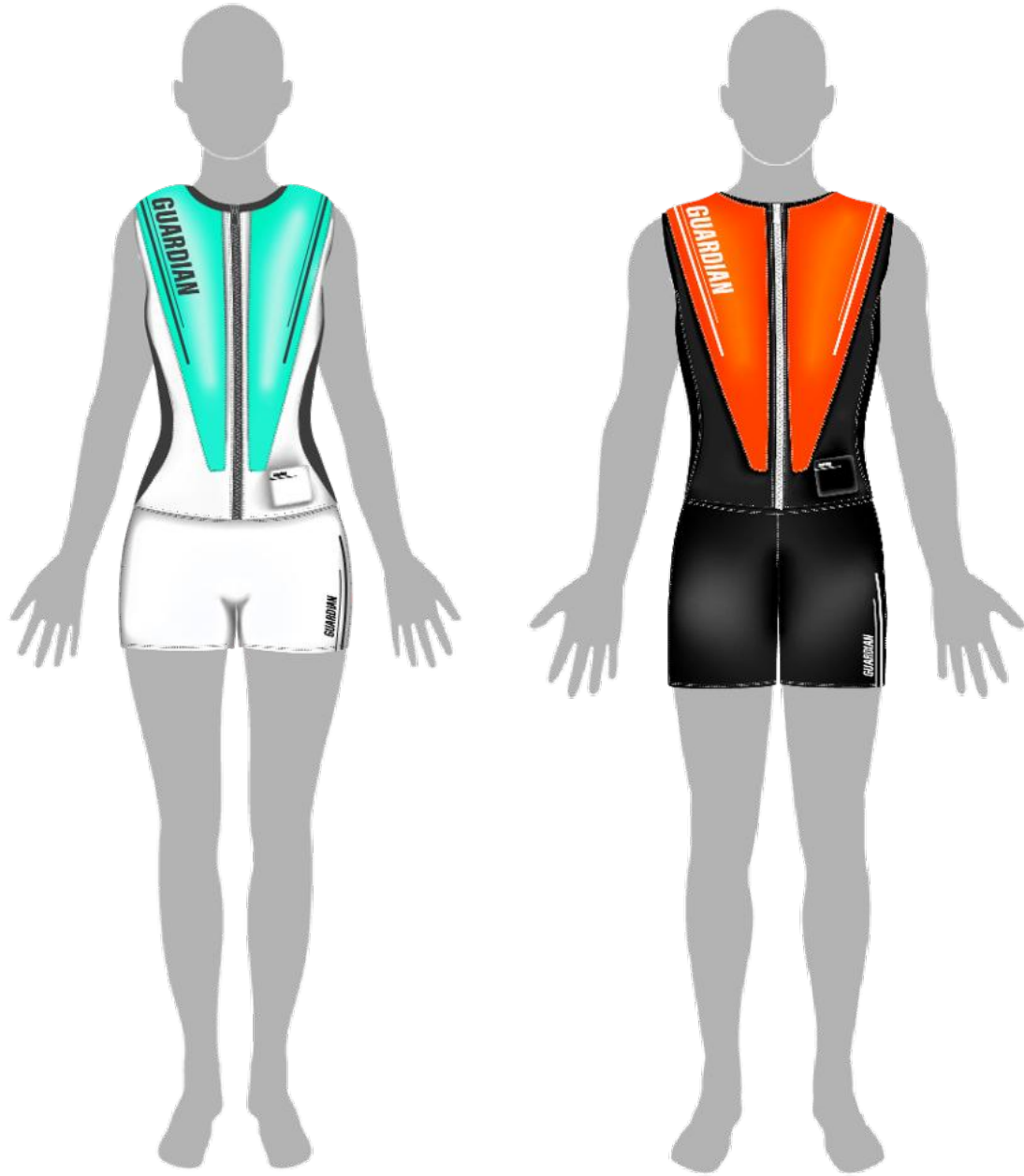


Fig. 115: Final rendering non-inflated, front view, women (left), men (right).



Fig. 116: Final rendering, non-inflated, back view, women (left), men (right).

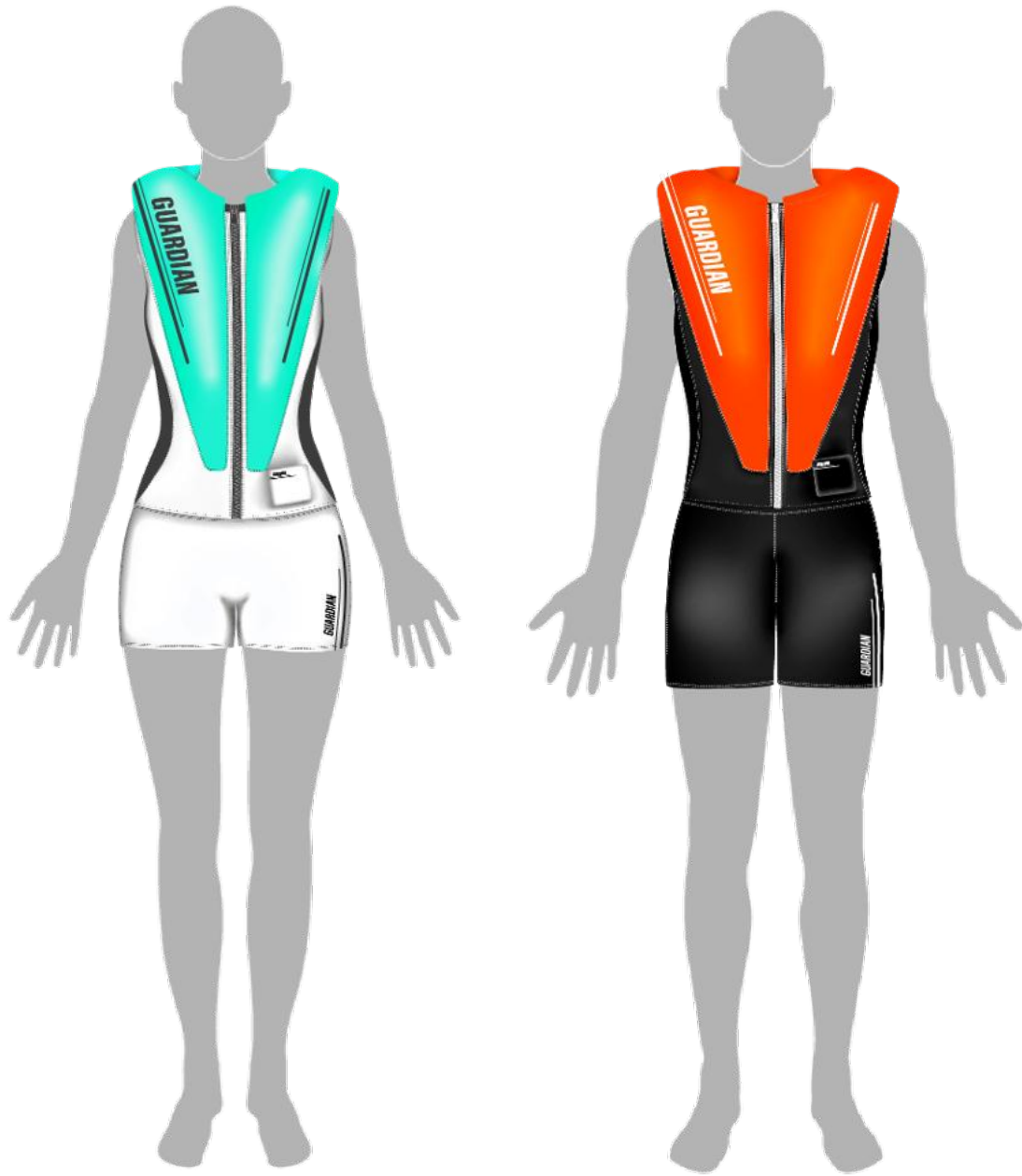


Fig. 117: Final rendering, inflated, front view, women (left), men (right).

Result



Fig. 118: Final rendering, inflated, back view, women (left), men (right).

Result

105



Fig. 119: Product in application case, women.

Result



Fig. 120: Product in application case, men.

Result

15. Conclusion

The aim of this work was to create a product solution to make people living with a chronic disease with the risk of spontaneous fainting more independent and giving them a higher feeling of safety while swimming. Technical and medical research as well as comparing already existing products showed, that it is possible to create a potential product solution. It was necessary to separate the device tracking the vital function from the inflating clothing. This is because – especially for persons with epilepsy – it is necessary to have long-time statistics about the individual vital function values beyond swimming times.

During the evaluation, the resulting design was widely accepted by the defined target group. In comparison, the potential cost for the product (without the smartwatch) was accepted only by half the participants, while the other half merely regarded the price too high.

The product itself has a high sustainability, because of its reusability and the usage of pure Nylon for the fabric and sewing threads, making it easier to recycle. One potential caveat is the need to separate the nylon from the polyester lycra blend.

Also, the development and maintenance of the smartwatch application is not expected to require many resources because of its minimalistic design. It should be considered creating a product together with already existing technology (e.g. SeizAlarm or Dexcom) to ensure a well-working product customised to the specific chronic disease of the potential user. In this context, the usage of devices or wristbands from medical companies serves as an interesting ansatz and can be considered as well.

To obtain a fully applicable product, more technical refinement and testing is required, especially regarding the inflation mechanism and the connection between swimming shirt and smartwatch. This will be necessary to obtain a medical product capable of saving the user's life in the worst case. Regarding this technical refinement, it may be necessary to adjust the design, but the overall appearance can remain as presented in this work.

Appendix

Appendix A - Survey before the Draft Phase

Introduction:

Thank you for choosing to participate in my research! My name is Nele Drechsler, I am a design student at Dresden, Germany. Through the following questions, you will help me understand how people living with a chronic disease are restricted in swimming. This study is part of a my Bachelor thesis for the Bachelor of arts in Product and Communication Design at HTW Dresden Hochschule für Technik und Wirtschaft — University of applied sciences.

To take part, you must have a diagnosed chronic disease like epilepsy, a heart disease, diabetes, or any other disease with the risk of spontaneous unconsciousness. The questionnaire will take approximately 10 minutes to complete. You have the right to withdraw from the study at any time without any consequences, simply by closing your browser. All responses will be treated anonymously and analyzed collectively, solely for research purposes.

If you have any questions, please contact me at

nele.drechsler@stud.htw-dresden.de

Questions about the Disease:

subject	Date and Time	Do you have at least one of the following chronic diseases?	Please briefly describe your chronic disease here:
1	2025/11/02 10:51:52 AM MEZ	heart issues	Heart disease with reoccurring ventricular Tachycardia, POTS, both cause fainting
2	2025/11/02 11:06:18 AM MEZ	diabetes	Diabetes Type One
3	2025/11/02 11:10:44 AM MEZ	heart issues	Long-Covid (POTS)
4	2025/11/02 12:18:12 PM MEZ	something else	Eye migraine
5	2025/11/02 1:22:48 PM MEZ	epilepsy	Jugendepilepsie
6	2025/11/02 1:38:17 PM MEZ	epilepsy	
7	2025/11/03 1:01:36 PM MEZ	epilepsy	Seit 2,5 Jahren diagnostiziert mit Epilepsie, seither anfallsfrei unter Medikation mit Lamotrigin
8	2025/11/04 3:53:23 PM MEZ	epilepsy	Bei Epilepsie treten kurzzeitig übermäßige Entladungen im Gehirn aus wodurch Anfälle ausgelöst werden
9	2025/11/05 3:19:37 PM MEZ	diabetes	Diabetes type 1 and Hypothyroidism
10	2025/11/10 10:50:55 PM MEZ	epilepsy	generalized epilepsy, Grand-mal
11	2025/11/10 10:54:46 PM MEZ	epilepsy	

subject	Are you restricted in your everyday life by your chronic disease?	Some chronic diseases (like e.g. epilepsy) can drastically increase the risk of drowning, making external supervision absolutely mandatory when taking a bath or swimming. Regarding your chronic disease, would you agree with this statement?
1	Agree	Agree
2	Agree	Agree
3	Agree	Disagree
4	Agree	Disagree completely
5	Disagree	Disagree completely
6	Disagree	Agree
7	Agree	Agree
8	Neither agree nor disagree	Agree
9	Agree	Agree
10	Agree	Agree completely
11	Disagree	Neither agree nor disagree

What could be worries of you, if you go swimming completely on your own? Describe it shortly here:
Sudden arrhythmia could make scoring the water more difficult
hypos and hypers during the activity, so I could possibly lose control over myself or lose consciousness
Solange man sich bewegt ist das Risiko gering, aber danach kann schwierig sein, weil Puls und Blutdruck schnell abfallen können. Ich hätte Angst, ab Beckenrand oder in der Umkleide umzukippen
Dass ich ertrinke, weil ich mein Bewusstsein bei einem Anfall verliere oder aber es für mögliche Retter schwierig ist mich während eines Krampfanfalls Retten zu können
Die Gefahr während des Schwimmens einen epileptischen Anfall zu bekommen und dadurch Gefahr zu laufen unterzugehen ohne, dass es eine externe Person es mitbekommt und mich retten kann.
Durch kurzzeitige Aussetzer zu ertrinken oder durch das umkippen irgendwo mit dem Kopf gegen einen spitzen Gegenstand zu kommen
I would be worried to have an hypoglycaemia and not realise it and have no strength to swim
If really don't feel comfortable swimming completely unsupervised. I am under medication and the risk of having an epileptic seizure is only minor, but if it would occur, the risk of drowning would be way too high. Especially if there is no person nearby that is "informed" about my chronic disease. This includes the lifeguard, who typically doesn't know about my disease (only my family members and friends know).
Man hat immer im Hinterkopf, den Gedanken, es könnte wieder zu einem Anfall kommen. Deshalb schwimmt nicht allein in tiefere Gewässer.

Imagine a product in the form of swimwear or a tool that you could wear while swimming. This product would be linked to a smartwatch with an installed app tracking your heart rate, blood-oxygen level and your motion. If the smartwatch detects a critical situation (such as an epileptic seizure, a heart attack or a glycaemic shock), it triggers a rescue mechanism that makes it easier to get you out of the water, e.g. by automatically inflating the product, like a life jacket.

subject	Would you consider trying or even buying such a product?	How much money would you pay for such a product (only the product without the smartwatch)
1	Agree completely	51 - 100 €
2	Agree	51 - 100 €
3	Disagree	101 - 200 €
4	Agree	101 - 200 €
5	Neither agree or disagree	1 - 50 €
6	Agree	51 - 100 €
7	Agree	51 - 100 €
8	Agree	101 - 200 €
9	Agree	1 - 50 €
10	Agree completely	51 - 100 €
11	Disagree	201 - 300 €

subject	Would you prefer a product that resembles current swimwear (swim shorts, bikini, swimsuit)?
1	Agree
2	Neither agree or disagree
3	Agree
4	Neither agree or disagree
5	Agree completely
6	Agree completely
7	Agree
8	Neither agree or disagree
9	Agree
10	Agree
11	Neither agree or disagree

If you usually only wear swim shorts or a bikini for swimming, would you be open to wear a swimsuit which covers your thorax and abdomen?
Agree
Agree
Agree
Agree
Disagree
Agree
Agree completely
Agree
Disagree
Neither Agree or Disagree
Disagree completely

subject	If you usually only wear swim shorts or bikini for swimming, would you be open to wearing a swim shirt which covers your thorax (additionally to your usual swim wear)?	Would you prefer a product, that you could wear additionally to your normal swim clothes like a belt or a waistcoat?
1	Agree	Disagree
2	Agree	Agree completely
3	Agree completely	Disagree
4	Agree	Agree
5	Disagree	Disagree
6	Agree	Agree
7	Disagree	Agree
8	Neither agree or Disagree	Agree completely
9	Neither agree or Disagree	Disagree
10	Agree	Agree completely
11	Agree	Agree

Would it be okay for you to use a smartwatch (e.g. Apple Watch, Samsung Watch, etc.) to use the product for swimming?
Yes, I own one, which I could use in particular for this product.
Yes, I already have one which I am wearing almost every day.
Yes, I own one, which I could use in particular for this product.
No, I would prefer a wristband or something similar delivered with this product solely for this purpose.
Yes, I already have one which I am wearing almost every day.
Yes, I own one, which I could use in particular for this product.
Yes, I already have one which I am wearing almost every day.
Yes, I would consider buying a smartwatch to use this product.
Yes, I would consider buying a smartwatch to use this product.
No, I would prefer a wristband or something similar delivered with this product solely for this purpose.
Yes, I would consider buying a smartwatch to use this product.

subject	If you do not want to buy or wear a smartwatch or wristband, please briefly explain your reasons here:
1	
2	
3	Habe eine, vergesse aber immer sie dran zu machen, vor allem nach dem Laden
4	
5	
6	
7	
8	
9	
10	I would be open to wearing a wristband, but would refuse the usage of a smartwatch for the following reasons: 1) I don't own a smartwatch and I don't want to buy one that I only use for this purpose. 2) I believe that a gadget (like a wristband), solely developed for detecting critical situations can be superior. 3) General data protection.
11	

Do you have any other recommendations or things to say?
Really cool idea! Would love to have an option like this for swimming:)
Bin vielleicht nicht ganz die Zielgruppe, da schwimmen meiner Krankheit eher gut tut :')
Mich würde als Kunde oder tester interessieren wie ich sicher sein kann, dass das Gerät keine Fehlauflösung bei einer großen Anstrengung haben kann und ob es mir bei auslösung durch zu hohen Druck irgendwie gefährlich werden könnte
I have been living with epilepsy for many years. Fortunately, the form that that I have can be treated very well with medication and I did not suffer from any epileptic seizures since medication started. There are some restrictions in my everyday life that I can handle. The real challenge however is, in my opinion, that epilepsy is not yet noticed or "accepted" as much as other illnesses like e.g. a broken leg. I believe that the development of new swimming gear for people like me would be a good step towards more acceptance of epilepsy.

Demographic Data:

subject	How old are you?	Your gender?	What is your highest education? (to map the answer to the German education system, you find the German pendant in brackets after each choice)
1	18 - 24	female	A-levels (Abitur)
2	18 - 24	female	University degree (Hochschulabschluss)
3	18 - 24	female	A-levels (Abitur)
4	25 - 34	female	University degree (Hochschulabschluss)
5	18 - 24	male	University degree (Hochschulabschluss)
6	18 - 24	female	A-levels (Abitur)
7	18 - 24	female	A-levels (Abitur)
8	18 - 24	female	A-levels (Abitur)
9	25 - 34	female	University degree (Hochschulabschluss)
10	25 - 34	male	University degree (Hochschulabschluss)
11	65	male	University degree (Hochschulabschluss)

Employment relationship
student
full-time employment
student
student
student
student
student
student
full-time employment
Other

Thank you for your time! I would be happy, if you could share this form with other people.

Appendix B - Evaluation after the Draft Phase

Introduction:

Vielen Dank, dass Sie sich für die Teilnahme an meiner Studie entschieden haben!

Mein Name ist Nele Drechsler, ich bin Designstudentin in Dresden.

Mit den folgenden Fragen helfen Sie mir meine entstandene Produktlösung für Menschen mit chronischen Erkrankungen zu evaluieren.

Diese Studie ist Teil meiner Bachelorarbeit für den Bachelor of Arts in Produkt- und Kommunikationsdesign an der Hochschule für Technik und Wirtschaft Dresden. Die Arbeit wird an der Fakultät Design unter Betreuung von Prof. Christian Scholz durchgeführt.

Um teilzunehmen müssen Sie eine diagnostizierte chronische Erkrankung wie Epilepsie, eine Herzerkrankung, Diabetes oder einer andere Krankheit haben, die das Risiko einer spontanen Bewusstlosigkeit mit sich bringt. Das Ausfüllen des Fragebogens dauert etwa 15 Minuten. Sie haben das Recht, jederzeit ohne Konsequenzen aus der Studie auszusteigen, indem Sie einfach Ihren Browser schließen.

Die Teilnahme erfolgt anonym. Es werden keine personenbezogenen Daten (Name oder E-Mail-Adresse) erhoben. Die Auswertung erfolgt ausschließlich zu Forschungszwecken.

Falls Sie nicht in der Lage sind den Fragebogen selbstständig auszufüllen, können Sie ihn selbstverständlich mit einer Hilfsperson oder einer erziehungsberechtigten Person ausfüllen.

Wenn Sie Fragen haben, wenden Sie sich bitte per E-Mail (nele.drechsler@stud.htw-dresden.de) oder Telefon (+49 177 5289636) an mich.

Questions about the Disease:

subject	Zeitstempel	Haben Sie mindestens eine der folgenden Erkrankungen (Mehrfachauswahl möglich)?	Bitte beschreiben Sie kurz Ihre chronische Erkrankung:
1	1/5/2026 18:33:52	Epilepsie	generalisierte Epilepsie, Grand mal
2	1/6/2026 15:00:26	Epilepsie	Epileptische Anfälle seit dem 12. Lebensjahr
3	1/7/2026 12:10:45	Epilepsie	Epilepsie. Anfälle mit Ankündigung durch Angstaure
4	1/13/2026 15:04:52	Epilepsie	Epilepsie mit 2-3 Anfällen pro Monat

subject	Fühlen Sie sich im Alltag durch Ihre chronische Erkrankung eingeschränkt?	Einige chronische Erkrankungen (wie z. B. Epilepsie) können das Risiko zu Ertrinken erhöhen, sodass eine Aufsicht durch Dritte beim Baden oder Schwimmen erforderlich ist. Würden Sie diese Aussage in Bezug auf Ihre chronische Erkrankung bestätigen?
1	Stimme zu	Stimme voll und ganz zu
2	Stimme zu	Stimme zu
3	Weder noch	Stimme zu
4	Stimme zu	Stimme voll und ganz zu

subject	Was könnte Ihnen Sorgen bereiten, wenn Sie ganz allein schwimmen gehen? Beschreiben Sie es hier kurz:	Was könnte Ihnen Sorgen bereiten, wenn Sie ganz allein schwimmen gehen? Beschreiben Sie es hier kurz:
1	Ich kann mir tatsächlich nicht vorstellen, allein Schwimmen zu gehen, weil es leichtsinnig wäre: Durch meine Medikation bin ich zwar seit vielen Jahren anfallsfrei, aber das Restrisiko bleibt.	Ich kann mir tatsächlich nicht vorstellen, allein Schwimmen zu gehen, weil es leichtsinnig wäre: Durch meine Medikation bin ich zwar seit vielen Jahren anfallsfrei, aber das Restrisiko bleibt.
2	Ich könnte während eines Anfalls ertrinken, schwimmen gern in Naturgeässern	Ich könnte während eines Anfalls ertrinken, schwimmen gern in Naturgeässern
3	Einen Anfall zu erleiden während des Schwimmens	Einen Anfall zu erleiden während des Schwimmens
4	Ertrinken	Ertrinken

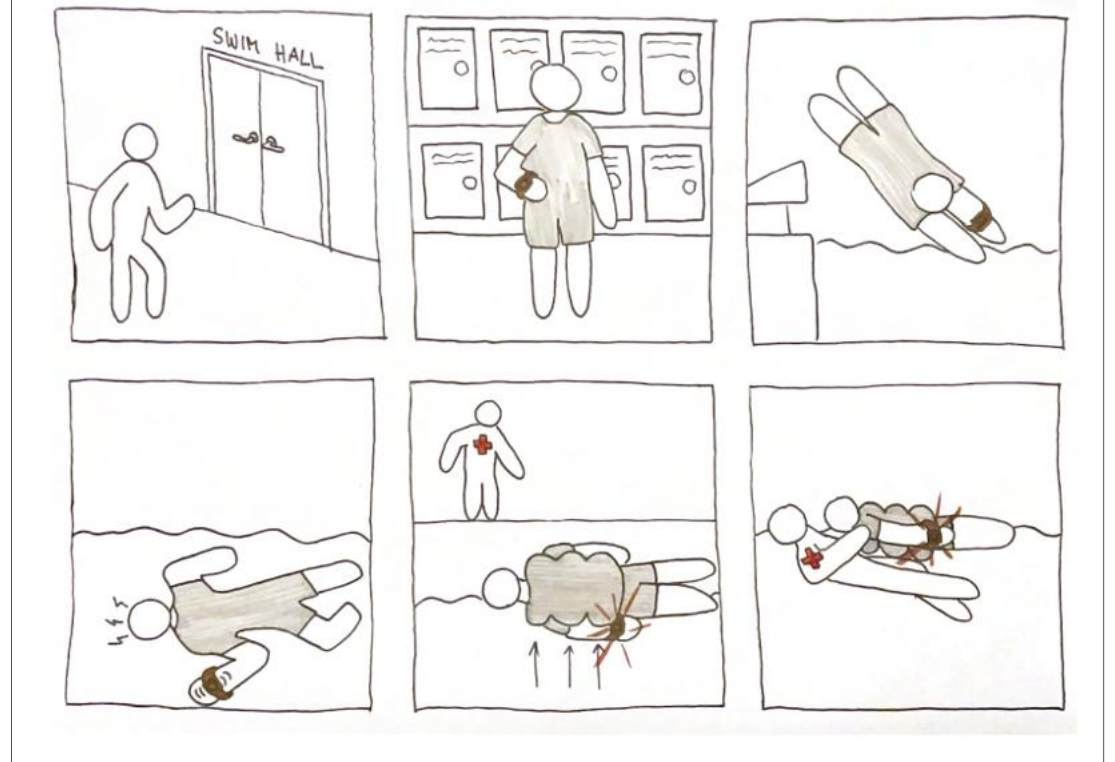
Questions about the Product Evaluation:

Ihnen werden nun ein Anwendungsszenario und eine dazugehörige Produktlösung präsentiert. Bitte lesen und schauen Sie beides in Ruhe an. Im Anschluss werden Ihnen einige Fragen bezüglich der Produktgestaltung und der Funktionsweise gestellt.

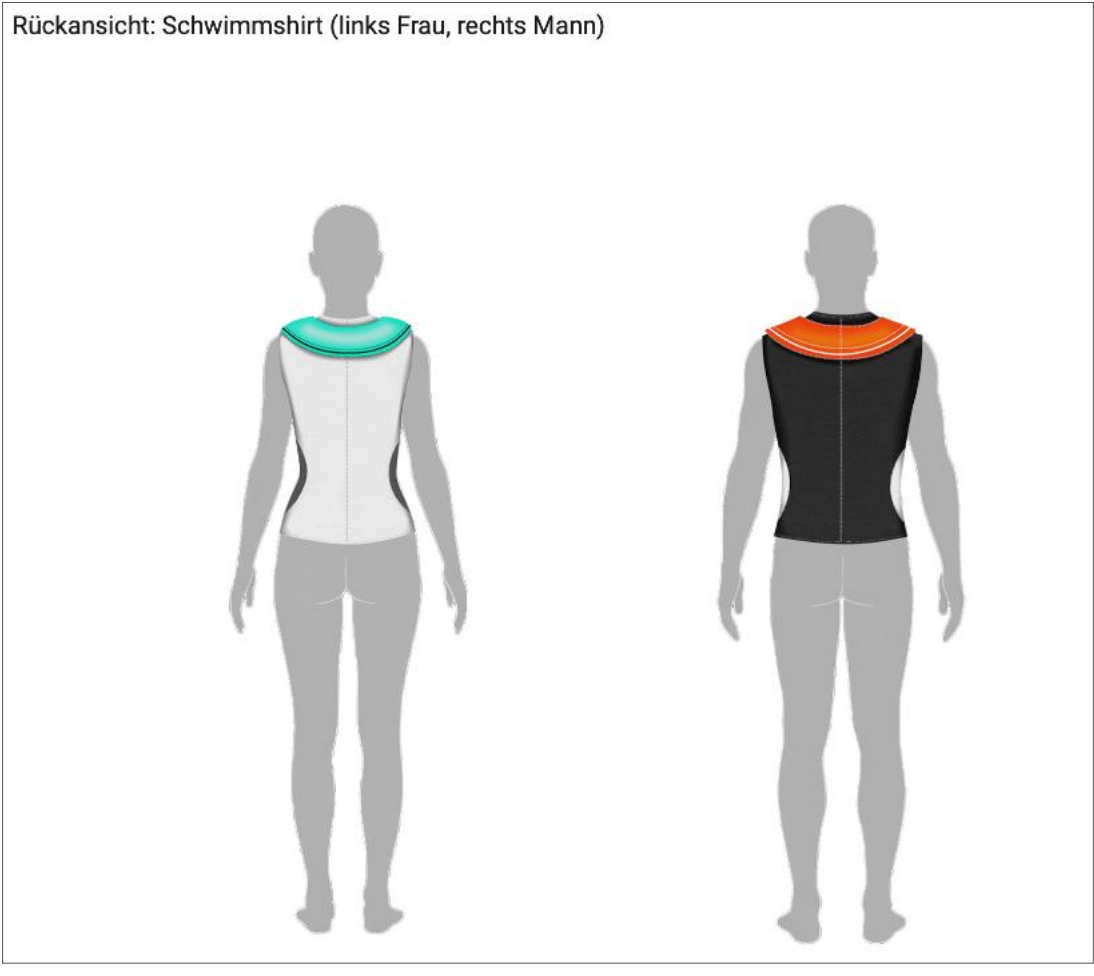
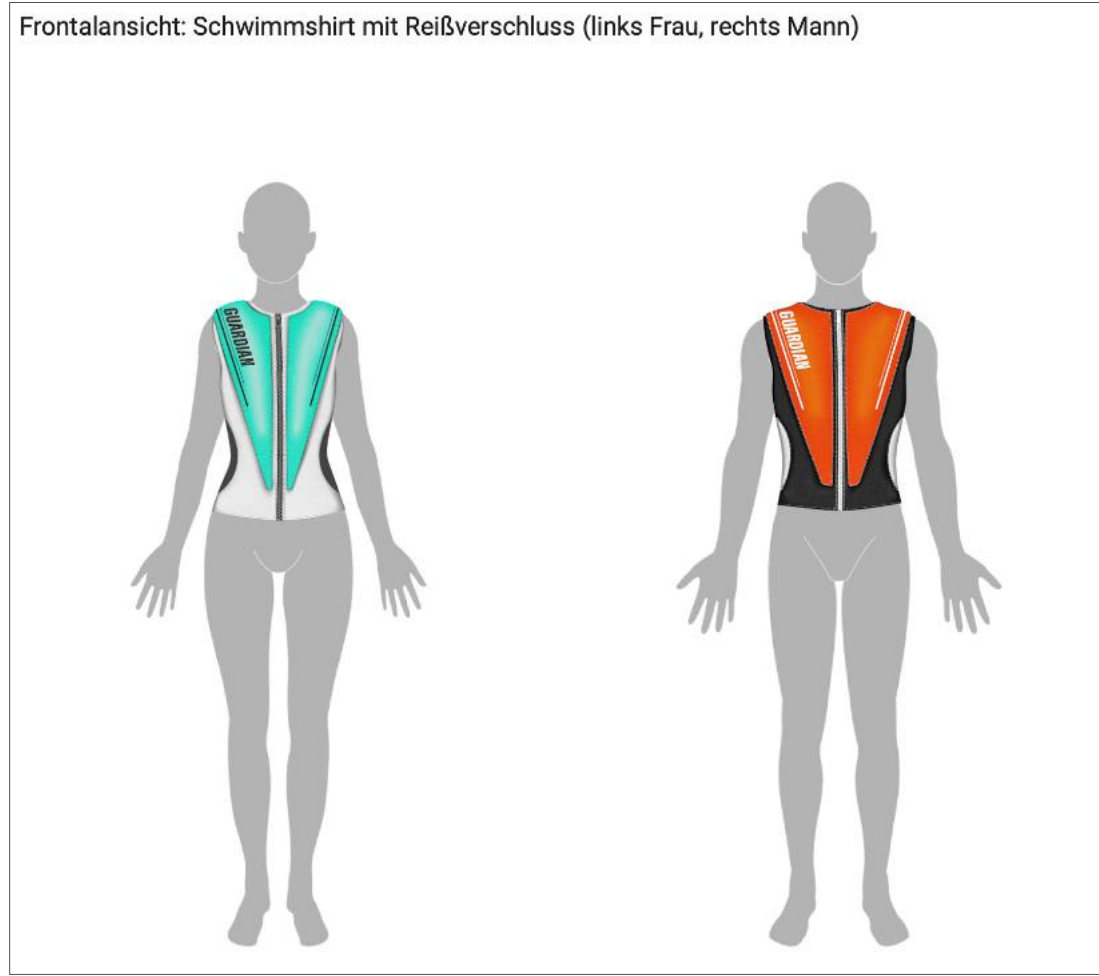
Anwendungsszenario (in Textform):

Das Produkt besteht aus einer Badekleidung und einer Anwendung für eine Smartwatch (z.B. Apple Watch oder Samsung Watch). Vor dem Schwimmen werden die Smartwatch und die Schwimmbekleidung angelegt und miteinander via Bluetooth gekoppelt. Der Benutzer kann wie gewohnt Schwimmen gehen. Im Falle eines medizinischen Notfalls erkennt die Smartwatch dies durch die kontinuierliche Überwachung der Vitalfunktionen und sendet ein Signal an die Schwimmbekleidung. Daraufhin bläst sich die Schwimmbekleidung selbstständig auf, sodass die betroffene Person sicher in stabiler Rückenlage an der Wasseroberfläche treibt und nicht untergeht. Gleichzeitig löst die Smartwatch einen akustischen und visuellen Alarm aus, um Außenstehende (z. B. den Bademeister) auf die Situation aufmerksam zu machen. Die an der Oberfläche treibende Person kann nun in Rückenlage geborgen werden.

Anwendungsszenario (in Bildern):



Für Frauen und Männer soll es ein Schwimmshirt geben, welches zusätzlich zur üblichen Badekleidung (Bikini, Badeanzug oder Badeshorts) angelegt werden soll. Das Schwimmshirt kann wie eine Weste übergezogen, sowie mit einem Reißverschluss frontal verschlossen werden und liegt passgenau aber beweglich an der Badekleidung an. Solange die Smartwatch keine Notsituation erkennt, bietet das Schwimmshirt keinen zusätzlichen Auftrieb, normale Schwimmbewegungen und Tauchen sind möglich. Das Material besteht aus robustem, wasserabweisendem Nylon. Falls es zu einer Notsituation kommt, werden die farbigen Bereiche (Frau: Türkis, Mann: Orange) durch eine CO2-Kartusche aufgeblasen, wie bei einer klassischen Rettungsweste.



Questions about the Swimming Shirt:

subject	Könnten Sie sich vorstellen, zu Ihrer eigentlichen Badekleidung ein Schwimmshirt zu tragen?	Beziehen Sie sich nur auf die Version, die Sie tragen würden (Frau oder Mann): Gefällt Ihnen die Farbwahl des Produktes?
1	Stimme zu	Stimme zu
2	Stimme zu	Weder noch
3	Stimme zu	Stimme zu
4	Stimme zu	Stimme zu

subject	Würden Sie (unabhängig vom Preis) in Betracht ziehen, ein solches Produkt zu kaufen? (Nur das Schwimmshirt ohne die Smartwatch)	Der Preis eines wiederverwendbaren Schwimmshirts beträgt ca. 300 € (Material, Arbeitszeit, Technik, App-Entwicklung und Wartung) ohne die Smartwatch. Würden Sie bei diesem Preis weiterhin einen Kauf in Betracht ziehen?
1	Stimme zu	Weder noch
2	Stimme nicht zu	Stimme nicht zu
3	Stimme zu	Stimme zu
4	Stimme voll und ganz zu	Weder noch

subject	Beziehen Sie sich nur auf die Version, die Sie tragen würden (Frau oder Mann): Gefällt Ihnen die allgemeine Ästhetik des Produktes?	Haben Sie Anmerkungen, was Sie an der Ästhetik verändern würden?
1	Stimme voll und ganz zu	
2	Stimme zu	
3	Stimme zu	Für den Mann nicht unbedingt schwarz verwenden. Eher auch eine helle Farbe
4	Stimme zu	

subject	Würden Sie das Schwimmshirt in Kombination mit einem dazugehörigen medizinischen Armband (d. h. beides als Set) bevorzugen? In diesem Fall müsste keine zusätzliche Smartwatch erworben werden.
1	Stimme voll und ganz zu
2	Stimme zu
3	Stimme nicht zu
4	Weder noch

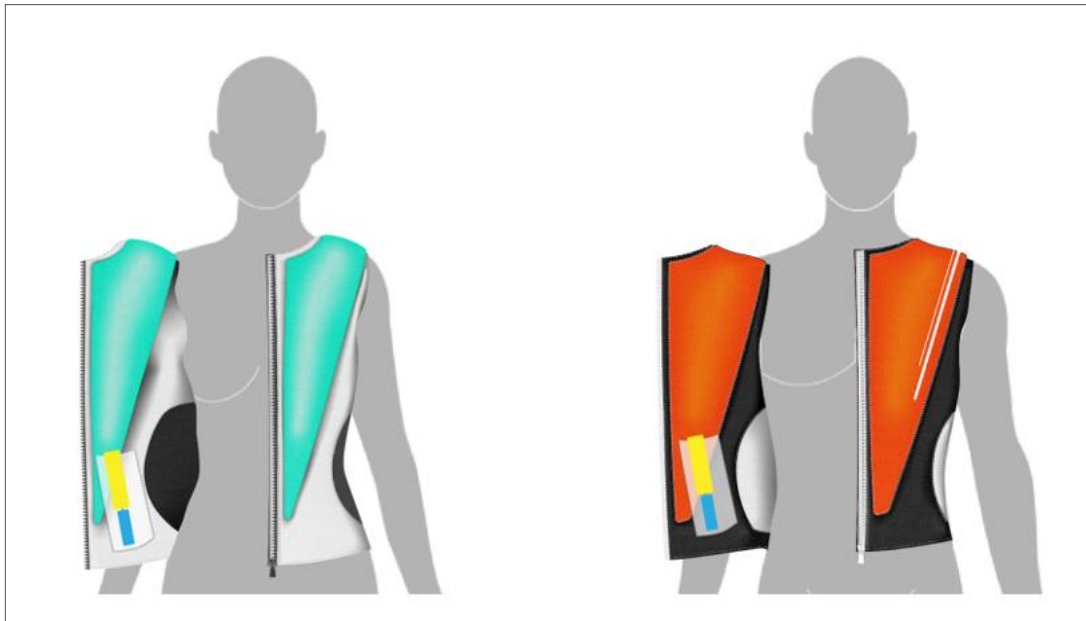
Explanation of the Technical Functionality:

In der rechten Innentasche des Schwimmshirts wird die CO2 Kartusche zusammen mit der Technik wasserdicht verstaut.

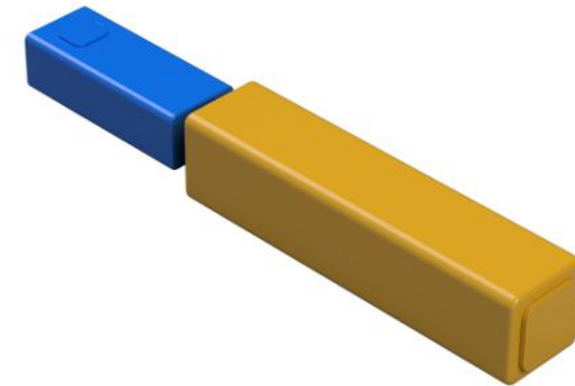
Um das Schwimmshirt nutzen zu können, muss es mit einer 33 g CO2-Kartusche (Maße: 13 x 2,5 x 2,5 cm) sowie mit vier 10-Jahres-Batterien ausgestattet werden.

Die CO2-Kartusche befindet sich in der gelben Box; die Batterien zusammen mit den technischen Komponenten in der blauen Box (siehe Abbildung).

Jeder Wechsel der CO2-Kartuschen und der Batterien wird automatisch von der Smartwatch registriert. Der Nutzende wird durch das System rechtzeitig informiert, sobald ein Wechsel der Kartuschen oder Batterien erforderlich ist. Weil die Kartuschen und Batterien austauschbar sind, kann das Schwimmshirt bei guter Pflege viele Jahre nachhaltig verwendet werden.



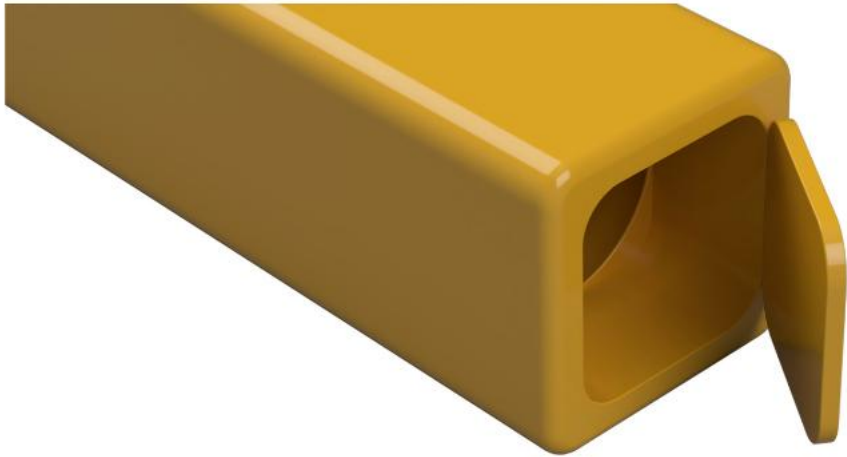
Nahansicht: Die blaue Box (Maße: 7,6 x 3,0 x 2,0 cm) für die Batterien sowie die gelbe Box (Maße: 17,0 x 3,5 x 3,5 cm) für die CO2-Kartuschen.



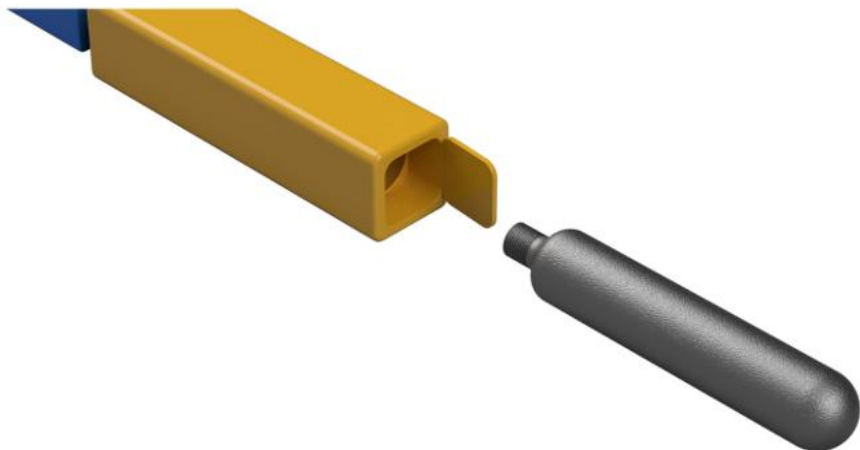
Insertion of the Carbon Dioxide Cartridge:

Die CO2-Kartusche muss nach jedem Auslösen des Rettungsmechanismus ausgetauscht werden, oder spätestens nach 3 Jahren Lagerung. Solche Kartuschen sind für ca. 18 € online oder in Fachgeschäften erhältlich.

Um die CO2 Kartusche einzusetzen, muss die Klappe der gelben Box geöffnet werden.



Anschließend kann die CO2-Kartusche eingeführt und durch Drehen im Uhrzeigersinn befestigt werden.



Anschließend wird die Klappe wieder geschlossen. Das sichere Schließen der Klappe ist am Einrasten des Schnapp-Mechanismus erkennbar.

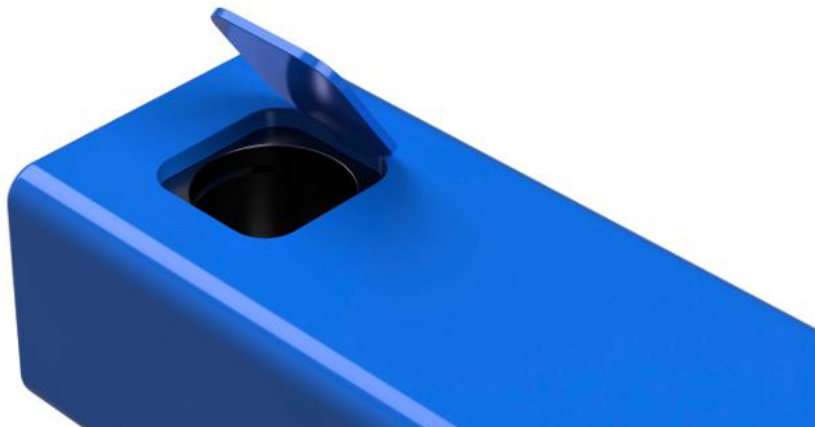


subject	Würden Sie sich das Einsetzen der CO2-Kartusche selbstständig zutrauen?	Würden Sie es bevorzugen, dass eine ausgewiesene Fachkraft die CO2-Kartusche für Sie einsetzt?
1	Stimme voll und ganz zu	Stimme nicht zu
2	Stimme voll und ganz zu	Stimme nicht zu
3	Stimme voll und ganz zu	Weder noch
4	Weder noch	Stimme zu

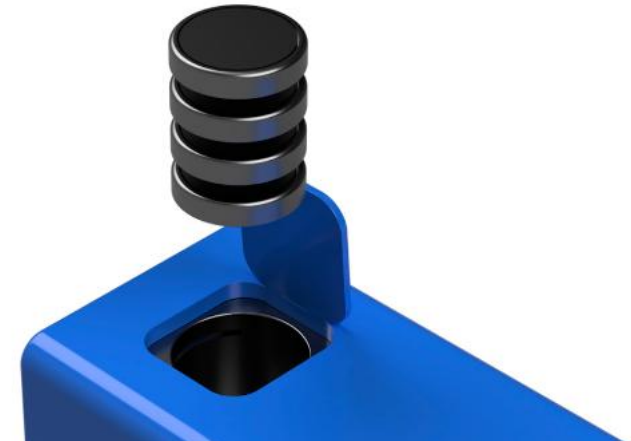
Insertion of the Batteries:

Die Batterien sind handelsübliche 3V-Knopfzellen (Typ: CR2032), die in Discountläden oder online erworben werden können. Der Preis für die benötigten 4 Stück liegt bei ca. 1,60 €.

Ähnlich wie bei der gelben Box, muss auch bei der blauen Box die Klappe geöffnet werden, um an das Batteriefach zu gelangen.



Anschließend werden die 4 Batterien in das Batteriefach eingelegt.



Zum Schluss wird die Klappe geschlossen. Das sichere Schließen ist auch hier wieder durch das Einrasten des Schnappmechanismus erkennbar.



subject	Würden Sie sich das Einsetzen der 4 Batterien selbstständig zutrauen?	Würden Sie es bevorzugen, dass das Einsetzen der Batterien durch ausgewiesenes Fachpersonal erfolgt?
1	Stimme voll und ganz zu	Stimme nicht zu
2	Stimme voll und ganz zu	Stimme überhaupt nicht zu
3	Stimme voll und ganz zu	Weder noch
4	Stimme zu	Stimme nicht zu

subject	Haben Sie noch weitere Empfehlungen oder Anmerkungen?
1	Mir gefällt, dass das Design an eine Rettungsweste erinnert, aber nicht "zu auffällig" ist. Wenn die Weste im Notfall aktiviert wird, assoziieren die Badegäste das Design vermutlich eher mit einer Rettungsweste und reagieren entsprechend. Gleichzeitig wirkt das Design elegant und sportlich.
2	
3	
4	

Demographic Data:

subject	Wie alt sind Sie?	Ihr Geschlecht?	Was ist Ihr höchster Bildungsabschluss?	Ihre aktuelle Beschäftigung?
1	25 - 34	männlich	Hochschulabschluss	Angestellte Tätigkeit
2	55 - 64	männlich	Ausbildung	Pensioniert
3	35 - 44	Ich möchte diese Frage nicht beantworten	Hochschulabschluss	Angestellte Tätigkeit
4	35 - 44	weiblich	Mittelschule	Angestellte Tätigkeit

Vielen Dank für Ihre Teilnahme! Es würde mich sehr freuen, wenn Sie die Umfrage mit anderen Betroffenen teilen würden.

Das entstehende Modell wird mit Hilfe dieser Umfrage weiter überarbeitet und anschließend auf der Winterwerkschau der Designfakultät am 06.02.2026 an der Hochschule für Technik und Wirtschaft Dresden (U-Gebäude, 6. Etage) zusammen mit den anderen Bachelor- und Semesterarbeiten ausgestellt.

Die Studierenden der Design-Fakultät freuen sich auf Sie!

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Declaration of Authenticity

I declare that I have completed this work independently, citing all sources and using only the literature and resources listed.

place, date

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