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The Use of 3D Reconstruction and Virtual Reality to Support Prospective Bariatric Surgery Patients
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The Hamlyn Centre

The Institute of Global Health Innovation

Clinical Background

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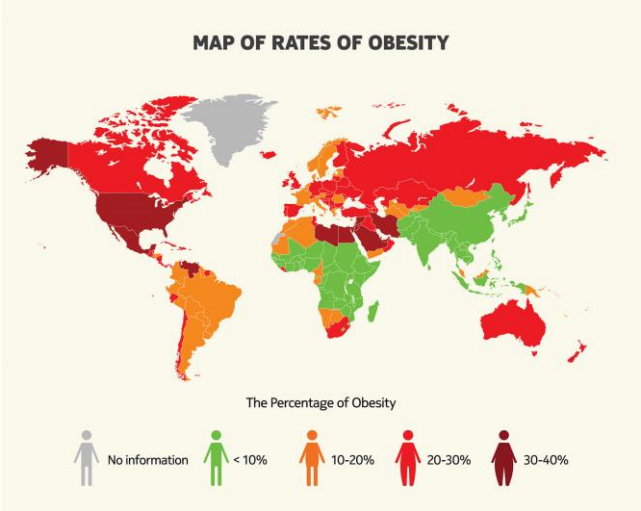
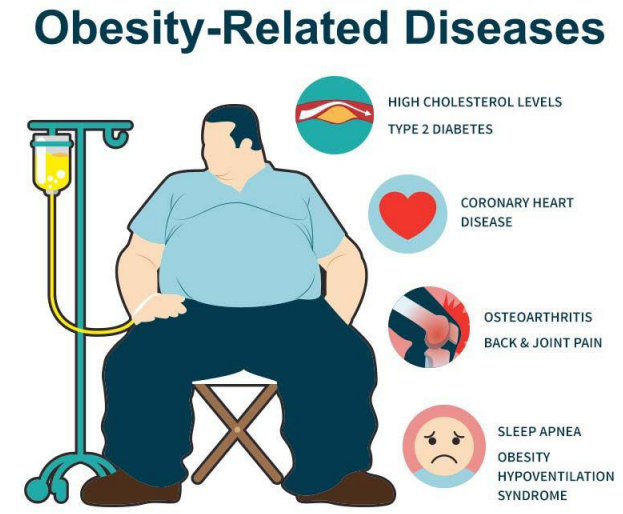
In the UK, around 1 in every 4 adults and around 1 in every 5 children aged 10 to 11 are living with obesity.



Risks:

- Type 2 Diabetes
- Coronary Heart Disease
- Some types of cancer, such as breast cancer and bowel cancer
- Stroke



Bariatric Surgery

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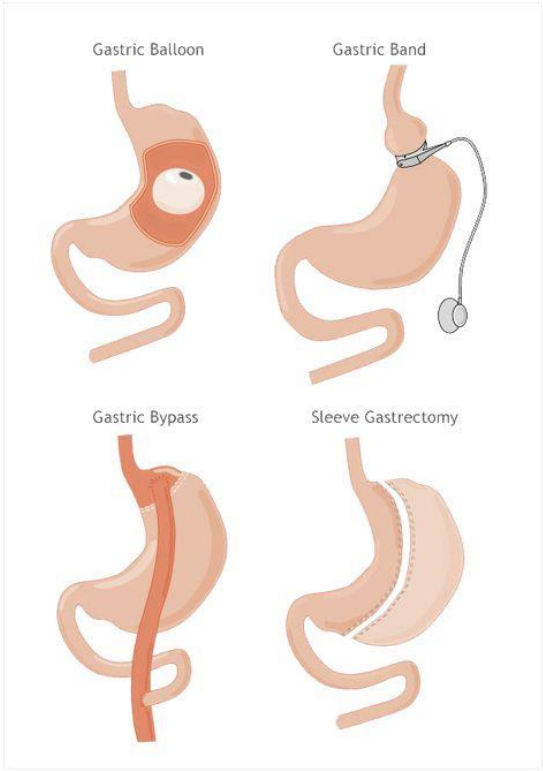
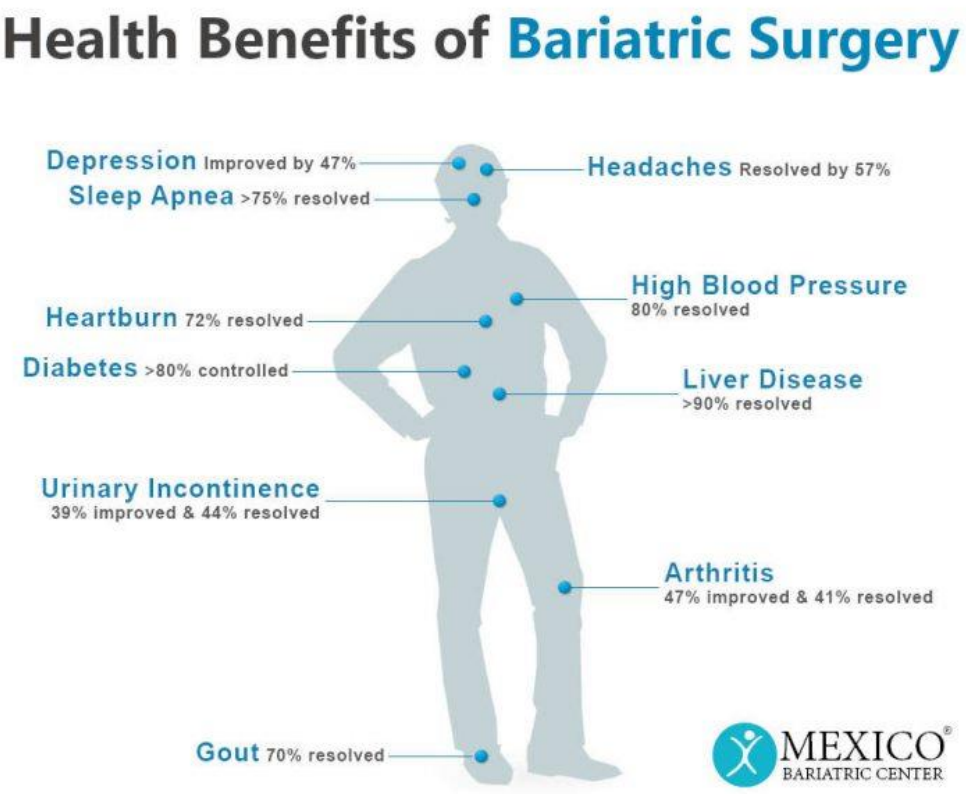
Body Mass Index(BMI)>40, or 35<BMI<40 with an obesity-related condition that needs bariatric surgeries.





Body Image in Patients' Mind (Without Intervention)

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After Bariatric Surgery, Body Image in Patients' Mind Does Not Change.

Negative Body Image

Internal Stigmatisation

Loss of Control Eating & Maladaptive Eating Pattern

Poor Postoperative Weight loss

Body Image in Patients' Mind (With Intervention)

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After Bariatric Surgery, Body Image in Patients' Mind Does Not Change.

↓

Show Postoperative Weight Loss Portraits

↓

Positive Body Image

↓

Regular Eating with Confidence

↓

Good Postoperative Weight Loss

How to Showcase?

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Image **VS** **Virtual Reality(VR)**

Lack of Immersion
Limited Perspective

Enhanced Realism
Immersive Experience

"3D reconstruction and VR is both a feasible and acceptable method of addressing body image in bariatric surgery" (Nazrin, 2022)

Aims & Objectives

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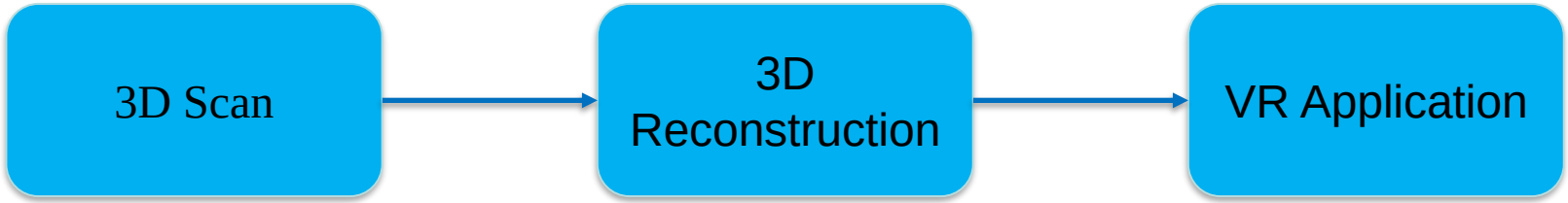
1. Use existing technology platforms to capture in 3D the shape of participants to create patient-specific avatars.

2. Use 3D design software combined with 3D scanning avatars to simulate what patients would look like after bariatric surgery.

3. Visualise in multi-view in Unity Engine.



3D Scan Device & Application

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3D Scanning Device: iPad Pro (3rd Generation) (Apple Inc, California, USA)
3D Scanning Application: “Polycam”, “3D Scanner APP” & “Scaniverse”(√)

Polycam

3D Scanner APP

“Scaniverse”(√)

3D Scan Method

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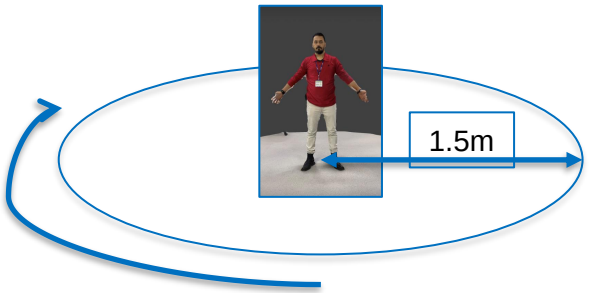
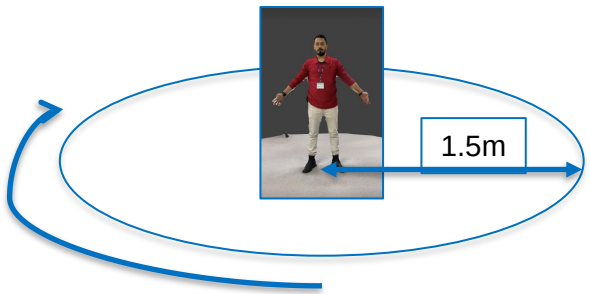
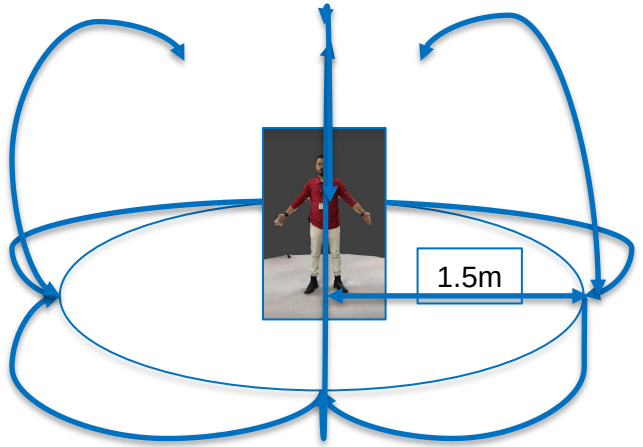
3D Scanning Device: iPad Pro (3rd Generation) (Apple Inc, California, USA)
3D Scanning Application: “Scaniverse”
3D Scanning Method: 1 min flat, 2.5 min flat & 2.5 min up & down



1 min flat



2.5 min flat



2.5 min up and down

3D Scan Method: Accuracy Measurement & Comparison

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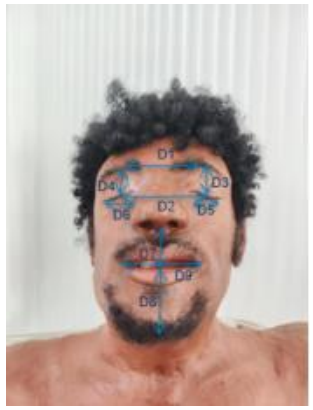

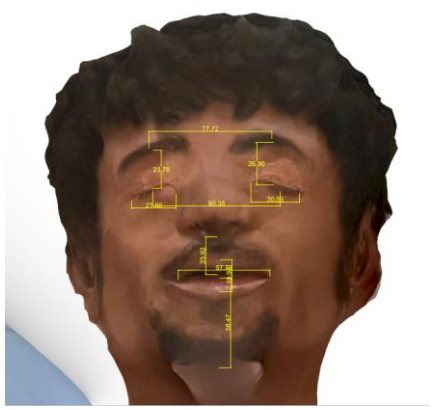

Table 4.1: Comparison of Eigenvalue Positions between Actual and Scanned Measurements

Feature	Actual (cm)	1-min Diff. (cm)	2.5-min Flat Diff. (cm)	2.5-min Up/Down Diff. (cm)
D1	80.1	-2.4	-0.9	+0.3
D2	85.9	-5,2	-5.0	-5.0
D3	29.0	-3.0	+0.2	-1.0
D4	26.5	-2.5	-3.0	+0.2
D5	33.1	-2.6	-2.0	-1.5
D6	30.0	-2.0	+2.7	-2.3
D7	28.5	-4.2	-3.0	-2.9
D8	55.0	+1.5	-0.7	+0.6
D9	65.0	-7.6	-4.1	-4.5

Mean Absolute Error(MAE) $MAE = \frac{1}{n}\sum_{i=1}^{n}|y_i - \hat{y}_i|$

- **1-minute flat scan:** MAE = 3.4
- **2.5-minute flat scan:** MAE = 2.4
- **2.5-minute up and down scan:** MAE = 2.0

2.5-minute up and down scan

3D Reconstruction: Armature Design and Binding

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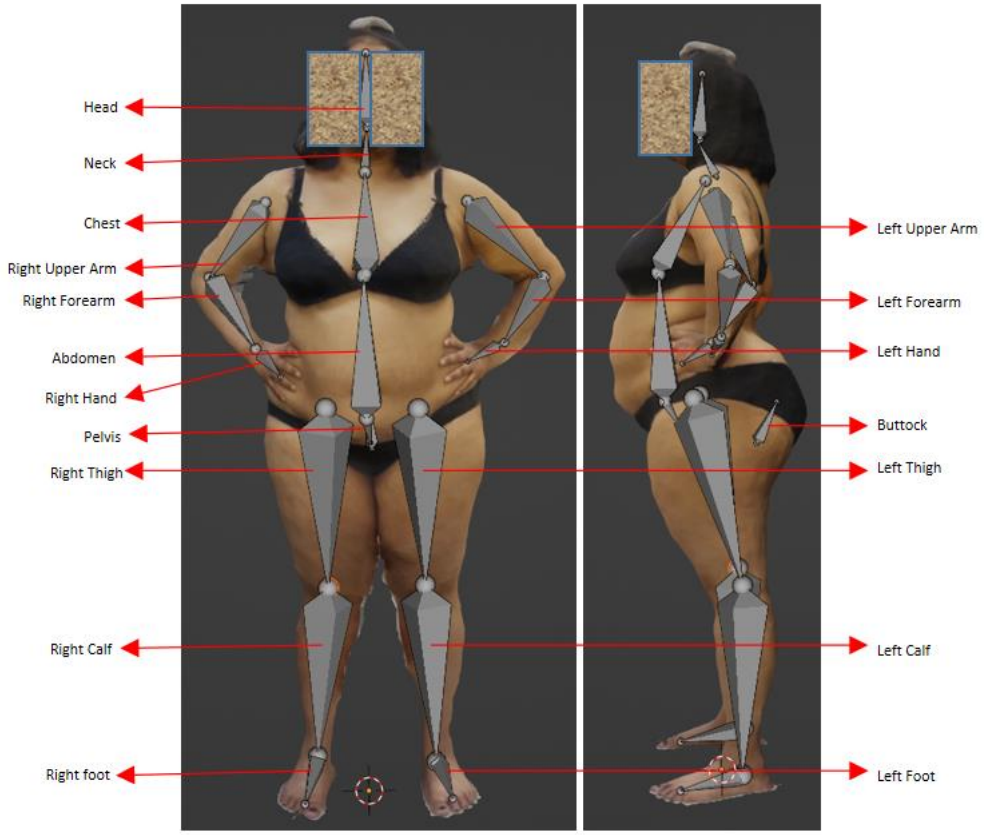

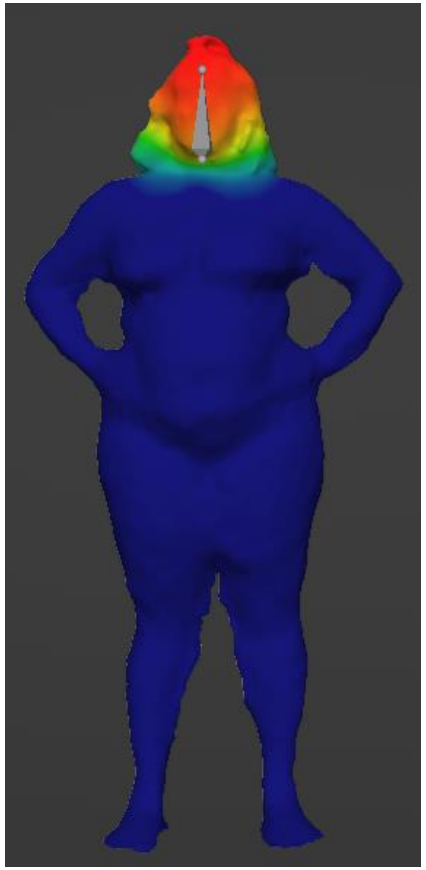

Armature Resizing Algorithm

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Input

$$V_{target} = V_{orig} \times (1 - R)$$

Body Part	Tolerance
Head	0.039
Neck	0.143
Chest	0.178
Abdomen	0.205
Pelvis	0.228
Buttock	0.228
Left Upper Arm	0.156
Right Upper Arm	0.156
Left Forearm	0.078
Right Forearm	0.078
Left Hand	0.039
Right Hand	0.039
Left Thigh	0.156
Left Calf	0.078
Left Foot	0.039
Right Thigh	0.156
Right Calf	0.078
Right Foot	0.039

$$SF_{bone,new} = SF_{bone,old} - T_{bone}$$

$$V_{current,new} = V_{current,old} \times \prod_{i=1}^{N} SF_{bone,new}^{(i)}$$

$$|V_{current} - V_{target}| < \varepsilon$$

$$\begin{cases} V_{orig} & if\ n = 0 \\ V_{current}(n-1) \times \prod_{i=1}^{N} SF_{bone}^{(i)}(n) & otherwise \end{cases}$$

"Anthropometrics by three-dimensional photonic scanner in patients with obesity before and after bariatric surgery," (A. Shah et al. 2021)

Body Weight Reduction(Without Skin Folds)

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Skin Folds

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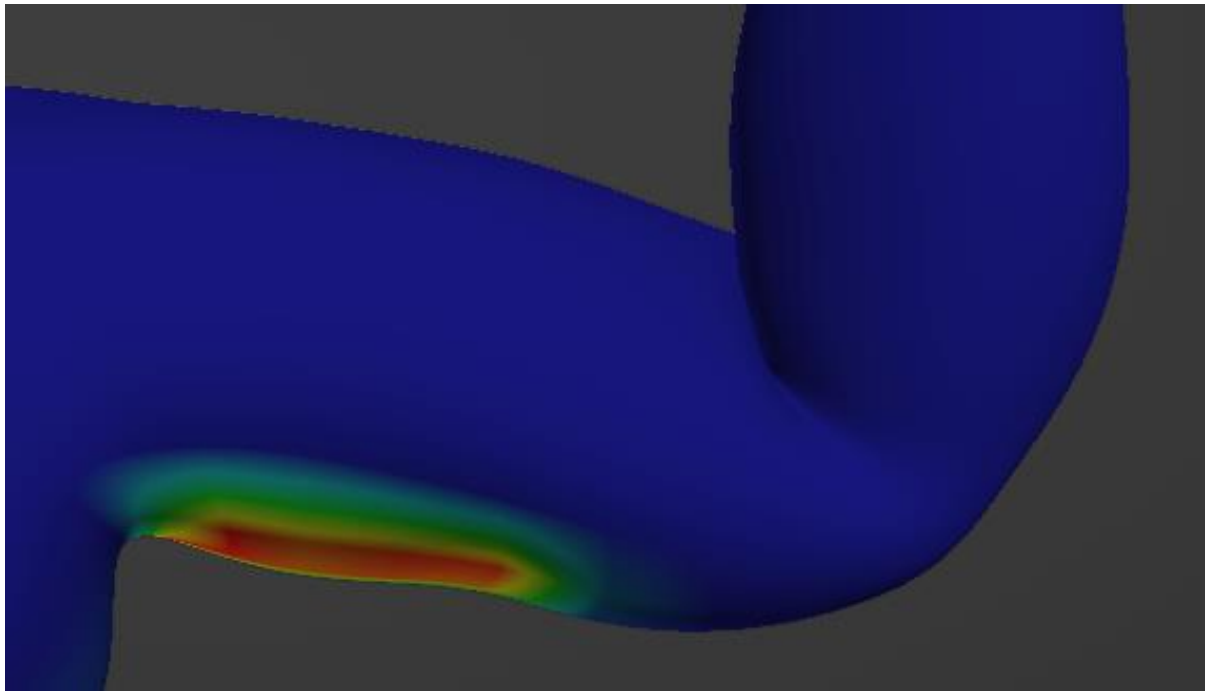

Skin Folds Simulation: Mass-Spring Model

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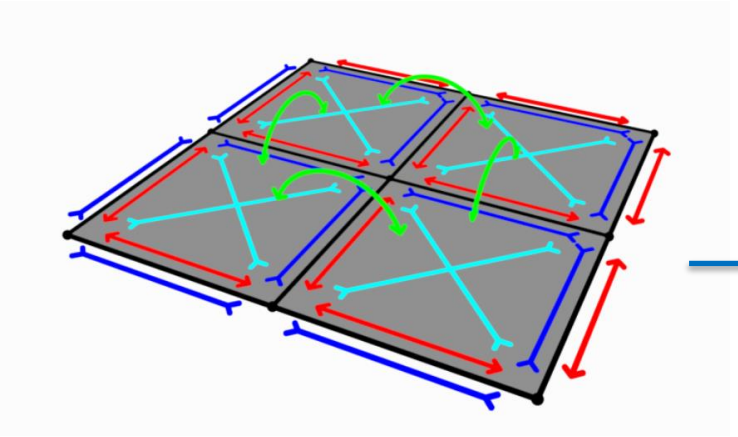


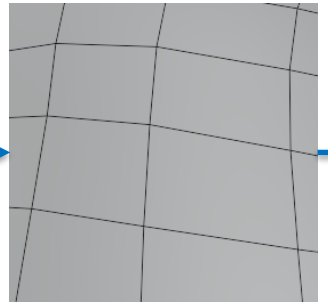
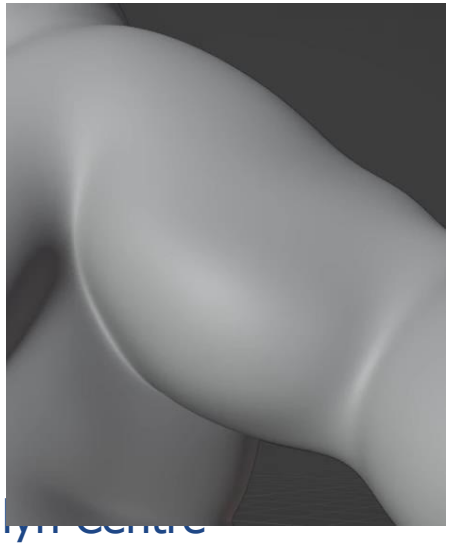
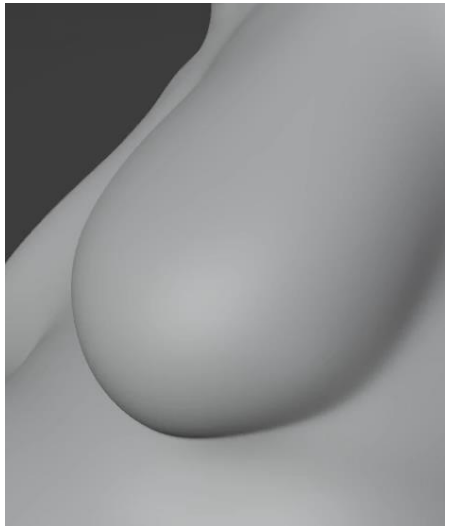
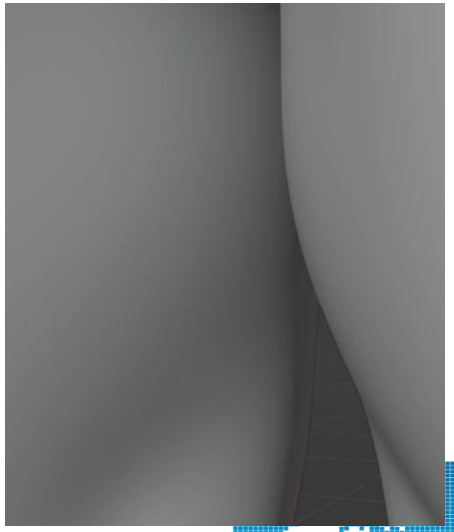


Illustration of Mess-Spring Model ; tension springs (blue), compression springs (red), shear springs (cyan), and angular bending springs (green).







Skin Folds Simulation Grading(Arm)

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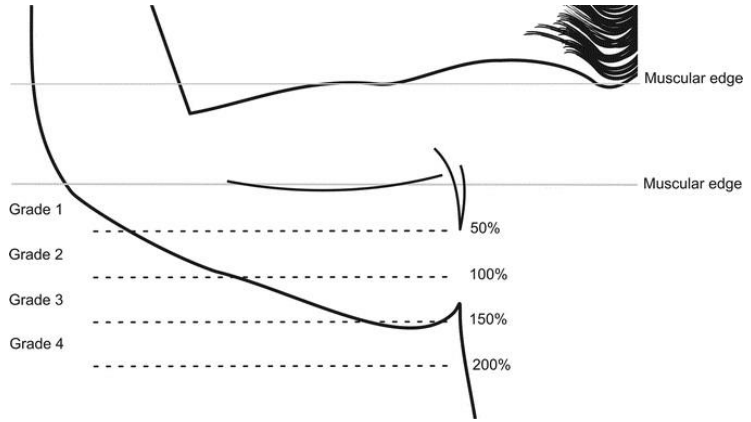
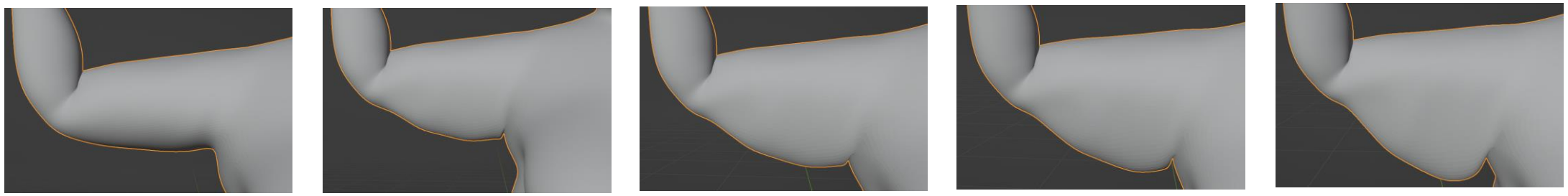


illustration *



Original | Grade 1 | Grade 2 | Grade 3 | Grade 4

* *"An anthropometric classification of body contour deformities after massive weight loss"(M. Iglesias et al. 2010)*

Skin Folds Simulation Grading(Thighs)

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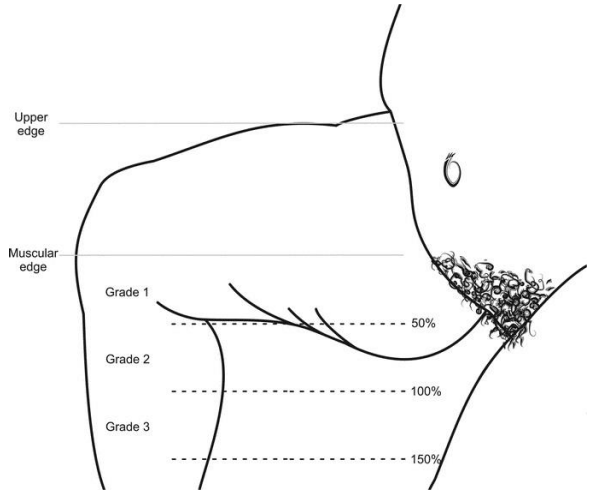

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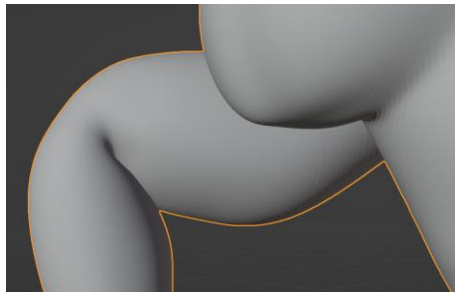
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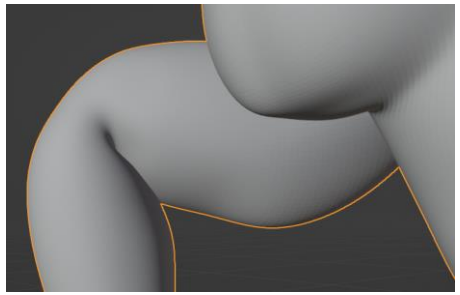
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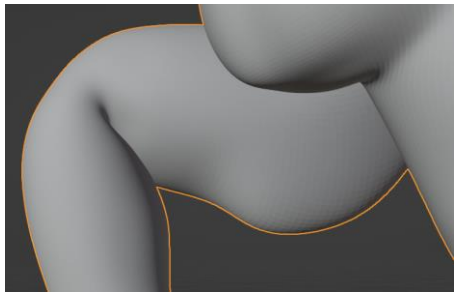
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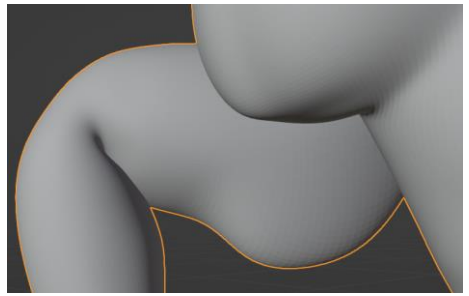
Grade 3

* *"An anthropometric classification of body contour deformities after massive weight loss"(M. Iglesias et al. 2010)*

Skin Folds Simulation Grading(Abdomen)

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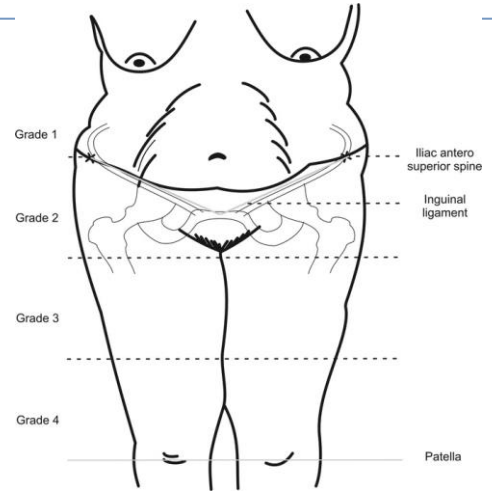

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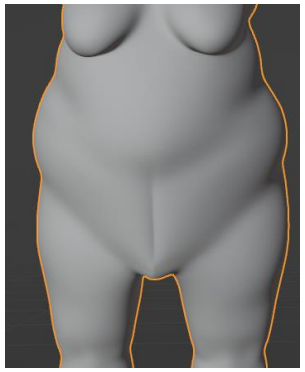
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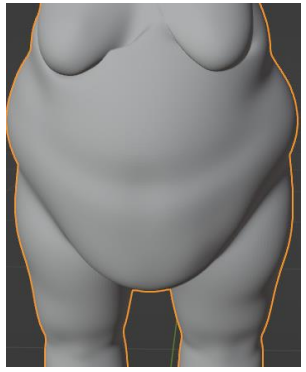
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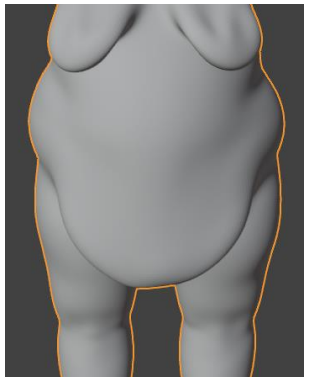
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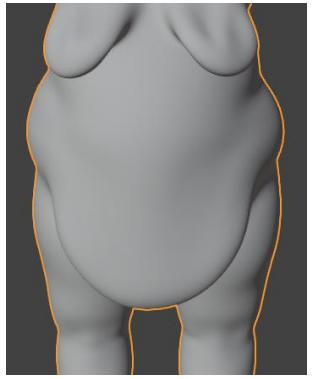
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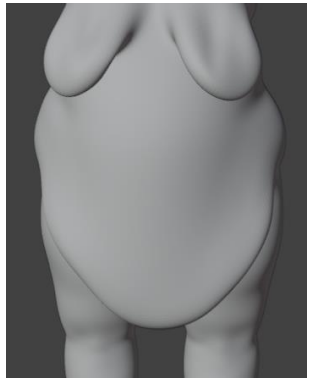
Grade 4

* *"An anthropometric classification of body contour deformities after massive weight loss"(M. Iglesias et al. 2010)*

Skin Folds Simulation Grading(Mammary Gland for Female)

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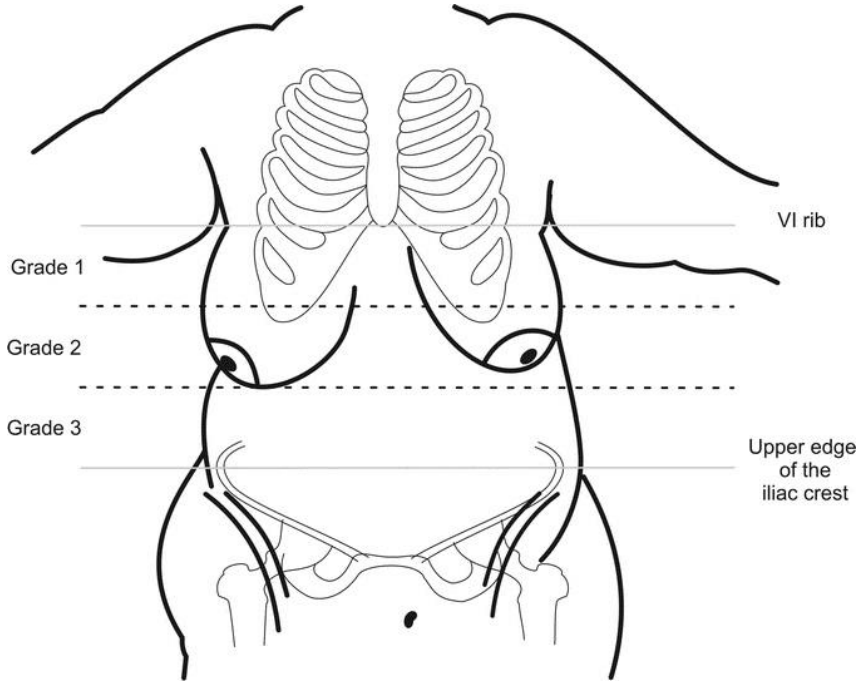

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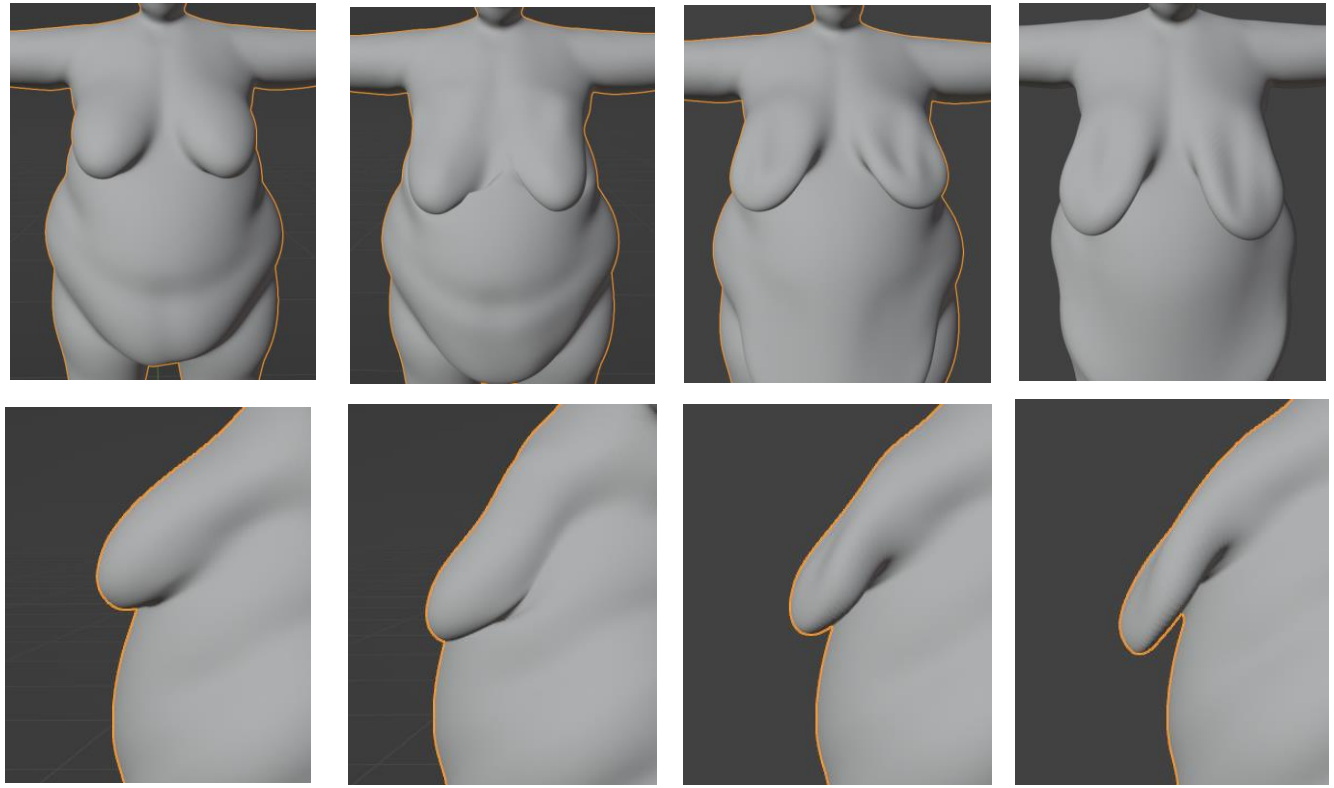

Original | Grade 1 | Grade 2 | Grade 3

* *"An anthropometric classification of body contour deformities after massive weight loss"(M. Iglesias et al. 2010)*

3D Reconstruction Results Showcase (Participant 1)

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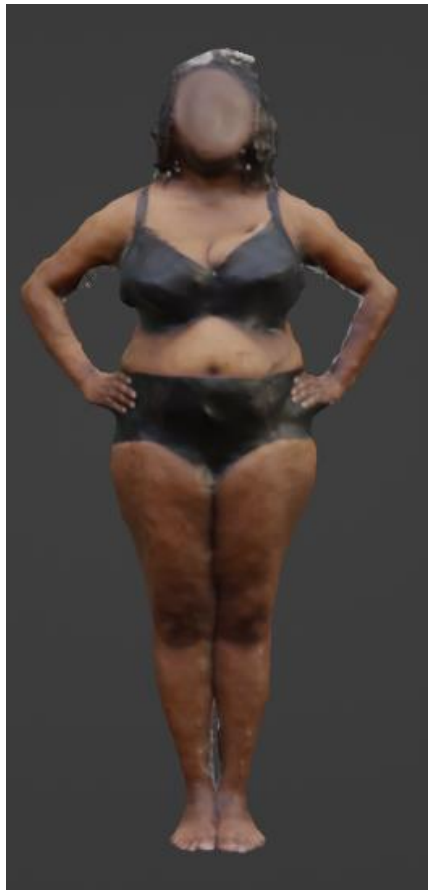
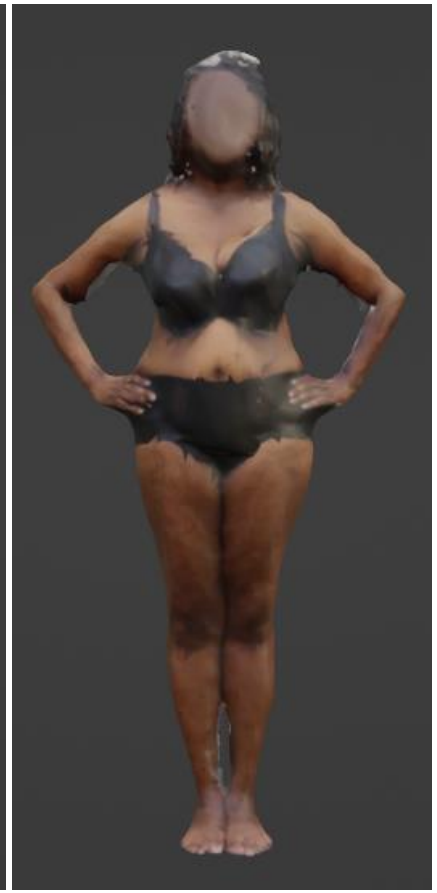
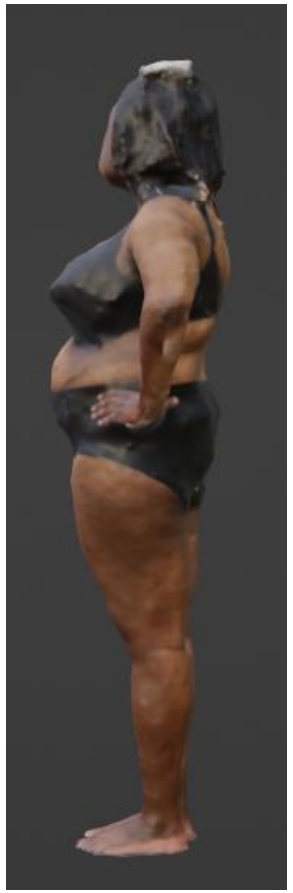
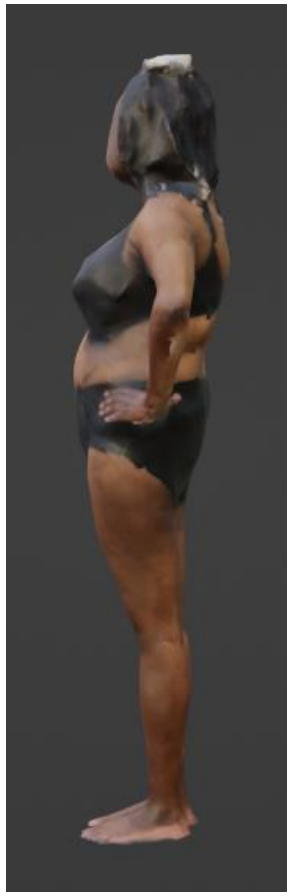

Original | 25% WL | Original | 25% WL

3D Reconstruction Results Showcase (Participant 2)

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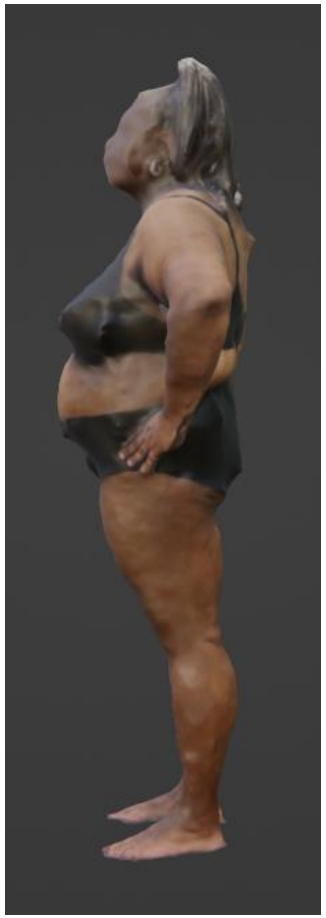
Original

25% WL



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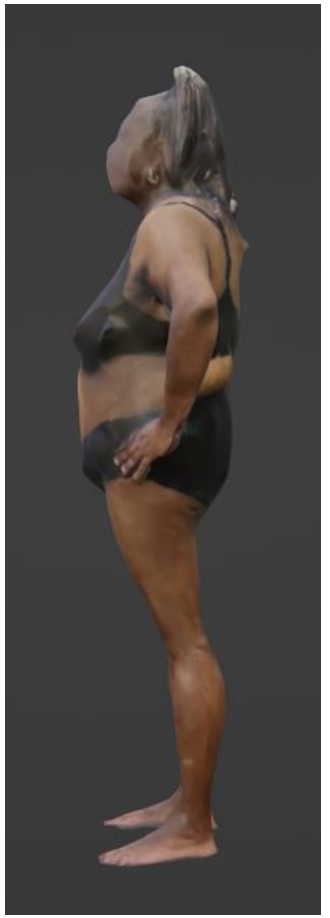

25% WL

3D Reconstruction Results Showcase (Participant 3)

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Original

25% WL

Original

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3D Reconstruction Results Showcase (Participant 4)

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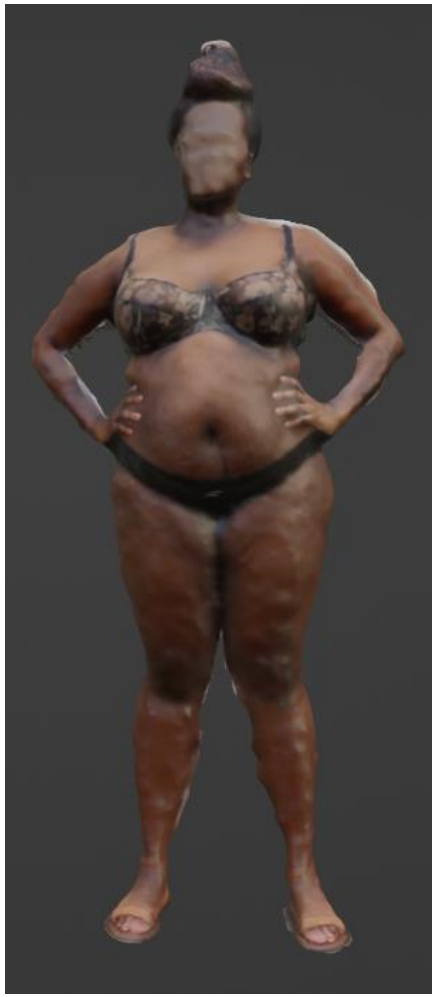
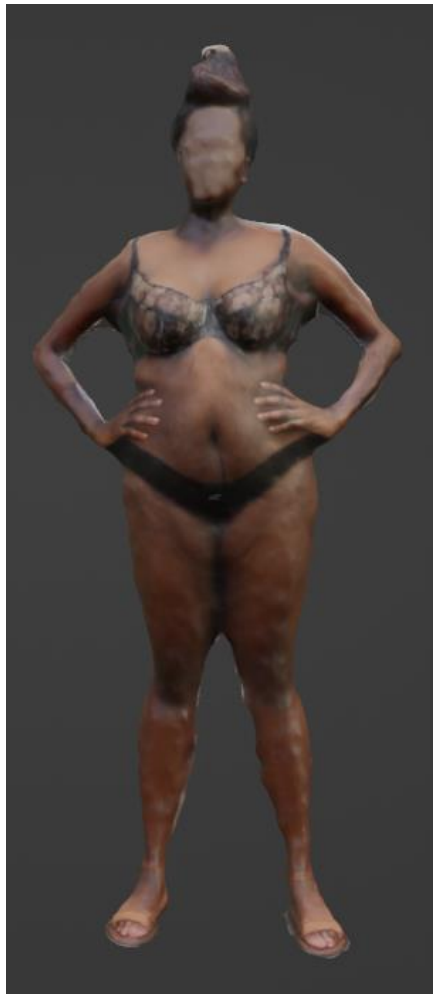


Original



25% WL

Original

25% WL

3D Reconstruction Results Showcase (Participant 5)

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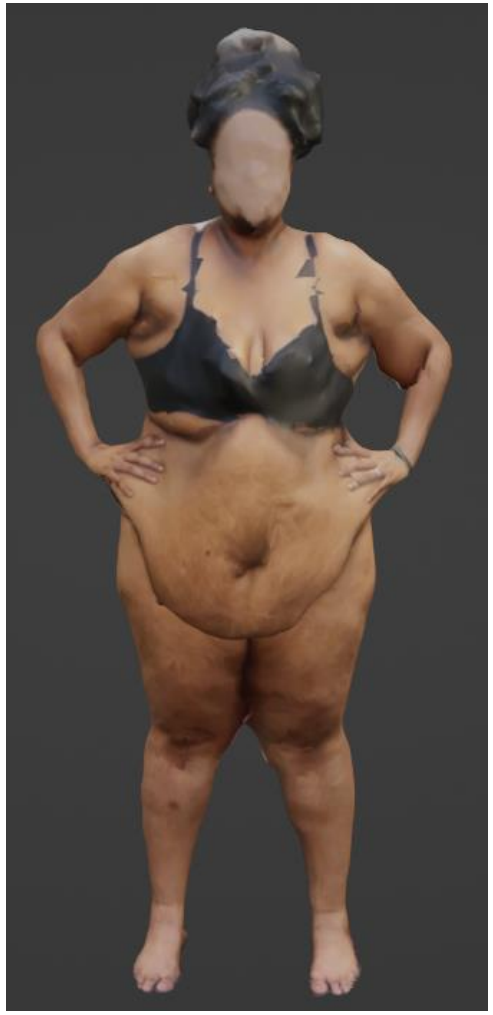
Original



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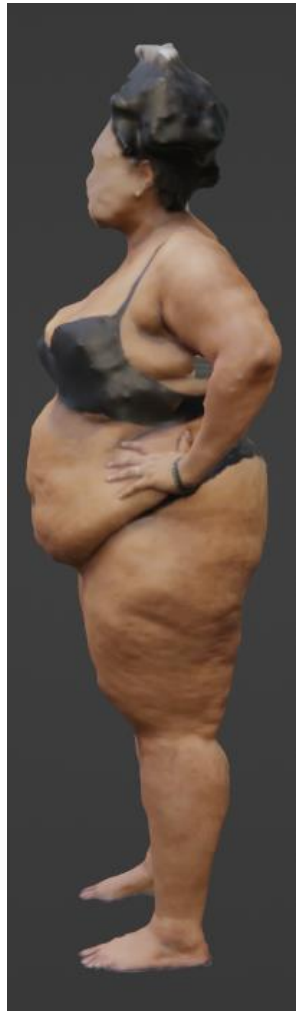

Original

25% WL

3D Reconstruction Results Showcase (Participant 6)

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Original

25% WL

Original

25% WL

VR Applications

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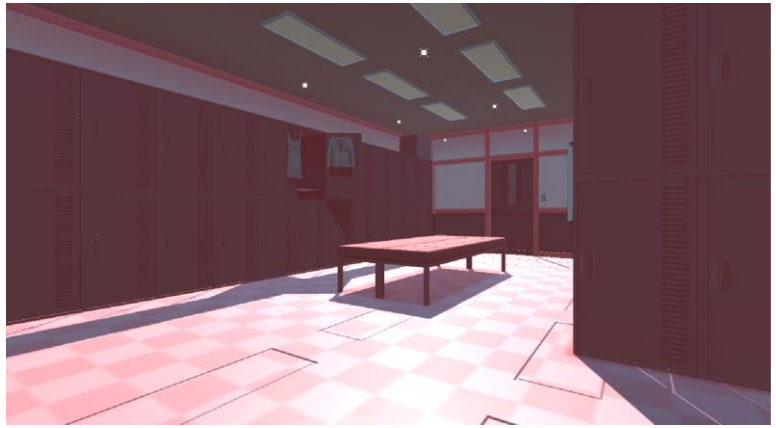

Cloak Room

Beach

Swimming Pool

VR Applications: 3rd Perspective View

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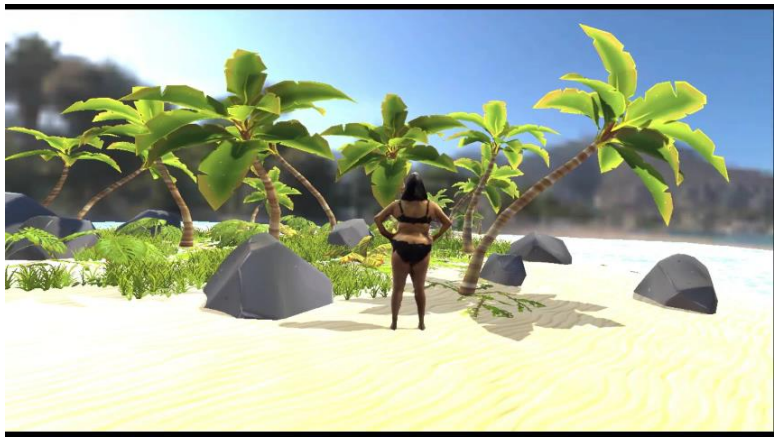

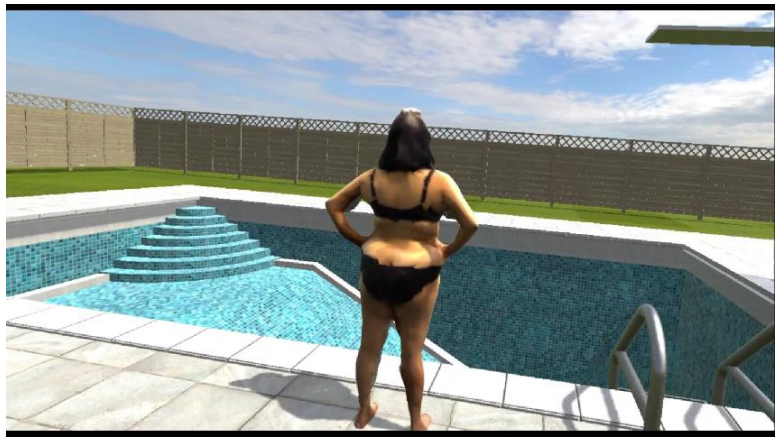

VR Applications: 1st Perspective View

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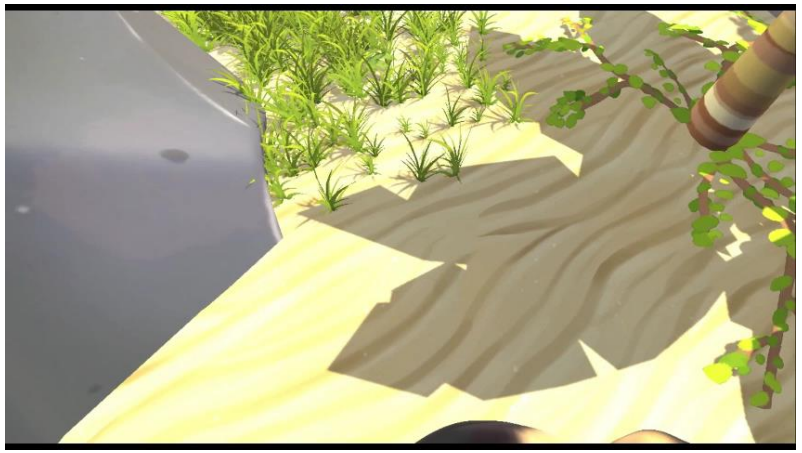

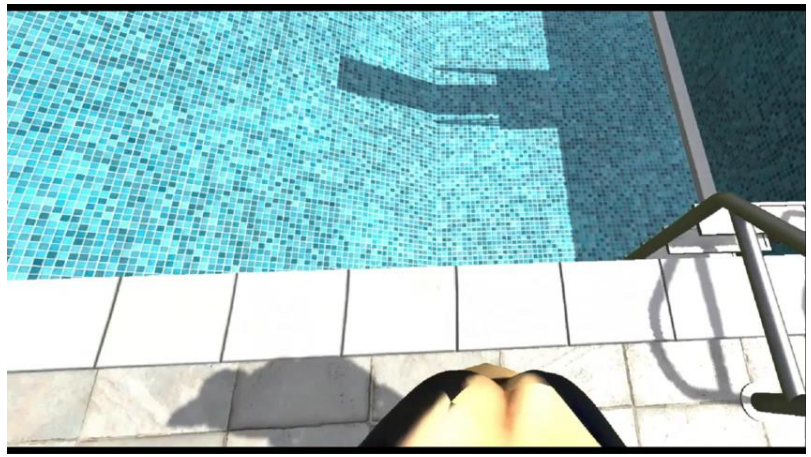

Key Achievements

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1. Improving scanning accuracy
2. Accurate weight loss by body part
3. Graded simulation of skin fold effects
4. Processing and automating 3D reconstruction
5. Designing multiple VR perspectives

Limitations

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1. Device limitations result in poor scanning texture accuracy
2. Requires manual adjustments and labeling leading to incomplete automation of the process
3. Lack of tracking and validation experiments to verify simulation performance

Future Work & Opportunities

1. Test simulation efficacy using expert ratings or postoperative follow-up, etc.
2. Recruiting more participants to validate simulation algorithms.
3. Skin fold simulation has some room for improvement.
4. With updated machine learning algorithms, there will be opportunities for fully automated simulations in the future.

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Q & A

Thank you!