IDC School of Design
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DEP 501 - MDes Design Project 2

Designing an Adult CPR Classroom Training Manikin

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Project Guides
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Declaration

I declare that this written document represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/ source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Approval Sheet

The project (P2) titled "***Designing an Adult CPR Classroom Training Manikin***" By Mr ***Sarthak Kanchan*** is approved by, for partial fulfilment of requirement for the degree of 'Masters of Design' in Industrial Design at IDC, Indian Institute of Technology Bombay

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Contents

Topic

CPR Classroom Training Manikin
“CPR Training can be a huge help in saving lives all over the world. Current models are bulk or flimsy. A good product can dramatically increase CPR training around the world”

Abstract

A new adult CPR classroom training manikin was designed, aimed to increase awareness and better educate the general civilian population about CPR, its benefits and risks. The Manikin comprises three components, a Compressible torso, the compression piston and a skin cover. The major aim of the project was to design a manikin which assists students regarding compression force and depth and hand placement. The manikin is designed to be compact and easy to set up and pack up, saving a lot of the instructor’s effort and time. The instructor can carry multiple manikins in a bag. A 3D CAD model with meticulously designed parts has been created keeping in mind manufacturing methods and constraints. This manikin focuses on compression only cpr. Rescue breathing training features are yet to be developed. A working prototype for user testing and evaluation is to be made.

Introduction

What is CPR?

Cardiopulmonary resuscitation is an emergency procedure that involves chest compressions and artificial breathing by manually beating the heart in order to maintain blood circulation to the brain to preserve brain function and restore breathing in a person who is in cardiac arrest. This procedure is also performed when someone is in a near drowning situation. Chest compressions and artificial breathing help eject water which has entered the lungs.

https://www.cprconsultants.com/wp-content/uploads/2016/12/AED-CPR-Being-Given-to-Victim.jpg

CPR alone will not restart the heart. Its main function is to provide partial flow of oxygenated blood to the brain and heart. This delays tissue death and briefly extends the window of opportunity for a successful resuscitation without permanent brain damage. Basic training allows a bystander to the incident to perform CPR until emergency services arrive. There are two commonly known levels of CPR.
For healthcare providers and those trained: conventional CPR involving chest compressions and mouth to mouth breaths in a ratio of 30:2 compressions to breaths. In adult victims of cardiac arrest chest compressions are recommended to be performed at a rate of 100 - 120 bpm and at a depth of at least 5cm (2 inches) but not beyond 6cm (2.4 inches). Breaths are to be delivered for no longer than 2 seconds to create chest rise in the victim.
For general public or bystanders: compression only CPR or hands only CPR which does not involve rescue breathing. The American Heart Association recommends starting CPR with hard and fast chest compressions on an adult or teen who is seen suddenly collapsing in an out of hospital setting. CPR should only be performed if there is no evidence of breathing.

How to perform CPR

1. **Position your hand**. Make sure the patient is lying on his back on a firm surface. Kneel beside him and place the heel of your hand on the centre of the chest. (fig 1a)
2. **Interlock fingers**. Keeping your arms straight, cover the first hand with the heel of your other hand and interlock the fingers of both hands together. Keep your fingers raised so they do not touch the patient’s chest

or rib cage. (fig 1b)

3. **Give chest compressions**. Lean forward so that your shoulders are directly over the patient's chest and press down on the chest about two inches. Release the pressure, but not your hands, and let the chest come back up. (fig 1c)

Repeat to give 30 compressions at a rate of 100 compressions per minute. Not sure what that really means? Push to beat of the Bee Gees song "Stayin' Alive."

4. **Open the airway**. Move to the patient's head. Tilt his head and lift his chin to open the airway again. Let his mouth fall open slightly. (fig 1d)

5. **Give rescue breaths.** Pinch the nostrils closed with the hand that was on the forehead and support the patient's chin with your other hand. Take a normal breath, put your mouth over the patient's, and blow until you can see his chest rise. (fig 1e)

6. **Watch the chest fall.** Remove your mouth from the patient's and look along the chest, watching the chest fall. Repeat steps five and six once. (fig 1f)

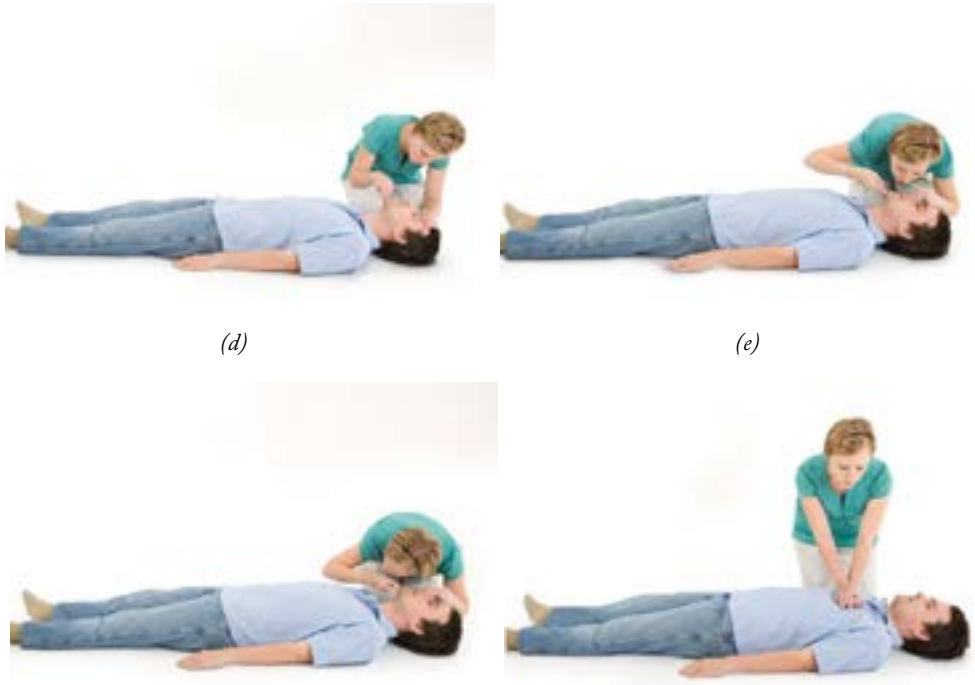
7. **Repeat chest compressions and rescue breaths.** Place your hands on the chest again and repeat the cycle of 30 chest compressions, followed by two rescue breaths. Continue the cycle. (fig 1g)

Compression to breath ratio is to 30:2 per cycle.

(a) *(b)* *(c)*

Fig 1. How to give CPR

https://www.readersdigest.ca/health/conditions/essential-cpr-steps/



(d) *(e)*

(f) *(g)*

Fig 1. How to give CPR

https://www.readersdigest.ca/health/conditions/essential-cpr-steps/

How to train for CPR: CPR training manikins

It is very dangerous to practice CPR on a person who is conscious and breathing. Therefore to train for CPR, manikins are designed. Manikins designed for the general public are simed to teach basic quality CPR, by educating them regarding compression depth, compression rate and rescue breathing under guidance of a trained instructor. Advanced manikins designed to train medical professionals and emergency responders allow for training of other medical procedures like cricoid pressure, carotid pulse and AED training as well. Manikins designed for the general public are aimed to increase awareness and bystander response in case of emergencies in out of hospital situations.

https://laerdal.com/images/L/AEBTSARK.jpg

Majority of the CPR manikins used to train the general public are large and bulky and difficult to carry around. Therefore the people who are interested in training themselves in CPR have to go to centres where they can be taught. Or the instructor carries a single Manikin to office and school spaces to demonstrate the process to the people. A single manikin does not allow for a large group (10-50) of people to observe and try their hands on the manikin. Classroom training kits are designed specifically to tackle this issue. A classroom kit contains 4-12 compact manikins which a single instructor can carry to demonstrate to large groups of people. These manikins have a slightly lower quality of teaching but help to generate awareness about CPR and its importance to a greater population.

Public Awareness Regarding CPR

America

In America, more than 356000 people suffer out of home cardiac arrests (OHCA) each year. Of these 90% are fatal.[13] Bystanders attempt cpr between 14% to 45% of the time, with a median of 32%. The numbers are a lot more diverse globally going as low as 1% and as high as 44% [14]. OHCA majorly occurs in homes/ residences (70%) followed by public settings (18.8%) and nursing homes (11.2%). Only about 46% of people who experience OHCA receive immediate help until professional help arrives. [10]

Europe

From October 1st to December 31st, 2017 37,054 OHCA cases were confirmed in 28 countries of Europe. In 25,171 cases, bystanders performed CPR. In one third of the cases return of spontaneous circulation (ROSC) was achieved and 8% of the patients were discharged from the hospital alive. Survival to hospital discharge was higher in patients who received CPR with ventilation 14%. [17]

India

In India the situation is a lot more grave. Less than 2% of the country's population know how to perform CPR and only 0.1% have ever performed it. [16] 4,280 people per 1 lakh population suffer from cardiac arrest every year and every minute 112 people succumb to cardiac arrest. In India OHCA comprises 80 - 82% of the total cases. [15]
Need to increase Awareness and Training
With each passing minute, the chances of survival after an OHCA are reduced by 7-10 times.[15] If CPR is performed in the first 5-6 minutes of cardiac arrest, chances of survival are doubled or tripled. [10] By learning CPR any layman can delay brain death until professional help arrives.

This skill takes 5-10 minutes of practice and has a significant effect in c=saving lives of cardiac arrest victims. Since most OHCA cases occur in the victims home, family members and loved ones of people suffering from cardiac diseases are encouraged to learn CPR.

Ensuring Quality CPR

Quality cpr is achieved when a continuous flow of oxygenated blood is supplied to the brain and heart via chest compressions and rescue breathing.
There are 4 factors which ensure quality cpr is being performed.

Compression Rate

The recommended chest compression rate as stated by the American Heart Association (AHA) guidelines is between 100 - 120 compressions per minute. This rate can be easier understood by following along to the chorus of the Bee Gee's song 'Stayin Alive'. Correct compression rate ensures that a continuous blood flow is maintained. If the rescuer performs compressions below the recommended rate, enough blood will not flow to the brain and CPR will have little to no effect. However, if the rescuer performs compressions at a rate higher than recommended the heart will not be able to adequately fill up with blood for circulation also resulting in inadequate blood flow. Thus it is important to maintain the rate as recommended.

Compression Depth

The recommended compression depth is between 5cm (2inch) to 6cm (2.4inch) which requires a force of 45 - 56.7 kg (100-125 lbs) as stated by the AHA guidelines. Chest compressions maintain blood flow by squeezing blood rich tissue to transfer the blood into arteries. This means that the harder you squeeze the more blood will flow into the arteries. A minimum depth of 5cm is required for adequate blood to flow. However if the compression depth exceeds 6cm, the rib cage and underlying organs like the lungs and spleen can get damaged. After each compression it is important to let the chest recoil completely. This allows the heart chambers to relax and fill up with blood. If excess pressure is applied, rib cage damage can reduce chest recoil. Therefore it is important to maintain the depth range so as to provide adequate blood flow to the brain while preventing permanent injury to the victim.

Hand Placement

CPR is performed on the chest, more specifically in the centre of the chest between the nipples. The rescuer should place the heel of their palm in the centre of the chest right above the end of the sternum which is the centre bone connecting the ribs. This point is the most flexible region of the rib cage. It allows for deep compression without causing permanent damage to the ribcage and underlying organs when recommended force is applied. If the rescuer places their hands in the top region of the sternum or towards either side of the sternum on the ribs, compressions will not be deep enough due to lack of flexibility and CPR will not have the desired effect. Moreover the compression force applied by the rescuer may injure the victim. If hands are placed below the sternum, the rescuer will miss the rib cage partially or entirely causing damage to underlying organs as there is no skeletal structure in that region to protect them.

Mouth to Mouth Breathing

Mouth to Mouth Breathing or rescue breathing is the artificial process of respiration applied to the victims lungs. The AHA recommends 2 breaths after every 30 compressions for a duration of 2 seconds for each breath. The breaths should be strong enough to see a visible chest rise as would be visible when a person takes a deep breath. It is important for the rescuer to allow the chest to depress completely before the second breath is given so that the lungs properly absorb oxygen.

If the above factors are properly educated to the potential rescuers, they can perform quality CPR.

Scope

In this project I aim to design a CPR training manikin which is focused on increasing awareness and basic CPR training of the general population and educating them in the same. I will explore the following areas:

- Analysis of performing CPR
- Factors resulting in quality CPR
- Mechanics involved in the manikin
- Ergonomics of load carrying for a classroom kit
- Creating a prototype

Problem Statement

To design an adult CPR training manikin which assists and educates students while training. The instructor should be able to carry multiple manikins at the same time.

Design Brief

- The manikin should be compact, lightweight and easy to carry multiple at the same time
- The manikin should have accurate body markers for correct compression area
- The manikin should indicate when required amount of pressure is applied during compressions as stated by the American Heart Association
- The manikin should have visual or auditory cues to follow along for proper compression rate
- The manikin should be easy to set up and pack to save time
- The manikin should have replaceable parts like lung bags and face shields to maintain hygiene
- The head of the manikin should tilt back for rescue breathing training

Market Research

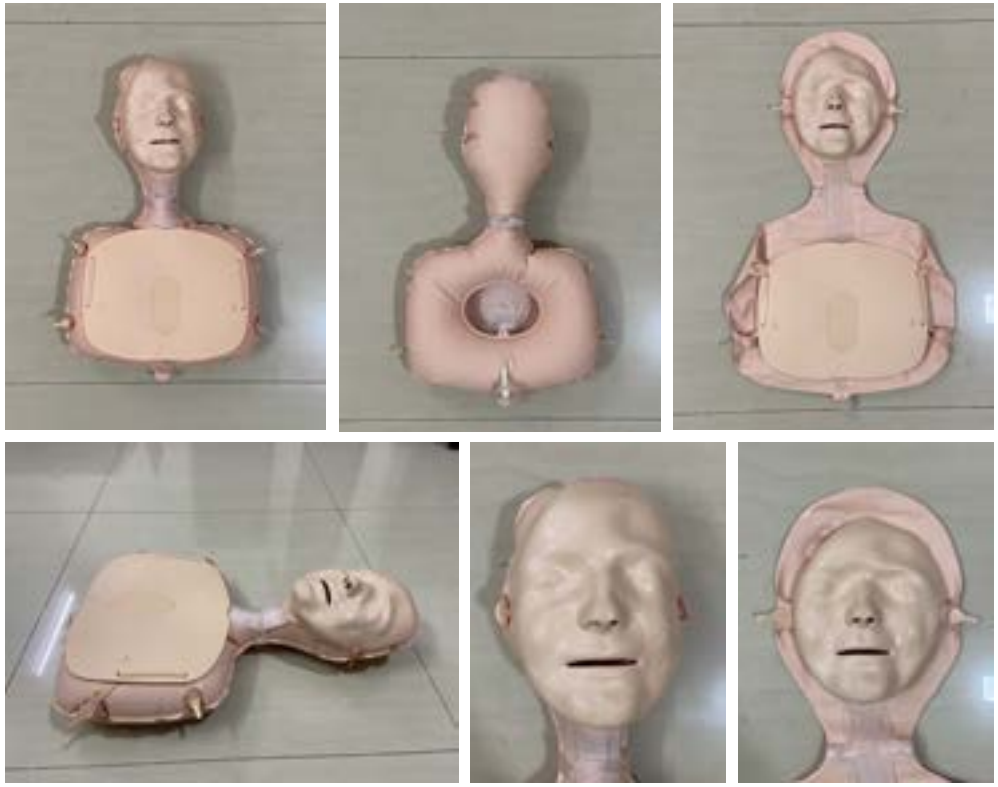
I looked at two classroom training manikin kits by leading brands in the CPR training industry.

Laerdal Mini Anne

Mini Anne by laerdal is one of the most compact designs available in the market. A single kit contains 10 manikins with additional accessories like spare lung bags, AED practice kits and DVDs for demonstration.

https://laerdal.com/cdn-49a079/globalassets/images--blocks/themed-images--blocks/community-lifesavers/aendeyfs.jpg?w=1152&h=648&mode=crop

The manikin is inflatable which saves a lot of space and makes the entire kit compact and lightweight. It consists of four components, the inflatable body, a hard plastic chest plate, silicone face and replaceable lung bags. The inflatable body forms the head, neck and torso in a single balloon.



Laerdal Mini Anne, inflated, deflated and taken apart

Chest Plate

Face and mouth

Air can be filled in the balloon via a pipe at the bottom of the manikin. There is a hole in the centre of the torso which adds strength to the entire structure while also allowing space for compression.
The chest plate has ribs on the underside which provides the resistance force for compressions. On the top surface, there are textural and anatomical landmarks which assist in hand placement. A rubber strip in the centre of the chest indicates where hands are to be placed and raised bumps on either side represent nipples. There is a clicker placed at the bottom of the chest plate which notifies users when a minimum amount of force is applied for adequate compression. The chest plate is held in place using silicone strips with tab endings.
The face is molded from silicone and contains a plastic piece on the inside onto which the lung bags are attached. The plastic piece holds the shape of the face and air is blown through the mouth to practice mouth to mouth breathing. The lung bag runs underneath the face and chest plate. Since it is below the chest plate, visible chest rise is seen when air is blown through the mouth.
Single manikins are also sold separately. Due to its inflatable nature, the manikin fits inside a 30x22x6 cm box along with an AED practice kit and DVD.

Pros:

- Super Compact & lightweight- deflates and is flat packed - instructor can carry multiple at a time with ease
- Chest clicker indicates minimum force required compressions
- Fast setup and pack up after class is over

Cons:

- Missing anatomical landmarks - collar bone, sternum, ribcage
- Head and chest sizes are disproportionate
- Looks unrealistic - thin neck, distorted face, small chest
- Structurally weak - inaccurate chest recoil
- Inflated body unable to actually withstand pressure - flattens when high pressure is applied
- Chest height is not accurate
- No assistance in learning for the user regarding compression rate and depth
- Not hygienic - lung bag stays inside the mouth
- Annoying process of replacing lung bag
- Buyers find it very toy-like. Training for such a serious scenario should not involve devices which look like an inflatable balloon toy
- People don’t know if it has been inflated enough - if the compressions will be accurate enough
- Chin lift does not work properly
- Textural marker is not ideal for training

Prestan Ultralite

The Prestan ultralite manikin is another popular classroom training manikin. A kit can contain 4-12 manikins depending on the number of people that are to be taught. This design saves space by stacking the mankins on top of each other. The manikin consists of four components - Head, Torso, compression piston and Replaceable lung bags.
The head is composed of two pieces, front and back halves which detach and can be stacked into each other. This greatly saves space. After assembling the two pieces the head attaches to the torso by sliding it near the neck.
The torso is hollow and made of hard PVC plastic to retain structure. There are cuts in a radial pattern from the centre of the chest which allow the hard plastic to bend when the user applies force for compression. A silicone skin is attached to the bottom of the torso on a rotating pivot. The skin can be easily unlatched near the shoulders and lifted when lung bags

https://www.wessex-medical.com/shop/cpr-training-manikins/family/prestan-ultralite-manikin-set/

https://www.preparednessshop.com/prestan-single-ultralite-cpr-training-manikin

https://www.mcrmedical.com/mm5/graphics/00000001/Prestan-Ultralite-manikin-with-feedback-light-piston-back-side_350x350.jpg

https://i.ytimg.com/vi/X02jOFUDAPU/maxresdefault.jpg

https://www.prestanproducts.com/images/directory/products/Main_Product_Images/PP-ULB-50_Ultralite_Manikins_Lung_Bags_lrg.jpg

are to be replaced. A stackable language is carried out throughout the manikin.
The compression piston is attached to the inside of the torso from the bottom. It has a clicker to notify the minimum force required for compressions.
The lung bag goes through the head and between the Torso and skin. The mouth tab of the lung bag covers the mouth of the manikin making it hygienic.

Pros:

Compact & lightweight - stackable design for body and head
Super fast setup and pack up using few components
Structurally strong
Realistic features - anatomical landmarks and feel of the body
Piston upgrade allows for compression rate assistance
Easy replacement of lung bag with attached skin at the bottom

Cons

Sternum and ribcage are not actually visible on a real human body which can be confusing
No indication for exceeding compression depth
Entire torso is not solid as shown in the manikin - below the sternum, there is no skeleton but just organs and muscles.

Task Analysis

Manikin Used - Minianne By Laerdal
I followed the CPR instructions from a video tutorial on youtube [18].
I observed the following:

- A lot of energy is required to perform two or more sets of compression and breaths
- If manikin is not inflated properly, compressions are not accurate
- Height of manikin is not enough to replicate feeling of actual compressions
- Textural landmark for hand placement helps while practising on mankin but it will be difficult to recall if actually performed on a human being
- Initially I applied too much force for compressions. This was a self assessment based on compression seen in the video. There was no feedback to caution me if the recommended force was exceeded.
- Since I am familiar with the song Stayin Alive by Bee Gee's, I was able to recall the chorus in my head and perform compressions along the rhythm.

I had a total of 5 people (including myself) practice compression-only CPR on the manikin. The same tutorial video was shown to the users, and data of their first attempt was recorded.
Since this was not my first time practising on the manikin, I knew how much force was to be applied. However, we see that the two large males (2 & 4) like myself applied too much force in their first attempt. While the lighter male and the female users were unable to apply enough force (audible click was not heard).

User	Gender	height (cm)	weight (kg)	Compression rate (per minute)	Compression Force(guess)	Hand Placement
user 1	male	183	93	102	Correct	correct
user 2	male	184	89	95	Excess	correct
user 3	male	184	56	100	Not enough	correct
user 4	male	179	85	120	Excess	correct
user 5	female	175	48	105	Not enough	correct

Feedback from users:

- User 3 and 5 did not expect the amount of force that would be required to perform compressions. They found the procedure very demanding
- User 2 and 4 requested some sort of feedback when excess force is applied when they learnt of the consequences.
- The rubber strip made all users place their hands in the correct location. All users agreed that it was however unrealistic and would not help in a real life scenario.
- Users 2,3 and 5 found the silicone face of the manikin unsettling.

User

The manikin to be designed falls in the category of classroom training manikins. The Primary Users are teens and adults from all walks of life, except medical professionals and emergency responders like police and fire departments, who will learn through these manikins. The secondary Users are the CPR instructors who will demonstrate, educate and train the people in CPR.

Primary User requirements

- The manikin should have realistic proportions to make the training realistic
- There should be accurate assistance regarding hand placement
- The user should receive feedback when they apply too little or too much force during compressions
- The manikin and/or instructor should provide compression rate assistance.

Secondary User Requirements

- The Manikins should be quick and easy to set up and pack
- The kit should be compact and lightweight
- Demonstration on the manikin should be easy
- Replacing the lung bag should be a hassle free process
- The manikin should help in identifying where the student is going wrong while practising so that the instructor can educate them better.

Identifying Focus Areas

Based on task analysis by myself and three other users, and secondary research, I identified the following problems currently existing classroom training kits:

Major Problems :

Lack of education regarding compression strength and depth

- Standard CPR procedure requires 2-2.5 inch (5-6 cm) depth during each compression for sufficient blood flow which requires a force of 45 - 56.7 kg (100-125 lbs)
- If Less pressure is applied, compressions will be insufficient which leads to incomplete blood flow and failed cpr causing brain death. In a study by Geddes et al, which tested the compression force of 104 untrained civilians and 83 firefighters, it was found that more than 60% civilians did not apply enough pressure.[19]
- If Excess pressure is applied, ribs can be damaged causing fractures, cracks and broken bones. At extremes it can break the ribs completely which can puncture the lungs and patients can die of these complications. The Study by Geddes et al, showed that more than 60% of the trained rescuers and 37% untrained rescuers applied excess pressure.
- The updated AHA guideline is to “push as hard and fast as you can” [4] for untrained rescuers. This is applicable to the majority of the rescuers as they don’t apply enough pressure. However if a large well built person were to follow this guideline, they might apply excess

pressure leading to complications

- In one study of 1,823 deaths in the city of Edinburgh, Scotland, over a 15-month period from 2000 to 2001, rib fractures were found in 29 percent of people who had received CPR. [7]

Lack of realistic assistance in correct hand placement

- Correct hand placement is necessary for safe cpr
- Standard CPR procedure requires hands to be placed in the centre of the chest between nipples. This information is often not enough. Correct location allows for pressure to be applied right above the sternum which is the most flexible part of the rib cage.
- Wrong placement will lead to failed cpr and other complications.
- To either side - damaged ribs
- Below - inaccurate compressions and organ damage
- Above - weak compressions and possible damage to rib cage

Minor Problems:

- The manikins should be quick and easy to set up. This allows instructors to reduce setup time and focus more on the training of the students. At the end of the session, an easy to pack design will mean less effort for instructor as well
- The kit should be easy to carry. It should be compact and lightweight and fit in a single bag/suitcase. The kit should have at least 5 manikins in one bag.

Revised Design Brief

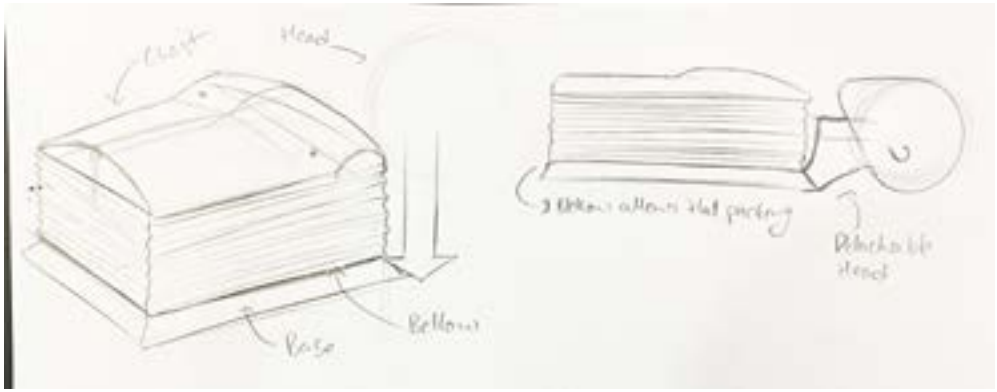
To design an adult CPR training manikin which educates students about correct compression depth and hand placement. The instructor should be able to carry multiple manikins at the same time with easy setup and packing.

Ideation

Making it Compact

It is important that the manikins be compact. To save space one of three methods can be applied to make the manikin compact while packing-

Compressible
Bellow
Using a bellow, the manikin can be compressed to a very flat form. The base and chest are hard form structure. When compressions are performed entire chest piece will move up and down. (below)



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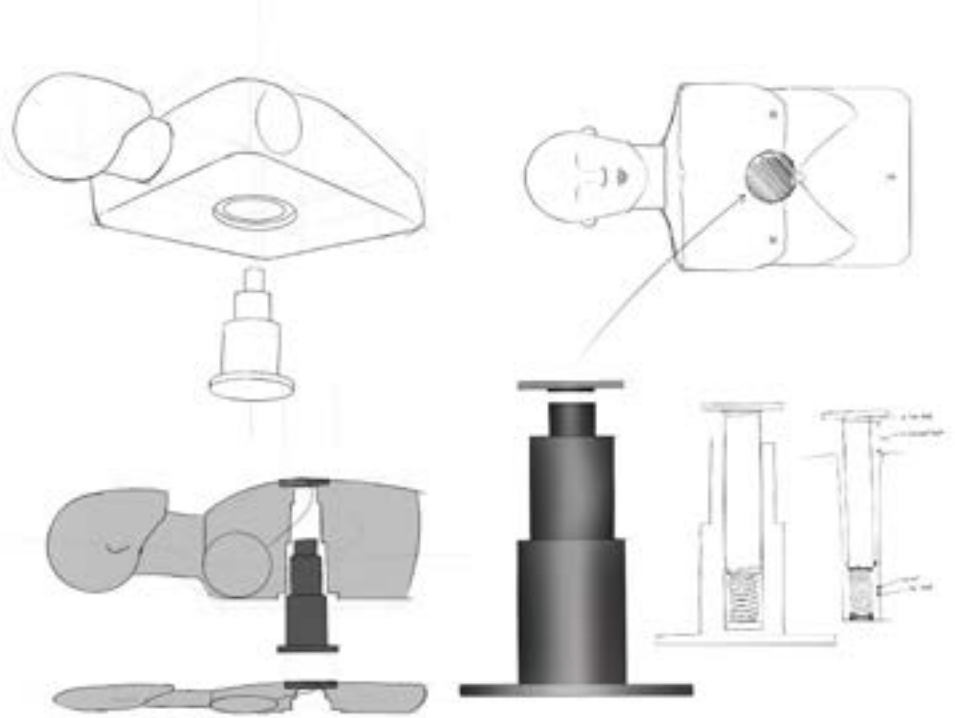
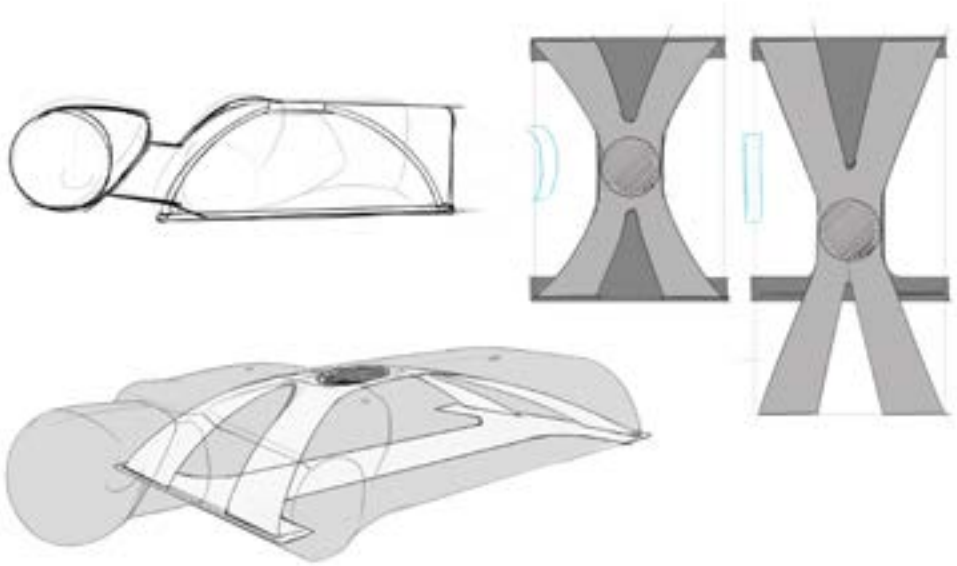


Foam Body
The body is made using memory foam. Upon being compressed and released, the foam will return the body to its original shape. The compression piston can be inserted from underneath and attached to a chest plate inside the body. The chest plate will provide the solid surface to place hands while performing compressions.

Collapsible

Bending Plate



Inspired by the lumbar relief back massager. The massaging plate bends and fixes at various levels for increasing curvature. Instead of levels, one end of the plate can be fixed to a base. The plate when not bent will flatten out, reducing space.

https://5.imimg.com/data5/SELLER/Default/2021/6/YW/EM/WY/75590397/lumbar-back-pain-relief-device-stretcher-for-lower-and-upper-back-massager-and-lumbar-support-500x500.jpg

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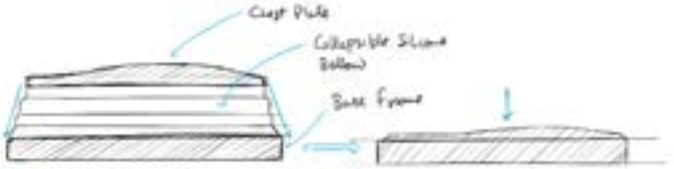
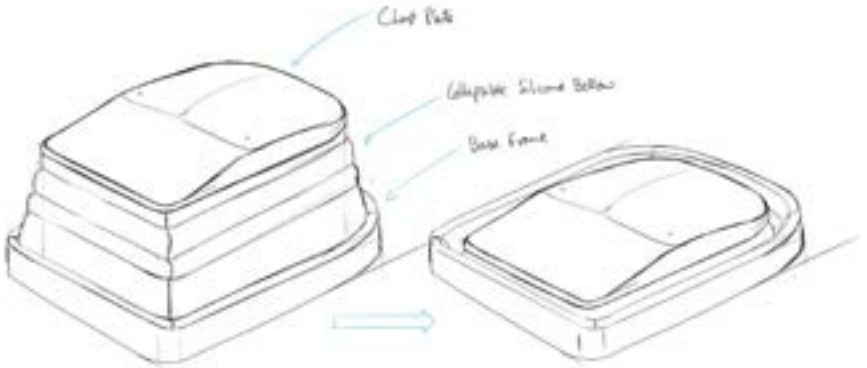


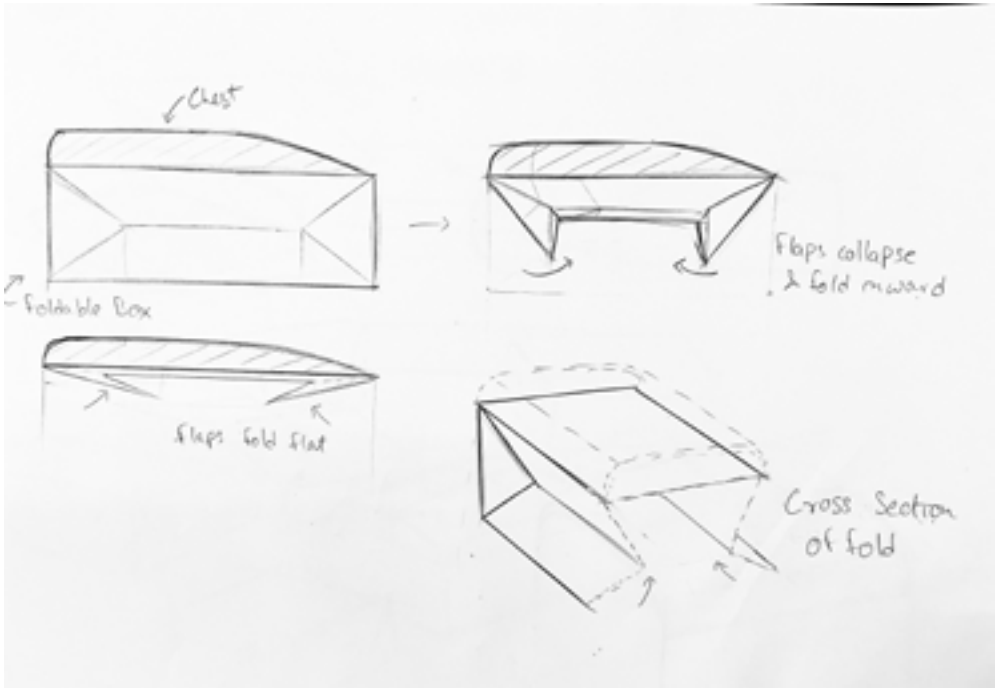


Silicone Structure

Inspired by silicon kitchen storage containers like bottles and lunch boxes. Silicon walls of a certain profile allow a product to collapse inside itself. This greatly saves space. Direction of collapse is parallel to the direction of compression.

https://m.media-amazon.com/images/I/71007UekOTL._AC_SS450_.jpg

https://cdn.shopify.com/s/files/1/0326/2421/4151/products/COLLAPSIBLEBOTTLE_605x.png?v=1602467271



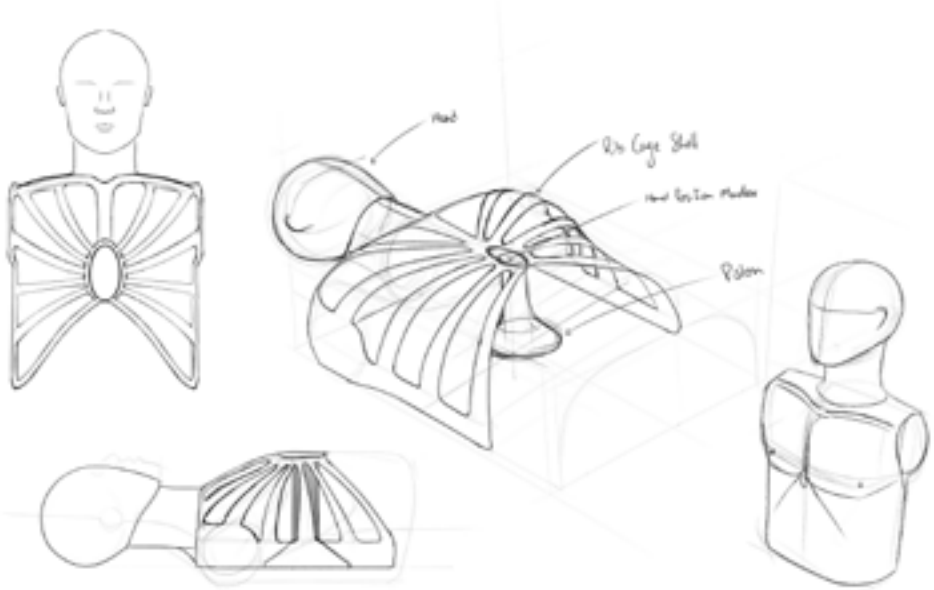
Foldable walls

The base of the manikin can fold inside itself like a paper bag. The front and back ends fold inwards along the crease on the side. When opened, it will be a sturdy and strong base and can be closed to a very low height profile. Chest Plate will remain constant.

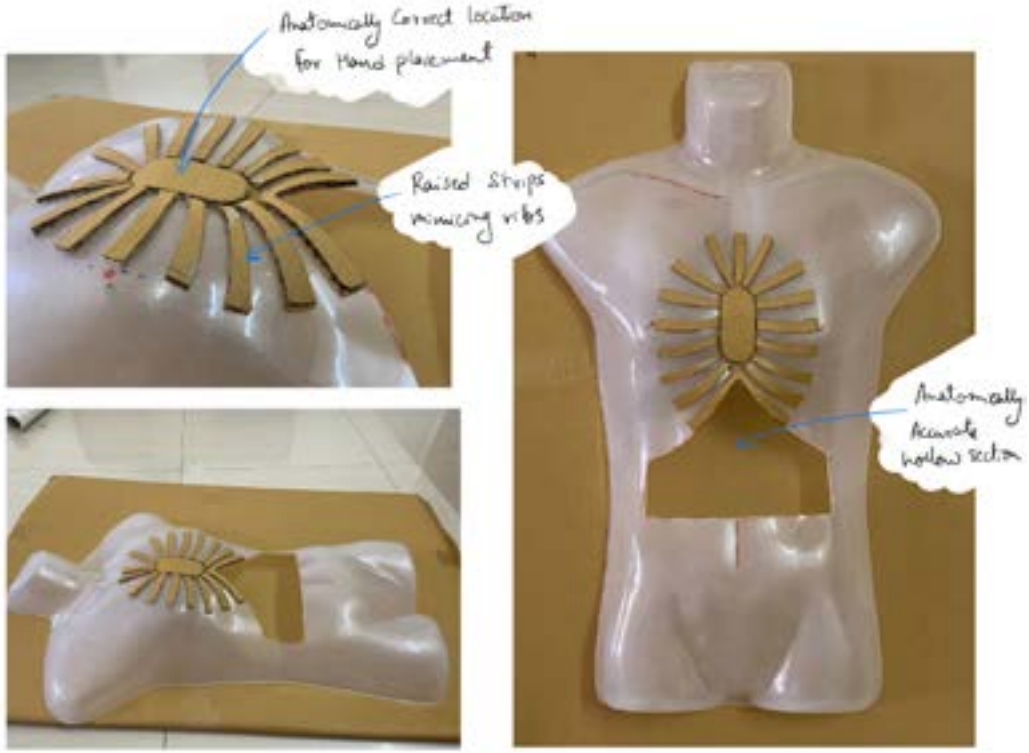
https://5.imimg.com/data5/ANDROID/Default/2020/11/OW/XY/ZO/88559333/product-jpeg-500x500.jpg

Hand Placement Assistance

Many manikins provide visual aids for hand placement. These include anatomical features like nipples, collar bone and two lines in the lower abdomen representing the rib cage and sternum. The latter two are the most important as CPR is compression of the ribcage.
These features are not realistic. A rescuer will not be able to see the ribcage when they begin to perform cpr. They can, however, feel it. During CPR, rescuers place their hands in the centre of the chest right above the bottom end of the sternum which is a flat surface as compared to the ribs around it. Since there is tactile feedback when a rescuer touches the patient's chest, this sensation can be replicated.
During initial ideations, I conceptualised a rib cage torso. The ribs give the desired realistic tactile sensation.



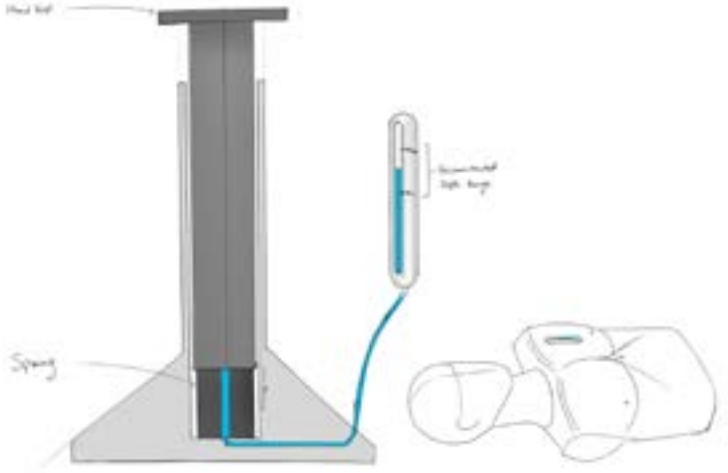
Although it is very realistic, the whole body does not need to mimic the ribcage. If the central area of the chest mimics the sensation, it is sufficient for the rescuer to identify the correct location for hand placement.



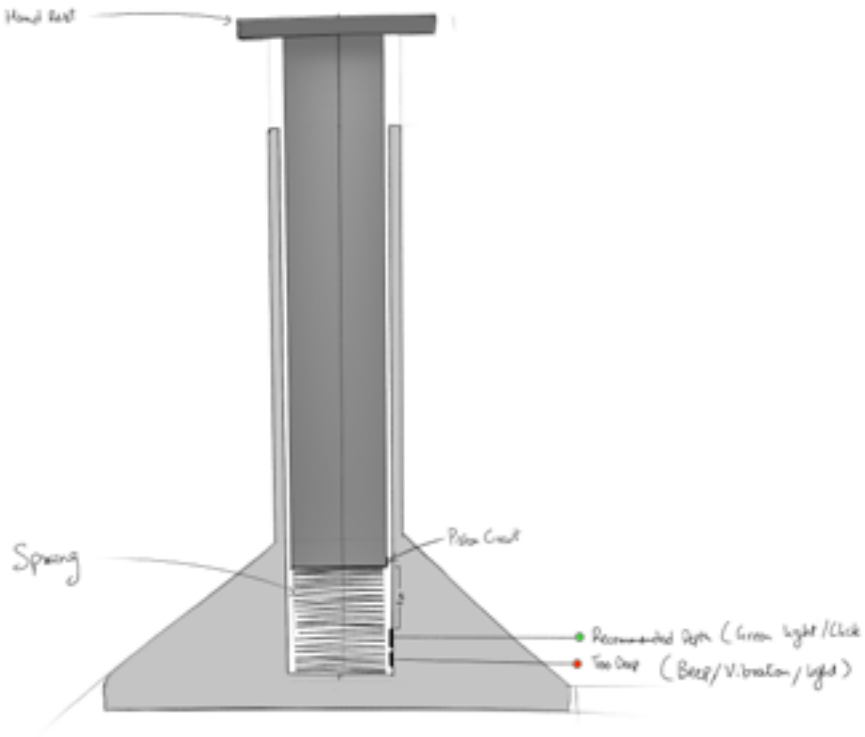
The mockup was created using an apparel display manikin commonly seen hanging outside small apparel stores. The ribs were abstracted and added using cardboard

Correct Compression Depth and Force

Most Manikins have a feedback mechanism for the minimum amount of pressure required, however there is no feasible solution to notify the limit of compression pressure for a classroom kit.
Beyond recommended depth the rescuer can harm the patient by damaging ribs (cracks, fractures etc) and in severe cases even puncture the lungs.
A feedback mechanism for indicating maximum limit of compression pressure and depth can be included. There are two types of feedbacks possible -
Instantaneous Feedback - sound (clicker, beeping), lights (red to alert rescuer), or vibrations.



Hydraulic piston indicates depth range instantaneously. The meter is fixed on top of the chest for clear visibility while practising CPR.



A circuit is connected to the piston which lights up at different depths. The dynamic LED lights give instantaneous feedback.

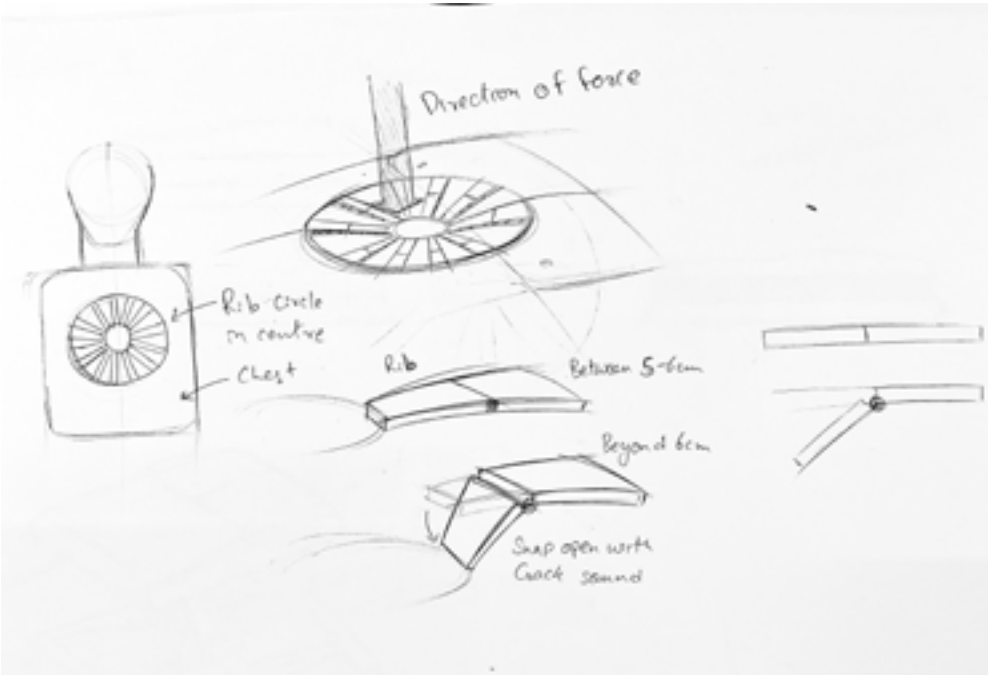
These methods can help students while practising CPR however in real life situations they may look for these indications if ever required to perform CPR and that is not possible. These also do not express the severity of applying excess pressure.

Simulation Feedback -

- Simulate damaging of ribs through a temporary breakage and cracking sound
- Simulate loss of chest recoil due to damaged ribs

Simulating the real life effect of compression depth educates students of the seriousness of performing CPR. It is an attempt to save a person's life and should not be taken lightly. This will help the students understand better the importance of correct depth and chest recoil.

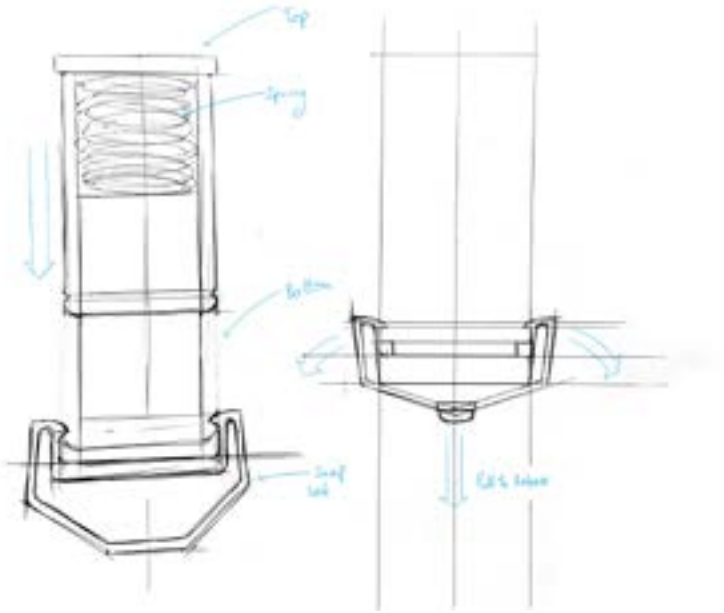
To simulate cracking of the rib cage, each rib can be made of two parts which are pivoted at the boundary of the central area of the chest. The ribs maintain their shape until pressure exceeds n which case the inner portion of the rib will bend at the joint while creating a crack sound.

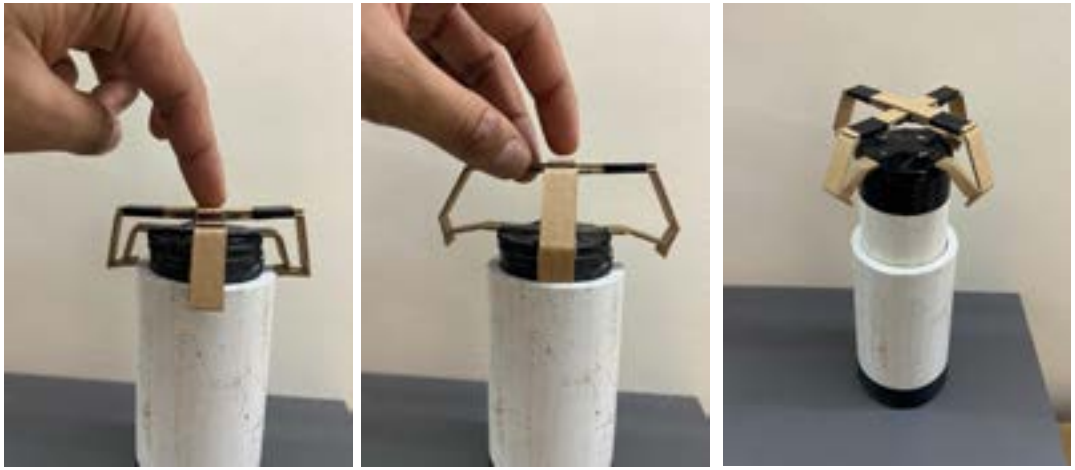


Loss of chest recoil can be achieved by locking the piston. If the student applies excess pressure causing the chest to displace beyond recommended depth, the piston will lock halting chest compressions. This will indicate that the rib cage has been damaged and compressions no longer have the desired effect. A simple reset mechanism to unlock the piston will prevent students from getting discouraged if they don't get it right the first few times.

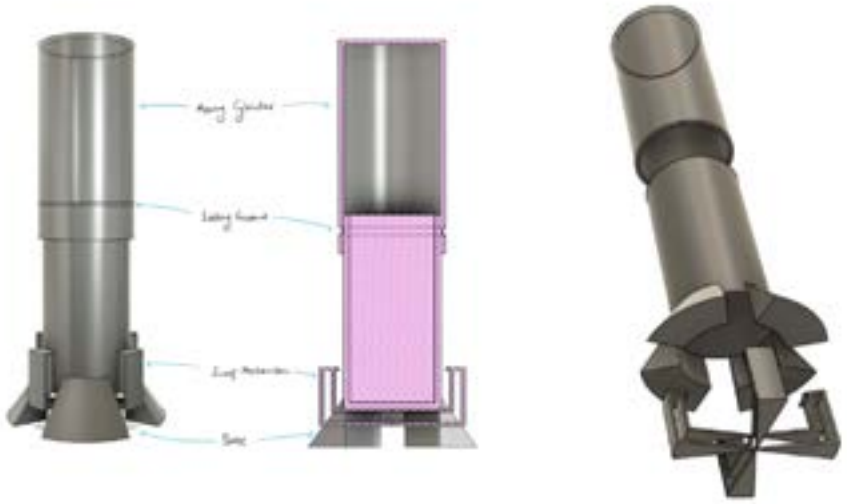
Iteration 1

Using a snap fit mechanism. The protrusions from the base snap in the groove on the surface of the moving cylinder of the piston. Once locked, the bottom section of the snap mechanism can be pulled to release the piston back to its original position.



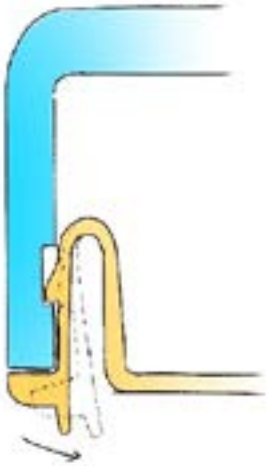


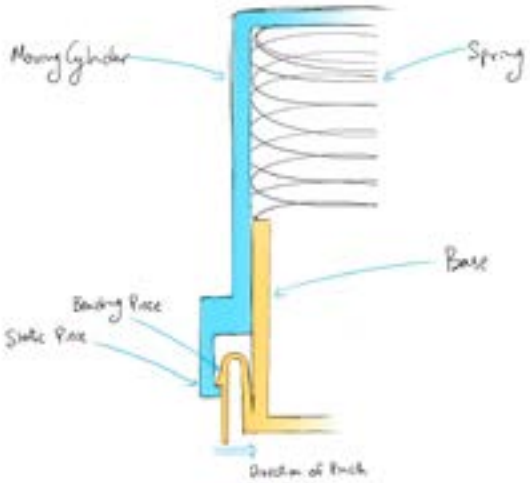
The mockup was created using cardboard and PVC pipe. The first image shows the mechanism locked in place because the piston has crossed recommended depth. The second image shows the lock being released by a simple pull.

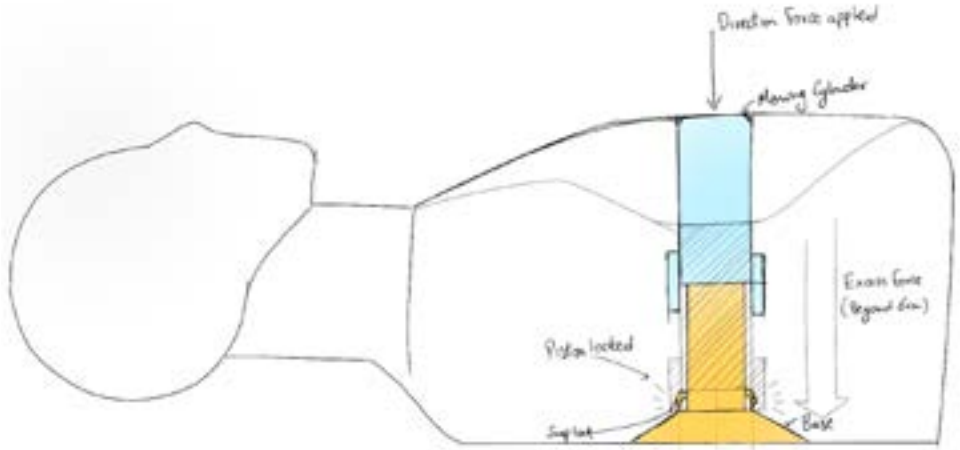


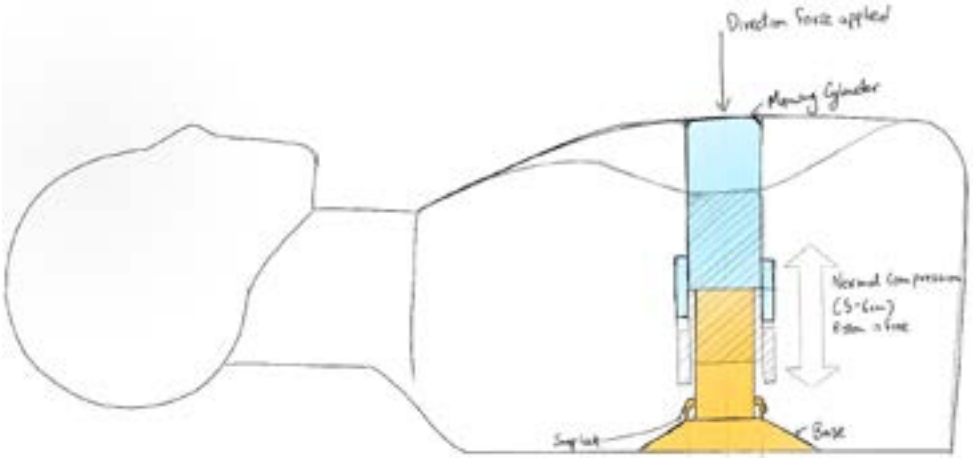
Iteration 2

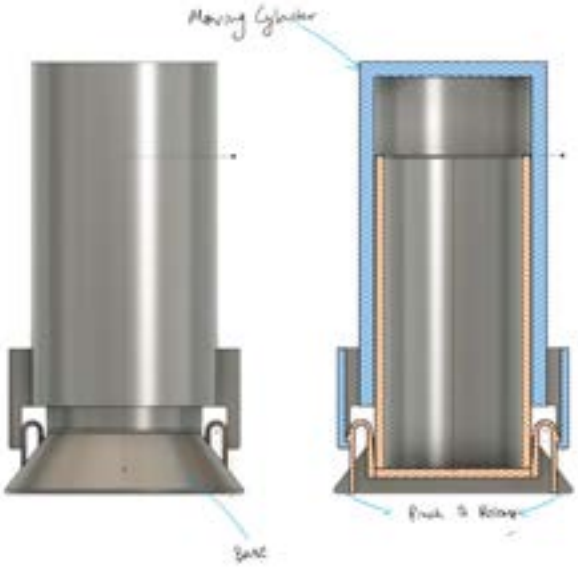
Using a u pin snap lock and release mechanism, the desired result can be achieved. When the cylinder moves too far down, the u pins will snap inside the hollow cuboids. To release, the pins have to be simply pinched inwards. This will unlock the piston and the student can continue practise.











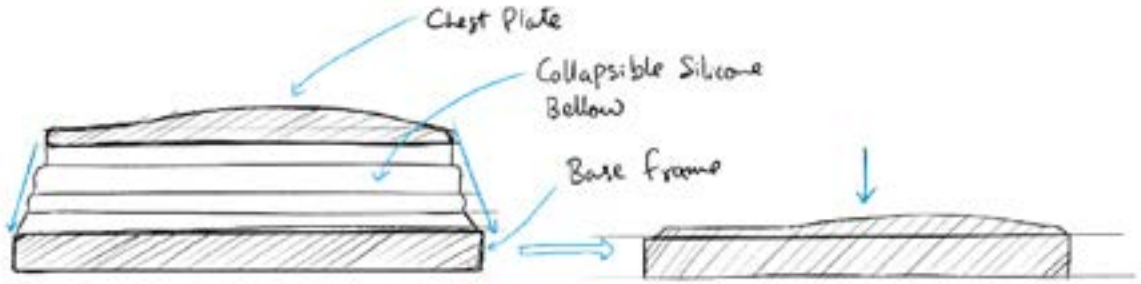
Concepts

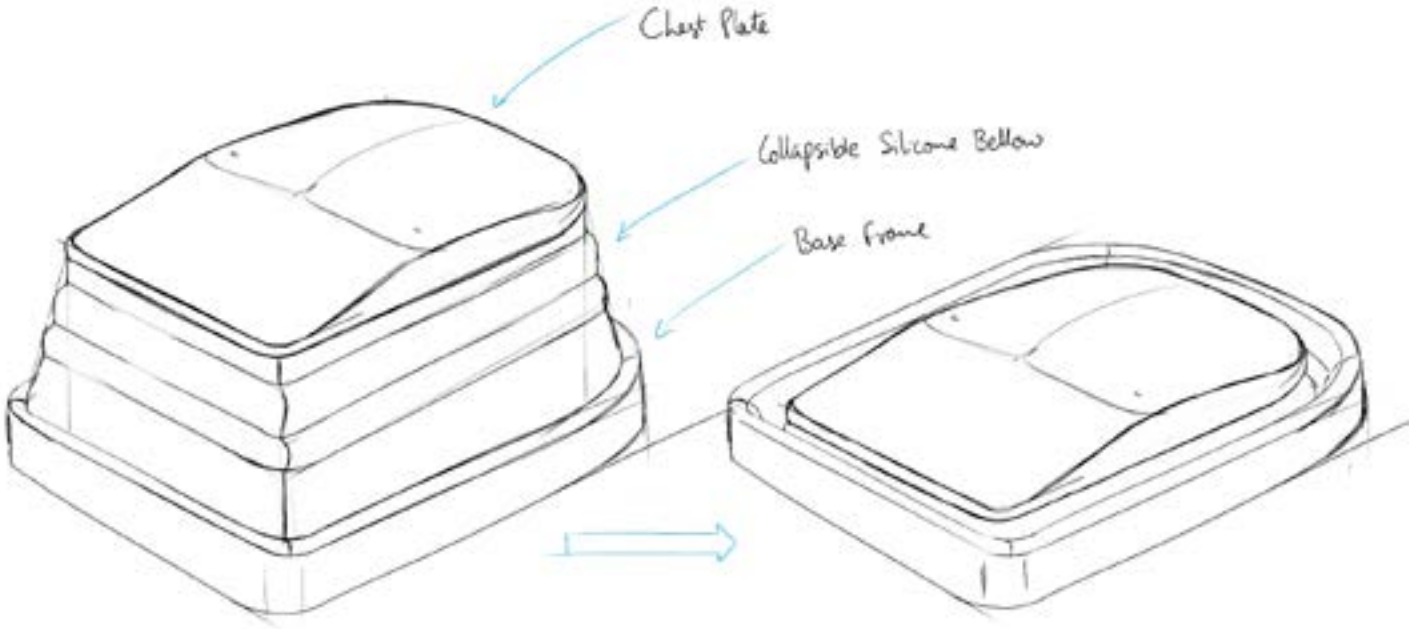
Concept 1- Collapsible

Set up and pack up is super easy. To setup manikin, push the chest plate from the bottom to expand the torso. Assemble piston from beneath. Start CPR.
To Pack up, remove piston and press down on the chest. This mechanism allows the manikin to be flat packed at a very low thickness

Dimensions:
Expanded - 433 x 360 x 213 mm
Compressed - 433 x 360 x 60 mm

Drawbacks:
angle created due to difference in face area of bottom and top surfaces
It might be difficult to incorporate a skin on top of this shell






213 mm


60mm


360 mm
433 mm

Concept 2- Compressible

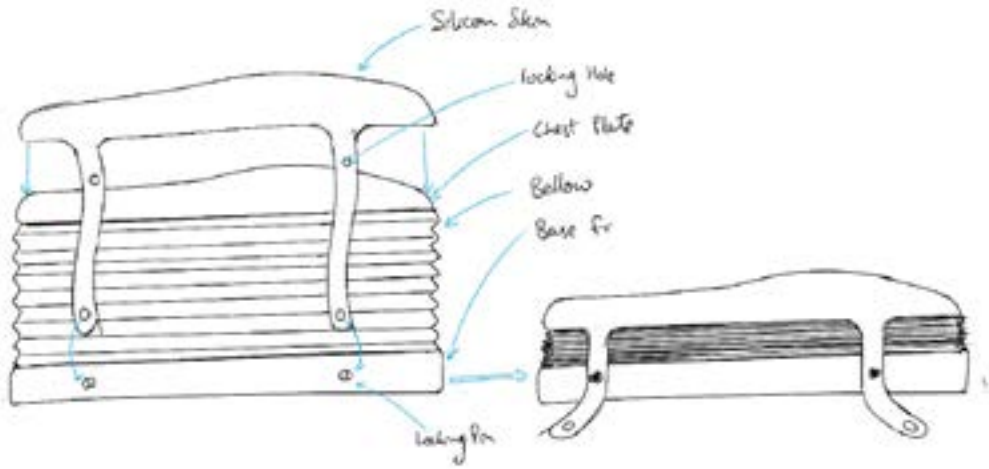
This design uses bellows to collapse. Bellow adds a sping effect which will make the compressions a visual activity. Students can see the chest actually being compressed.

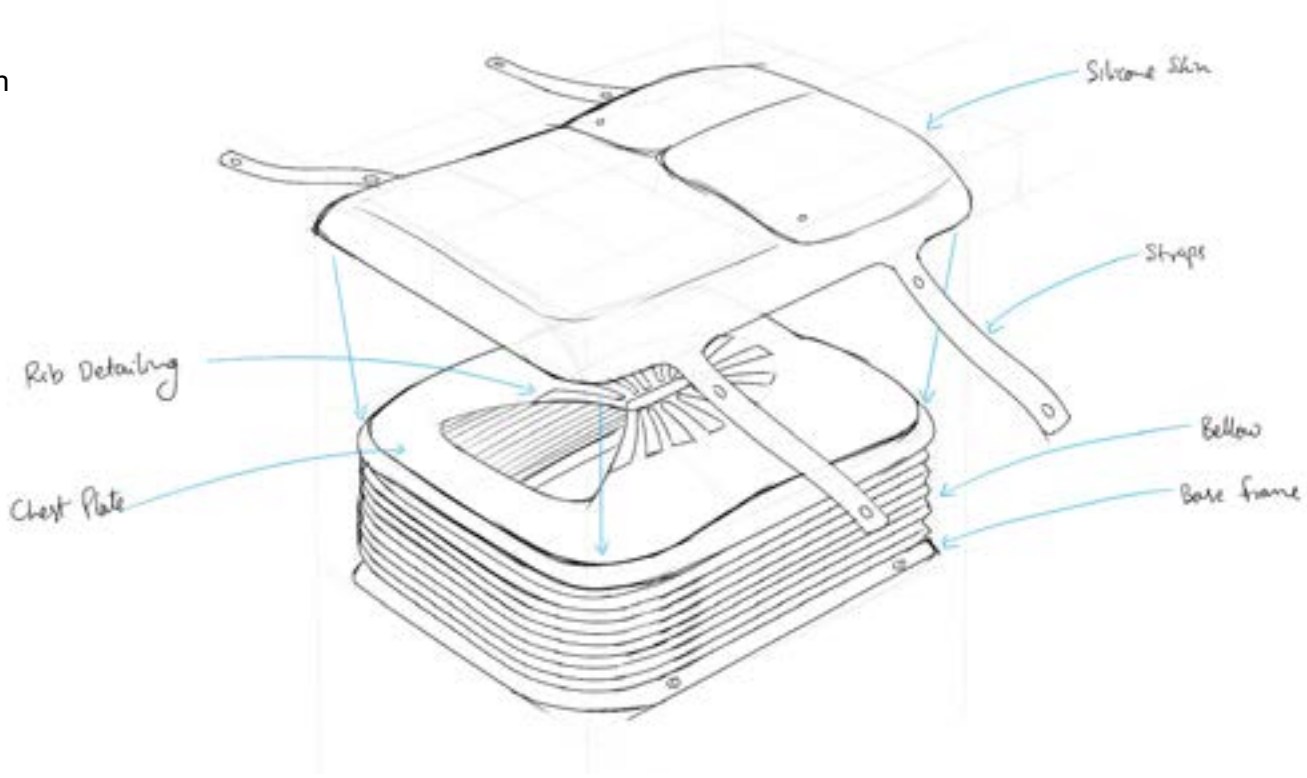
The chest plate is molded to the bellow

A silicone skin cover of the same profile as the chest plate is placed on top
Two straps from the cover extend out in each direction. The holes at the end keep the skin in place when CPR is practised and the holes at the top hold the compressed form when packing.This mechanism also allows the manikin to be flat packed.

Dimensions:
Expanded - 375 x 293 x 213 mm
Compressed - 375 x 293 x 79 mm

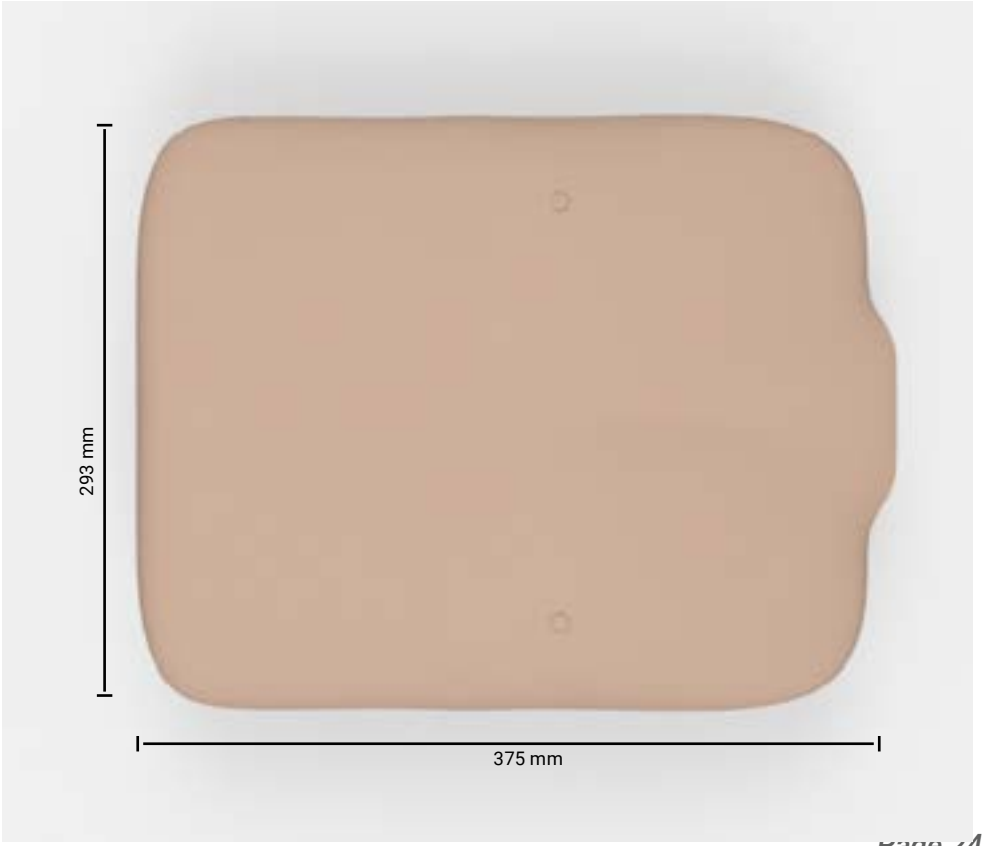
Drawbacks:
Thicker than iteration 1






213 mm


79 mm


293 mm
375 mm

Concept Evaluation

Parameter	Concept 1 - Collapsible Torso	Concept 2 - Compressible Torso
	8 Dimensions of Quality	
performance	3	5
Features	4	4
reliability	3	4
conformance	5	5
durability	4	3
serviceabilty	2	3
aesthetics	2	4
perceived quality	3	4
	Qualitative analysis	
Following Medical Standards	5	5
Realistic	3	4
Quality of Compression	2	5
Ease of set up	5	3
Ease of Packing	5	4
Hand Placement Assistance	5	5
Compression Force Training	5	5
Total	**56**	**63**

The evaluation was conducted using the 8 dimensions of quality and other important aspects as parameters. Each concept was scored on each parameter out of a rating of 5. The chosen concept is the one which attains the highest score from the evaluation.
As seen from the table in Fig.X, Concept 2 is the better design. Both concepts rank equally in compression force training and hand placement as the same components and features are used. The below design of Concept 2 allows for compact packing while not hindering compressions performed during CPR. The area of the base is also smaller than that of concept 1. Concept 2 was finalised and i proceeded further with detailing of the components.

Detailing

Piston
There are three parts to the piston, the top moving cylinder, the base which contains the snap lock mechanism and the spring which goes inside the removing cylinder. The snap lock is designed to be easily released using the U shaped snap fit feature. The sketches and software iterations have been discussed in ideation.

Rib Feature
For hand placement assistance, the ribs will be simulated through bumps. The actual shape of a normal human rib cage has been slightly abstracted for easier learning. The ribs will be raised at a 4mm height from the chest plate. This will allow the students to feel them through the silicone skin

Skin Cover
The skin cover has two purposes. It gives a realistic feel to the students when they perform cpr. The skin has two straps which extend out on either side of the manikin. The straps hold the skin in place when the manikin is expanded for training. While packing, the upper holes in the strap hold the shape of the compressed manikin.

Base
The base has the same profile as the chest plate and bellow. This allows all three parts to be easily molded together. There are four hooks on the base to which the straps of the skin cover latch onto. The base also acts as a structural feature, retaining the shape of the manikin.

Materials

Piston
Both parts of the piston will be injectionmolded PVC. The parts are designed to avoid undercuts.

Chest Plate
Chest plate will be manfactured using injection molded PVC

Skin Cover
The skin cover will be formed out of silicone for a reailstic skin texture

Base
The base will also be made using injection moulding PVC.

Bellow
The bellow will be made using silicone. The chest plate and base will be fused with the bellow.

Software Prototype

Expanded Manikin

Side view

Front 3/4thView

Back view

Bottom View

Compressed Manikin

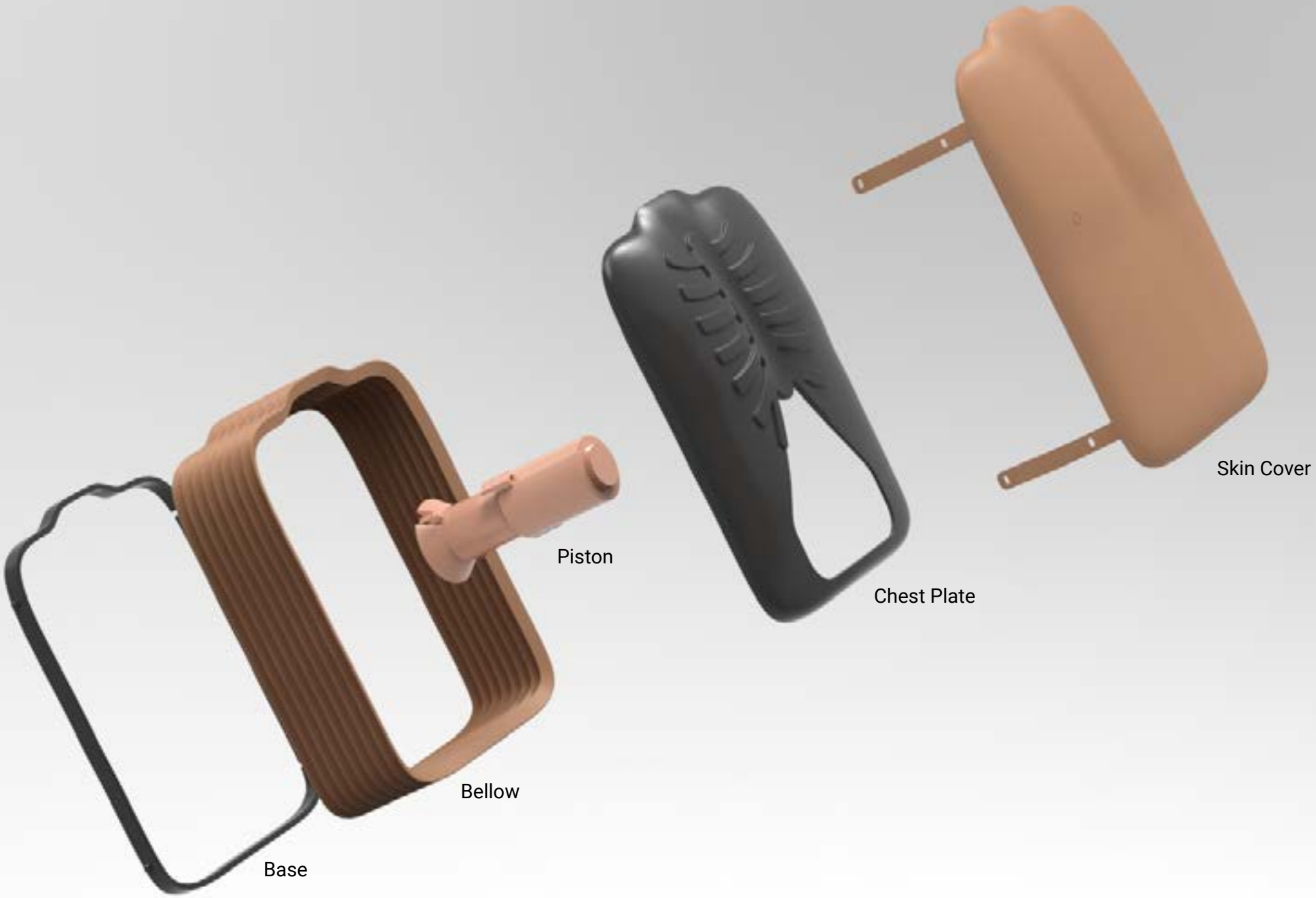
Rear 3/4th view

Front 3/4th View

Side view

Top View

Exploded View



Piston

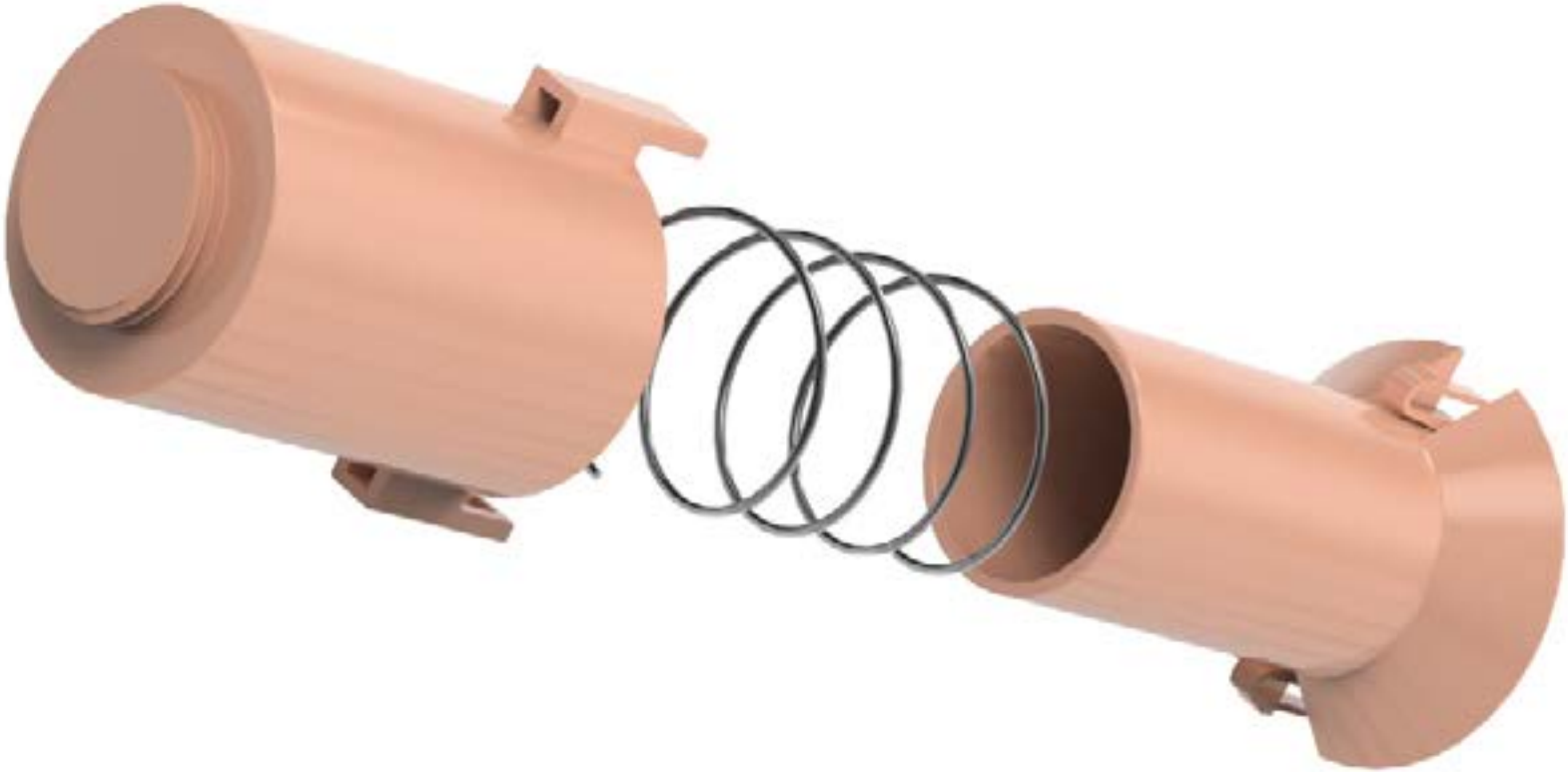
3/4th view

Side View

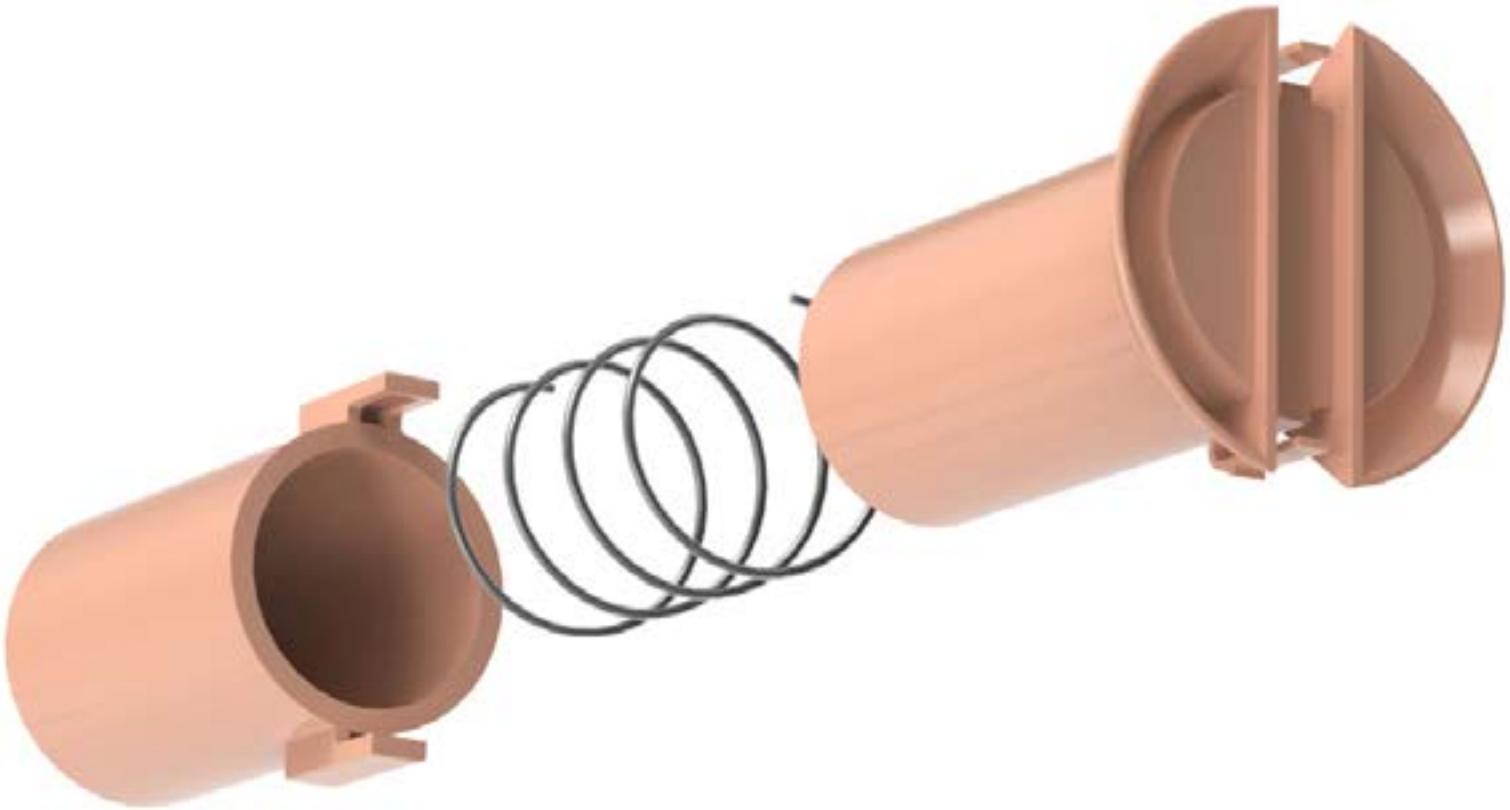
Top view

Locked Piston

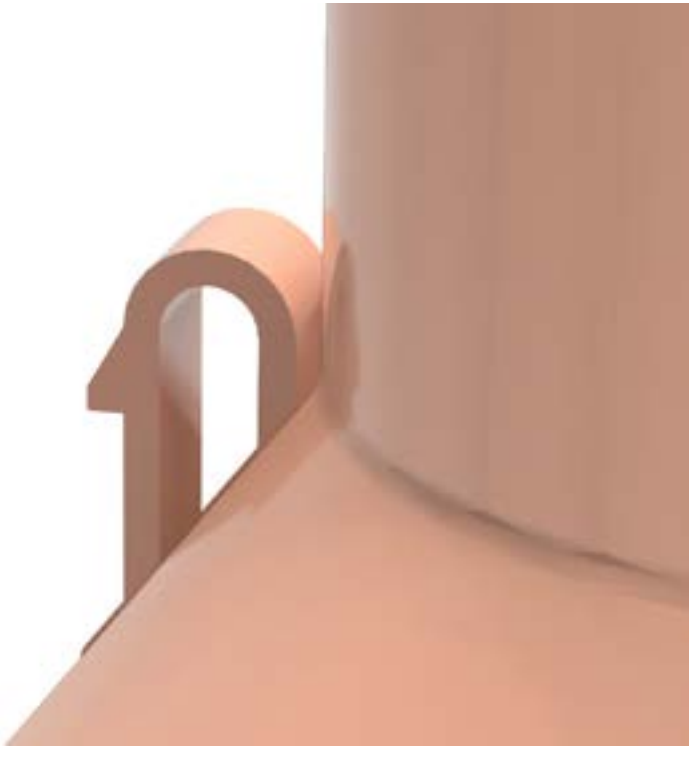
Exploded View

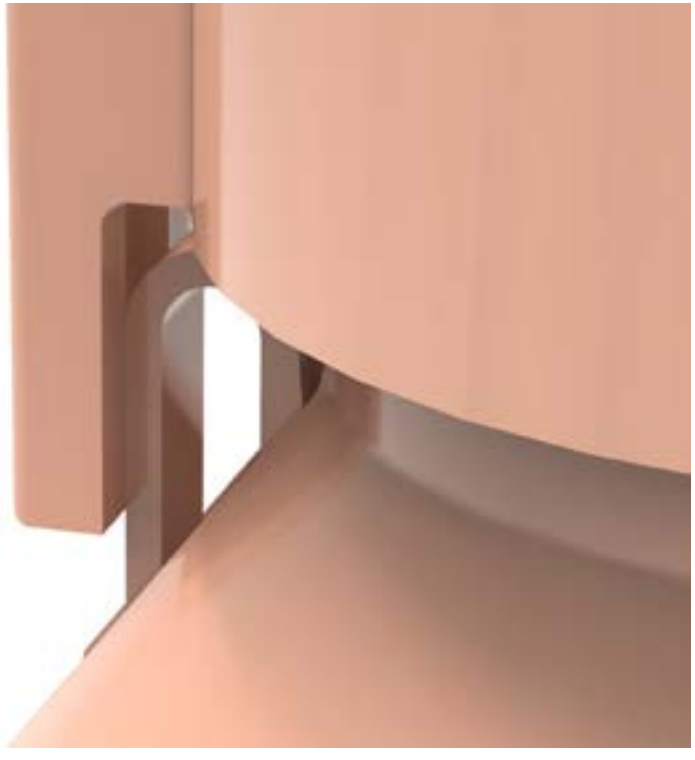


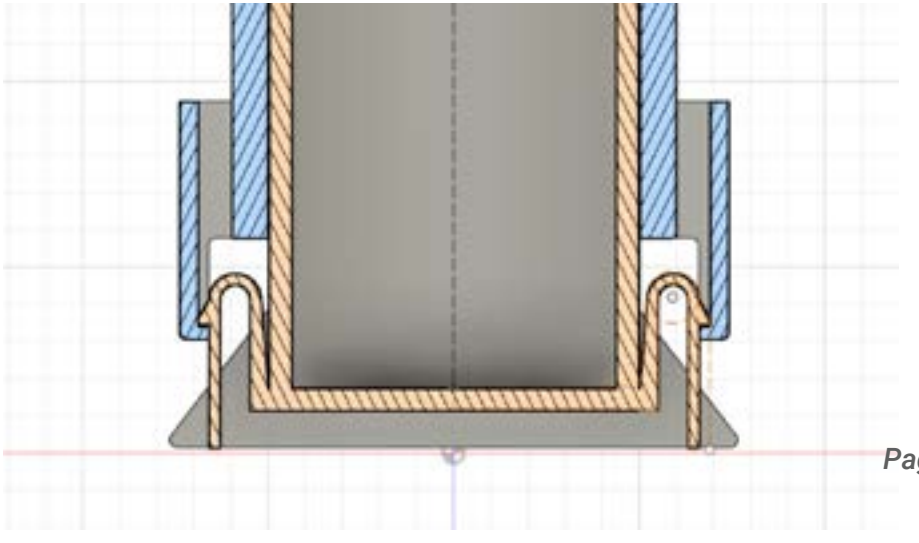
Exploded View



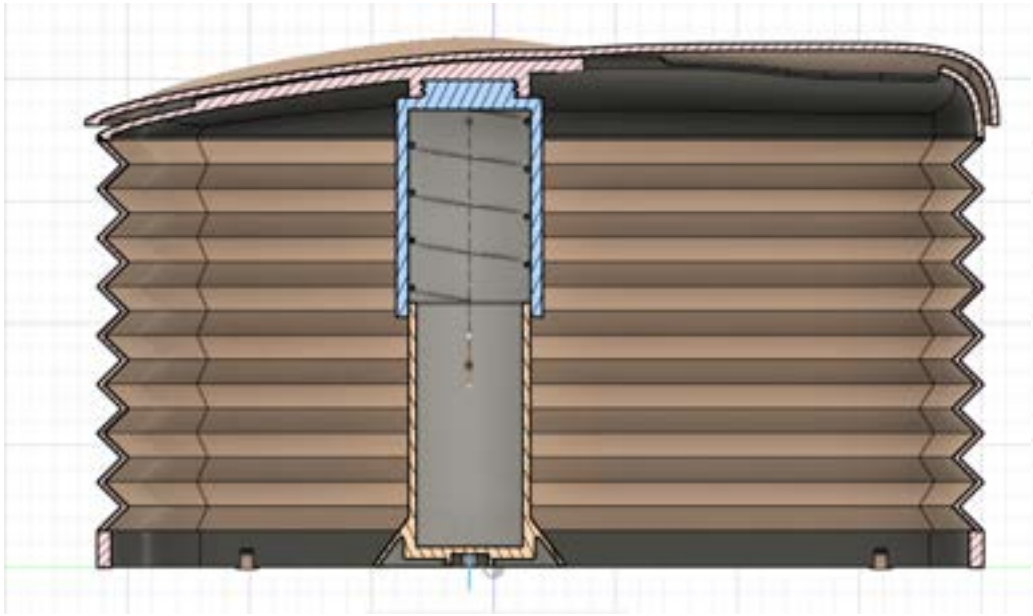
Piston Locking Detail

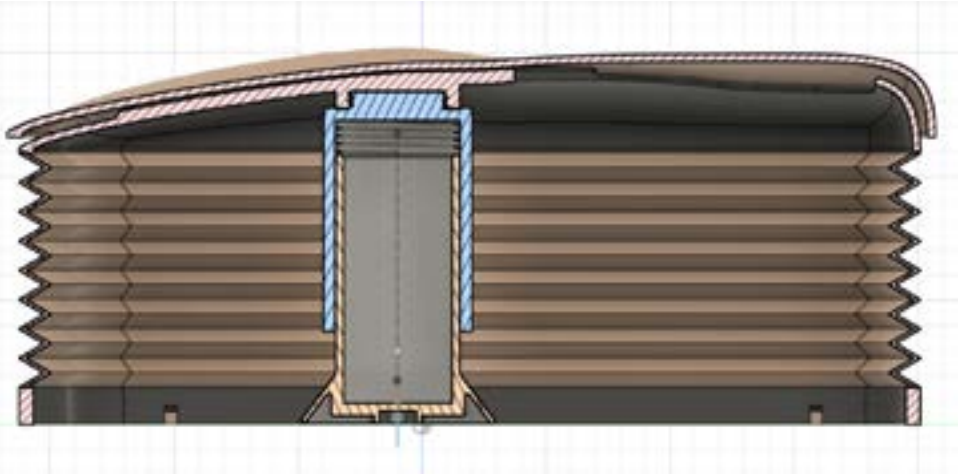






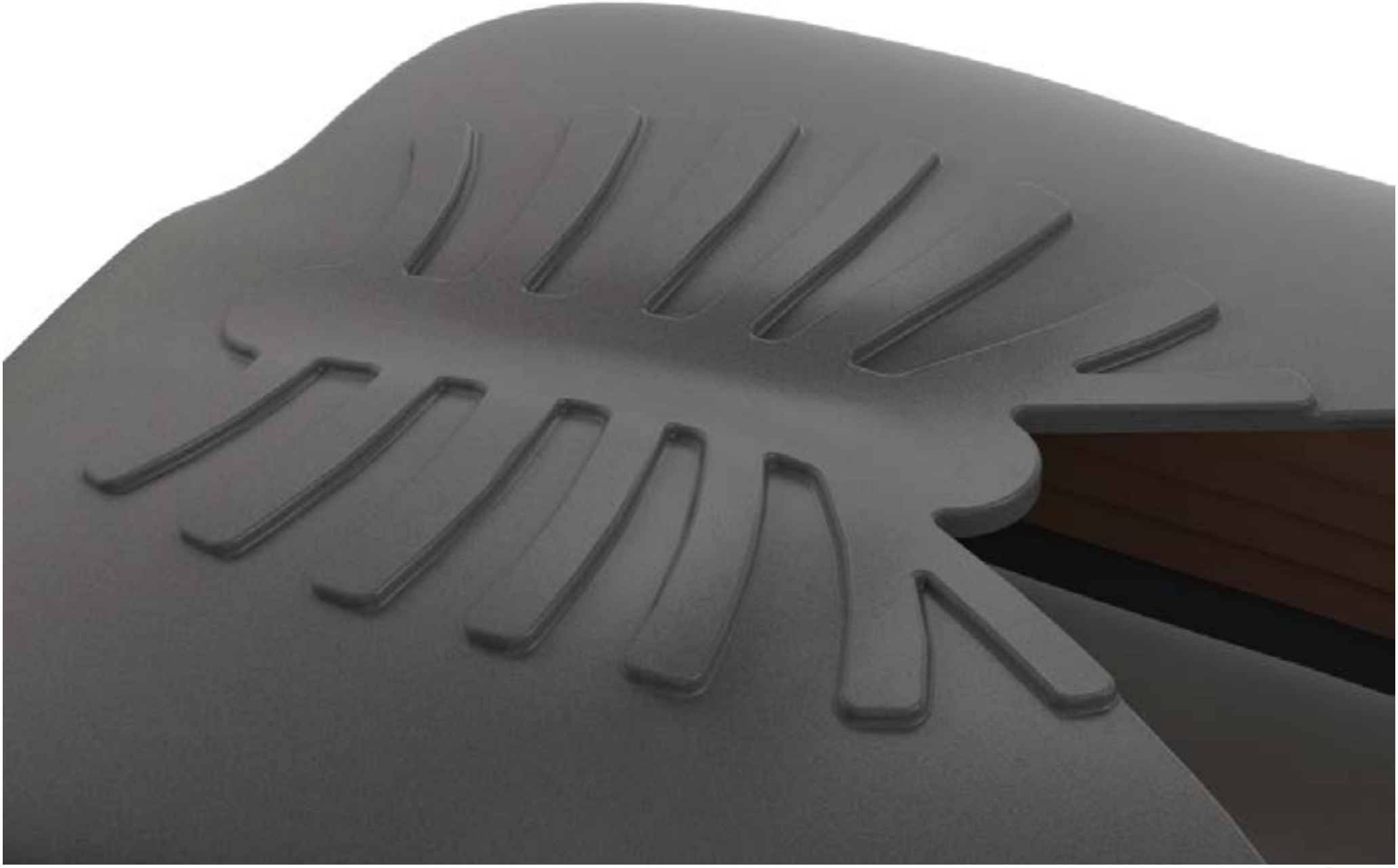
Piston Compression During CPR Practice



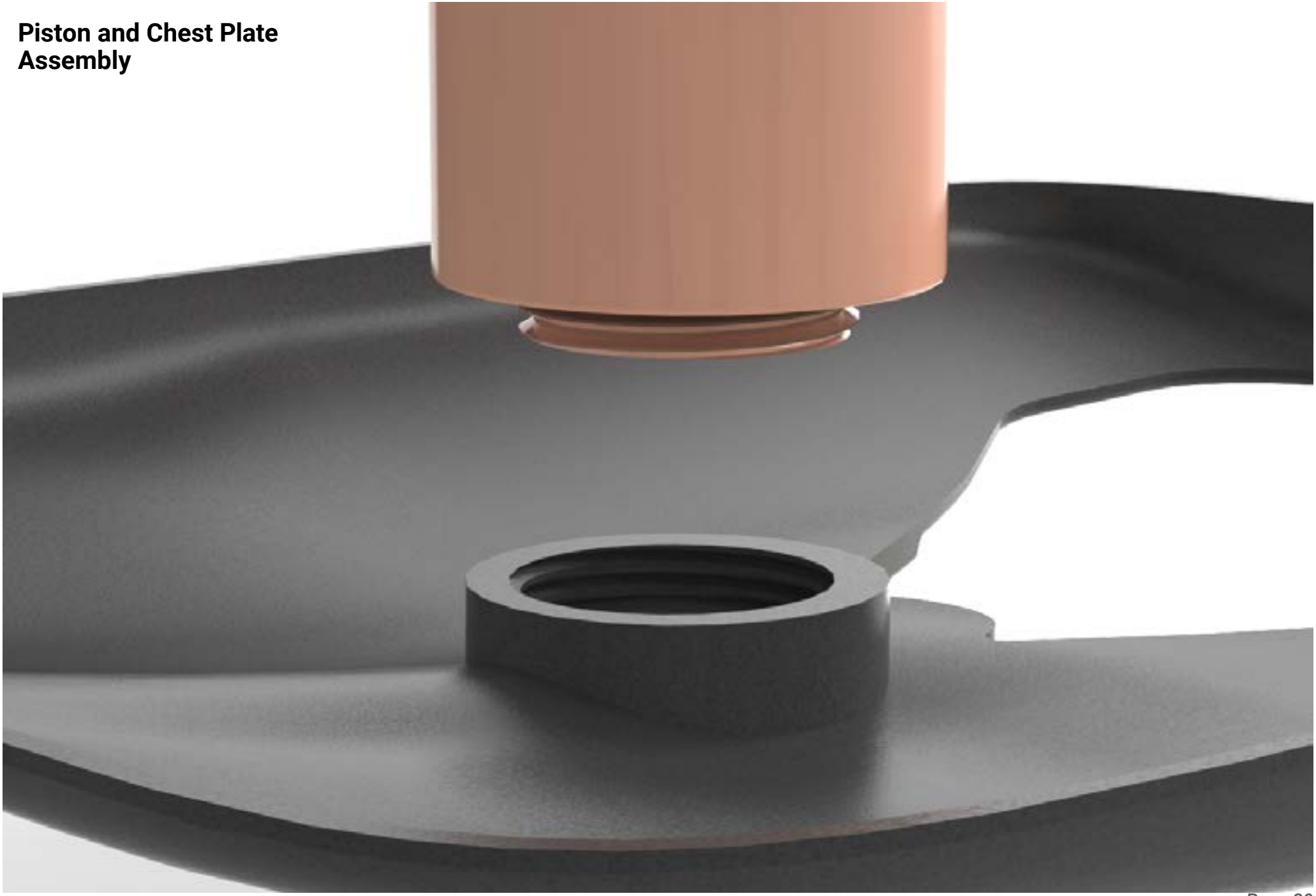


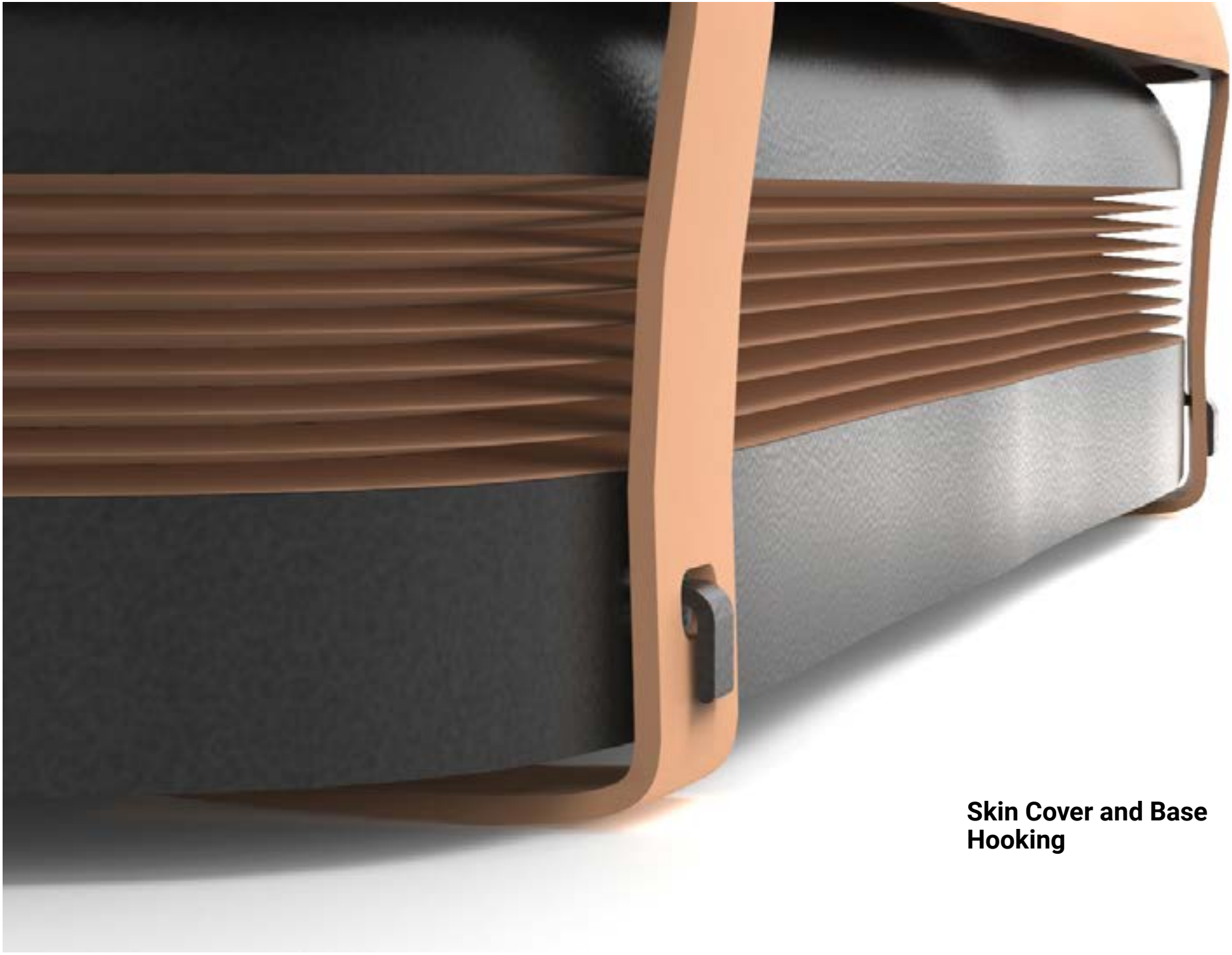
Manikin without Skin Cover

Rib Detail



Piston and Chest Plate Assembly





Skin Cover and Base Hooking

Conclusion

The broader goal of this design project was to design an adult CPR classroom training manikin which aids and educates the students regarding factors which result in quality CPR. The process of CPR was studied and major and minor focus areas to improve current manikin designs were identified. Three novel features were designed. First, Hand placement assistance in the form of raised ribs on the chest plate, which provide realistic tactile sensation which the student can recall if they were to ever be in a situation to actually perform CPR on a human suffering from cardiac arrest. Second, the limit of compression force was informed to the students through simulating the loss of chest recoil by piston locking. The risk of performing CPR without proper training was emphasized hoping to reduce the number of injuries received by victims on whom civilians have performed CPR. Third, the manikin was designed to compress and pack in a compact size reducing the total volume of a CPR training kit. The components were modelled in 3D CAD software keeping in mind the manufacturing methods and limitations. A few rough mockups were created to test the design of the novel features. There is more work to be done on the project including rescue breathing training features which have not been explored till now. A working prototype is to be made for user evaluation of the novel features.

Further Work

At the current stage, the manikin is a hands only cpr training manikin. Further research and design needs to be done to include rescue breathing training features like lungs bags, head tilt etc. A working prototype is to be made for user testing and evaluation of novel features developed in this project. Once The prototype is ready, the following phase will include kit design user manuals.

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