MASTER PROJECT

Course: MA Innovative Fashion Production
Unit Title: Master Project
Tutor: Mihka Mekler David Hopwood
Name: Jiahong Shi
Student ID: 24012355

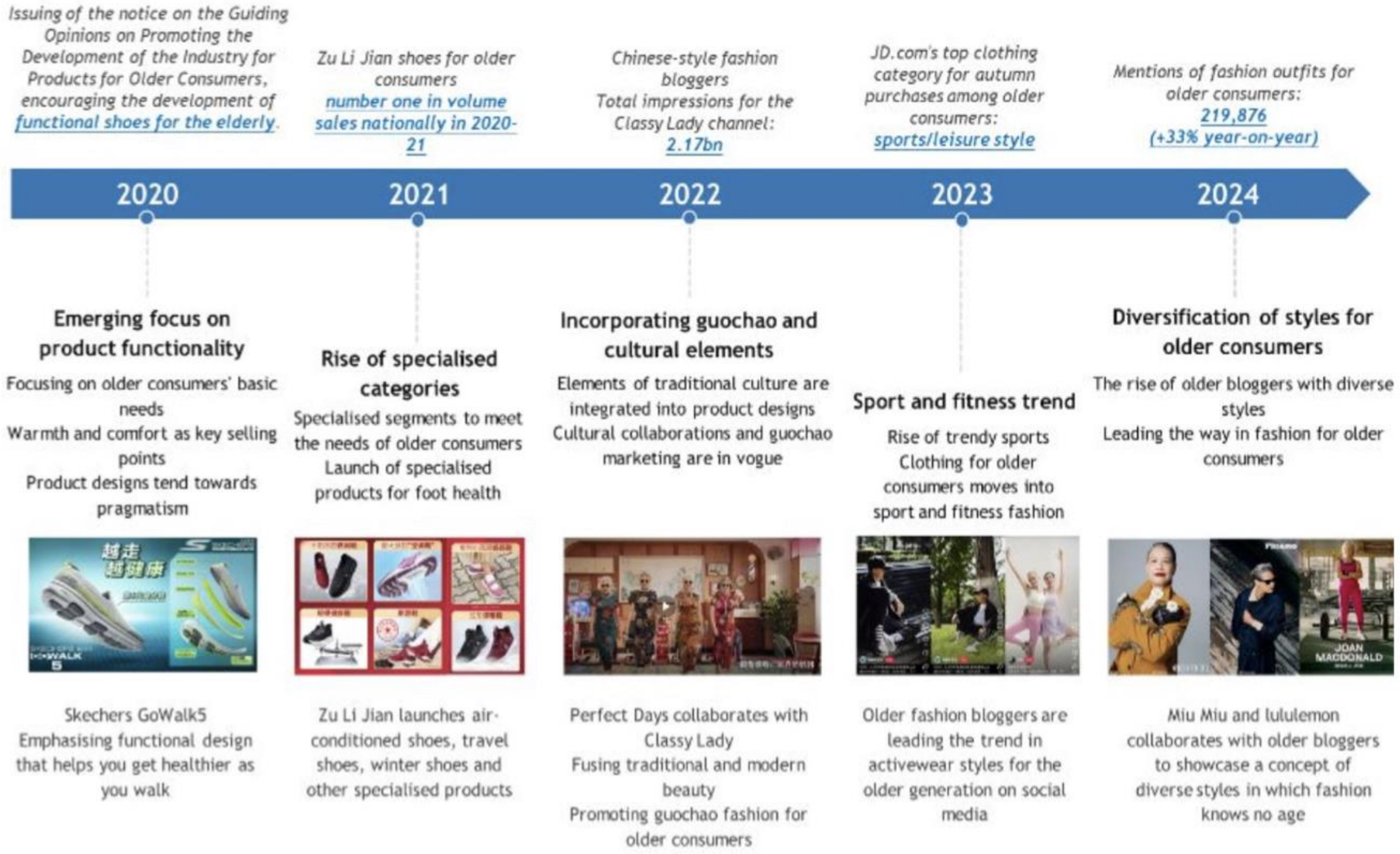
Topic: How to categorize the body types of middle-aged Chinese women through 3D scanning in order to create 3D avatars of their body types to better meet the fashion needs and fit of women in this market.

1.1 Market Trend

In 2024, the number of mentions of 'outfits for older people' on social media grew by 33% year-on-year. This shows that the older generation is actively asserting their individual style, place in society and aesthetic freedom. Brands are also responding with strategies to introduce more diverse styles, such as using older models and engaging in co-branding partnerships, to tear down the stereotypical conservative image of older people. In the future, older fashion will not just focus on functionality: the integration of trendy styles and experiential consumption will also become new entry points for this market.(Mintel, 2024)

Analysis: The increased discussion surrounding "clothing for seniors" indicates that this group's aesthetic awareness and desire for expression are being rediscovered, and the senior consumer market is shifting from passive demand to active expression.

The diversification of brand strategies signifies that senior fashion is moving from a function-oriented approach to one guided by emotional and cultural values, with trendiness and experiential consumption becoming the core driving forces for the market's upgrade.



(Changes in fashion trends for older people, 2020-24)

2.1 3D Body Scan Research

Why use 3D scanning?

The apparel industry and academia are beginning to utilize the vast amounts of anthropometric data collected by body scanners to adjust clothing sizing systems to improve fit. Advantages include: gaining new knowledge about human growth and measurement; providing manufacturers and retailers with up-to-date body shape data; statistical analysis of anthropometric data; and the development of new size charts and improved clothing sizing standards (Apeagyei, 2010).

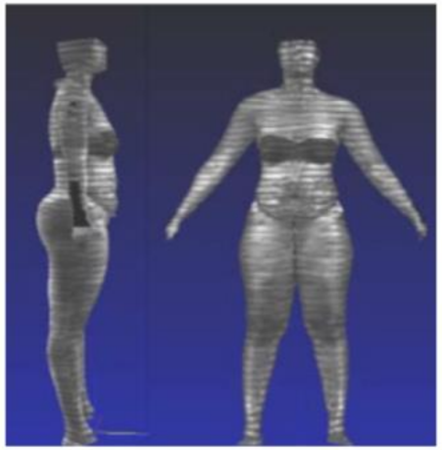
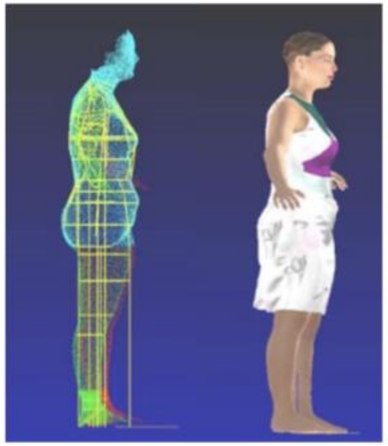
Since most refunds are due to sizing issues, I decided to use 3D body scanning technology to obtain more accurate anthropometric data and size classifications for middle-aged women. Differences in body shape among middle-aged women are more concentrated in changes in three-dimensional structure, features that cannot be accurately captured by traditional two-dimensional measurements or visual inspection. 3D scanning can completely record the body's volume, contours, and key curves, such as the degree of abdominal protrusion, waist-to-hip ratio, back curvature, shoulder angle, and fat distribution—all core indicators affecting clothing fit and pattern construction. By generating accurate 3D avatars, I can make quantifiable comparisons and classifications of middle-aged women's bodies, and perform digital sample garment and structural verification in a virtual environment, significantly reducing fitting costs and errors.

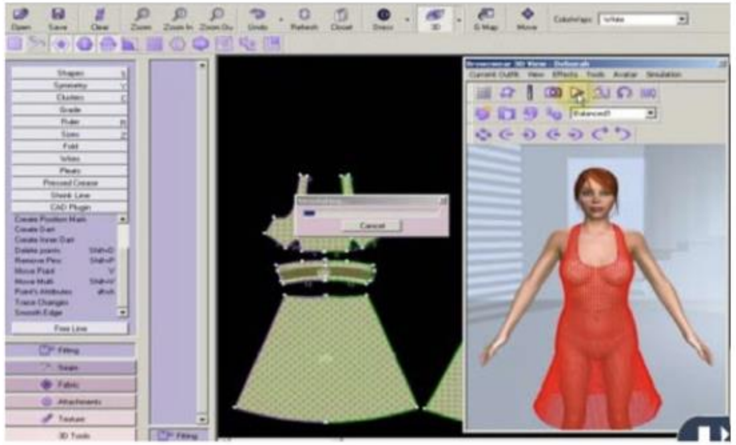
3D Scanner Research

Current scanning solutions can be broadly categorized into three types: professional hardware scanners and mobile scanning applications.

1. Professional Hardware 3D Body Scanners
Representative Brands: TC2, Human Solutions (Vitus), Size Stream.
These devices typically consist of multiple depth cameras or structured light systems, generating a high-precision mesh within seconds through 360° simultaneous capture. They offer high accuracy and abundant data, suitable for scientific research or the establishment of large-scale human body databases. They also boast strong scanning stability. However, they are bulky, expensive, and require dedicated space and operators.

2. Mobile 3D Scanning Apps
Representative Products: 3DLOOK, Styku Mobile, NetVirta VerifyFit.
These apps use ordinary mobile phone cameras to capture images and automatically reconstruct the 3D human body using artificial intelligence models. Features: Convenient, no specialized equipment required, low cost, usable anytime, anywhere, moderate accuracy, suitable for clothing design and fit studies(Huang et al., 2025).



(Application of 3D scanning in clothing design and production)

2.2 Researcher Test Data

To find a more accurate scanning method, measurement data was collected using four 3D human body scanning systems (TG3D, Size Stream, 3DLOOK, and Human Solutions(VITUS Smart XXL)), along with manual measurements used as a reference.To compare the virtual avatar outputs, I conducted a controlled test using the same subjects, clothing conditions, and scanning environment. Subjects underwent multiple scans in a standardized upright posture to ensure consistency and minimize variations caused by movement or lighting. All scans were performed under similar lighting conditions, and form-fitting clothing was used to minimize interference from loose fabrics.

I evaluated the generated virtual avatars against a set of predefined criteria, including shape accuracy (body symmetry), measurement accuracy (difference between the virtual avatar's perimeter and manual measurements), mesh quality, surface smoothness, and overall realism.

Scanner	3DLOOK	TG3D	SIZE STREAM	VITUS smart XXL
Scanning Method	Mobile	Fixed location	Mobile	Fixed location
Scan Result				
Analysis	While avatars generated by 3DLOOK exhibit some left-right differences from real human bodies (such as shoulder height, leg length, and pelvic tilt), 3DLOOK's algorithm automatically symmetricalizes the scanned data. The surface is relatively smooth, with only slight simplification in details; the generated avatar surface undergoes noise reduction and smoothing by the algorithm. The overall model mesh is reconstructed by AI rather than directly scanned, resulting in a lower mesh density compared to professional scanners. The AI "completes" and "corrects" the proportions of the human body: limb lengths are maintained in reasonable proportions, the torso avoids local stretching caused by scanning, and body curves are smoothed into standardized geometric shapes. Local details are somewhat weak.	Research revealed that TG3D does not directly use scanned surface point clouds as the final body model. Instead, it automatically fits the point cloud data onto an official human template. TG3D targets apparel companies and pattern makers, aiming to allow users to directly use scanned avatars in pattern-making software. It accurately captures human body shape (clearly showing asymmetrical shoulders), and the generated virtual character model displays clear measurement lines, precisely showing the position of each body part.	In terms of body proportions, Sizestream can reliably reproduce core measurements such as chest, waist, and hip circumference. However, it exhibits some flattening or volume reduction in areas that are difficult to capture (such as the lower abdomen, inner thighs, and lower armpits). Although it can output basic human body dimensions, some automatic measurements may have an error of 1–3 cm. Therefore, for situations requiring high-precision body measurements, third-party software is still needed for verification.	The VITUS Smart XXL uses a high-precision multi-camera array to capture body surface morphology. Its advantage lies in its ability to capture more realistic body postures, muscle contractions, and soft tissue deformation under gravity, resulting in avatars that are significantly superior to other consumer-grade scanning systems in terms of naturalness and dynamism. However, the core technology of this system still leans towards "point cloud capture" rather than "automated digital body measurement," so the scan output often lacks a standardized data structure cleaned by algorithms. This leads to generally less rigorous automatically generated anthropometric reports, requiring manual measurement and secondary processing of the raw mesh data in external software. It is more suitable for high-precision human morphology recording.

2.6 Participant Scan Result Details and Manual Measure Data

Participants	higher	waist	hand manual	hips	hand manual	bust	hand manual	thigh	hand manual	neck to waist	Size
1	162	83.2	84.3	97.4	95.9	92	92.8	55.1	55.7	39.5	L
2	165	72.8	71.6	92.3	91.8	88.4	87.6	54.9	54	39	M/L
3	153	79.6	80.3	96.9	95.6	88.6	88	57.4	57.8	36.5	M
4	170	90.3	89.6	102.2	102.8	106	107.2	57.3	56.2	43.5	XL
5	160	92.3	91.2	105.1	104.7	106.2	105.5	60.5	60.1	39.6	XL
6	165	98.8	99	111.6	112	103.7	103.6	61.7	60	42.4	L/XL
7	155	88.3	88.5	98.7	99.1	94.2	93.6	53	53.6	38.1	M
8	153	90.6	90	98.8	99.4	91.4	90	55.5	56.7	37.8	M
9	162	80.5	82	97.3	97.5	90.1	90.7	55.7	55	41.7	L
10	156	87.8	88.3	100.6	101	95.7	96.1	53.7	52.3	39.2	M
11	173	84.9	83.5	101.4	102.5	90.9	100	58.6	58	41.8	XL
12	163	68.1	67.7	87.4	88	83.4	84.5	47.8	49	34.2	M
13	160	90.3	92	100.4	99.8	99.4	100	53.8	52.6	40.5	L
14	165	88.1	87.9	103.7	103	100.2	99.5	59	57.8	42.6	L
15	164	88.3	86.9	98.4	96.8	99.8	99.2	54.6	53.9	43.2	L
16	165	91.1	92.4	102	102.5	99.5	98	57.8	58	42.8	L/XL
17	167	80.5	80	103.8	104.2	90.6	91.5	59.7	59.5	41.1	L/XL
18	155	97.4	97.9	109.6	108.7	103.9	104	59.7	60	40.7	M
19	168	96.9	96.2	116	116.8	107.4	97	65.1	64.5	44.4	L/XL
20	160	91.4	91	104.7	103	97.2	97.8	60.5	61.2	43.4	L/XL
21	166	88.7	89.2	101	100.5	99	98.5	58.6	57	41	L
22	162	84.7	84	98.5	99.3	93.5	92.7	56.4	56	41.7	L

Bust girth

Definition:
Horizontal girth measured at bust point level.

Source: ISO 8559-1
Equipment: Tape measure

Waist girth

Definition:
Horizontal girth of the body measured at the waist level. Person stands erect with the abdomen relaxed.

Source: ISO 8559-1
Equipment: Tape measure

Hip girth

Definition:
The measurement is taken around the fullest part of the hip.

Source: ISO 8559-1
Equipment: Tape measure

Thigh girth

Definition:
Maximum horizontal girth of the thigh below the gluteal fold. Person stands erect with legs shoulder width apart.

Source: ISO 8559-1
Equipment: Tape measure

Neck girth

Definition:
Girth of the neck at a point just below the bulge at the thyroid cartilage (Adam's apple) and measured perpendicular to the longitudinal axis of the neck.

Source: ISO 8559-1
Equipment: Tape measure

Armscye girth

Definition:
Girth of the armscye measured from, and to, the shoulder point passing under the arm

Source: ISO 8559-1
Equipment: Tape measure

This study included 22 middle-aged female participants. Two types of data were collected from each participant: 3D body scan measurements and manual measurements. The 3D scan data provided detailed circumference data; for easier comparison, the dimensions of chest, waist, hips, thighs, and neck to waist (quantitative data) were selected. In addition to quantitative measurements, this study also recorded each participant's preferred body size through interviews. This qualitative information provided important contextual information, helping to compare participants' actual body shapes with their self-reported size preferences. By combining 3D scan data, manual measurements, and actual body size information, this dataset provides a comprehensive understanding of the body characteristics, sizing habits, and fit requirements of middle-aged women. Furthermore, it can aid in subsequent virtual avatar development, fit stress testing, and size specification optimization during the design phase.

2.7 Size Chart Definition According to Data Analysis

Body Scan average across key Points of measure:

Body height average: 163cm
Chest average: 96 cm
Waist average: 87 cm
Hips average: 101 cm

Body Scan ranges across key Points of measure:

Body Height: 153 – 173 cm
Chest: 83.4 – 107.4 cm
Waist: 68.1 – 98.8 cm
Hips: 87.4 – 116 cm

Based on the database obtained from the scans, I primarily considered chest circumference, combined with waist and hip circumference data, to create an S/M/L size system. I first calculated the average values for key body parts (chest, waist, hip, and height) and statistically determined their complete data ranges to understand the overall distribution characteristics of the sample group. The average values helped me grasp the typical body shape of the research subjects, while the measurement intervals reflected the actual range of differences within the user group. The results showed that size M was the most common size, indicating that it best represents the body shape of most participants. This size chart will serve as a reference for my subsequent designs, ensuring that clothing fits the target population's body shape more closely.

Size	Chest range(cm)	Waist range(cm)	Hip range(cm)	Applicable people
S	84 – 91	68 – 79	87 – 95	Slim body, upright figure, and inconspicuous abdomen
M	92 – 99	80 – 89	96 – 103	Medium body shape, slight variations in waist and abdomen, most specimens
L	100 – 108	90 – 99	104 – 116	A plump figure with more pronounced abdomen and buttocks

3.3 Four Body Shape Definition

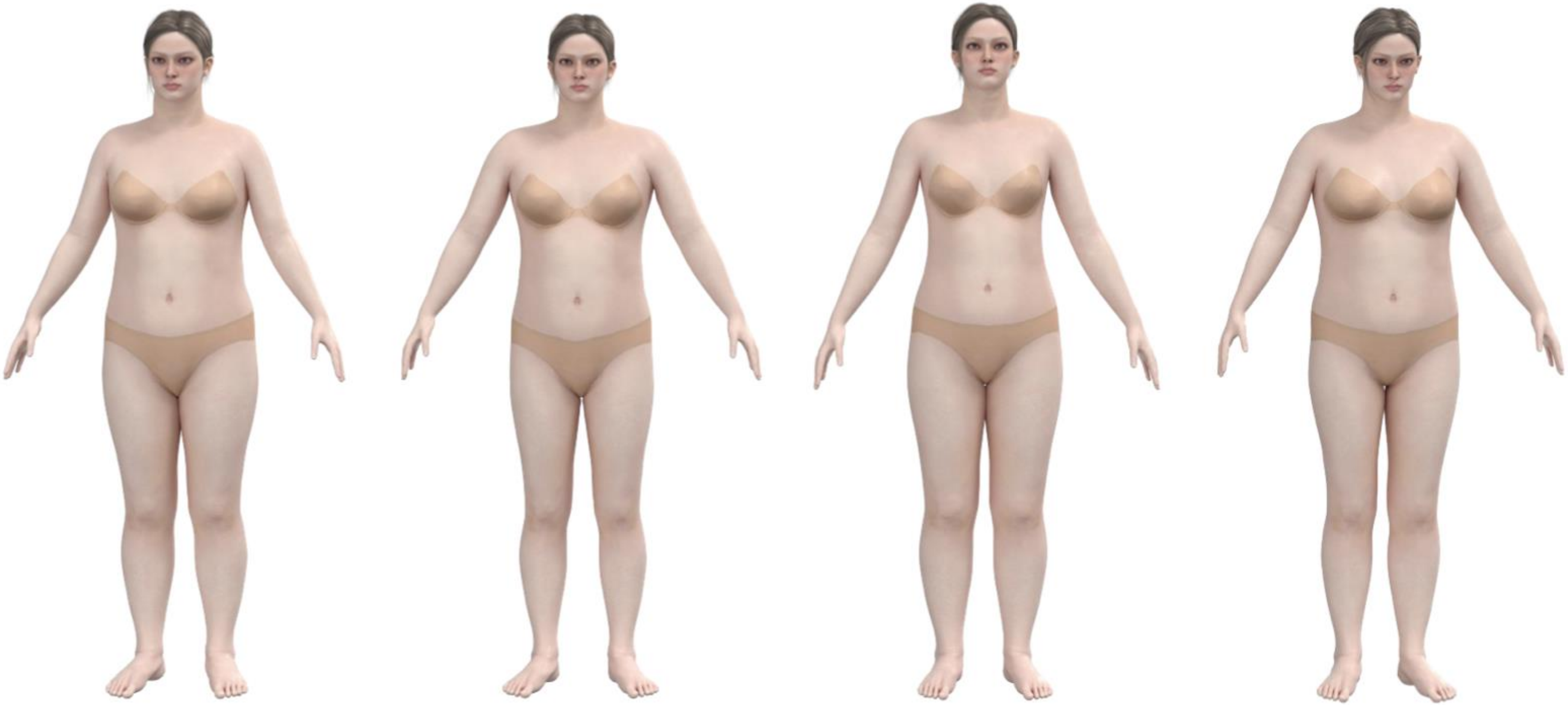
Body Shape Assessment Scale (BSAS)

BSAS four basic body type classification methods (based on Bust–Waist–Hip measurements)
Bust–Waist Difference (BWD) = Bust – Waist Hip–Waist Difference (HWD) = Hips – Waist

	Participants No.4 Waist: 90.3cm Hip: 102.2cm Bust: 106cm 170cm Bust-waist: 15.7cm Hips-waist: 11.9cm	T Shape Features: Chest-to-waist ratio is greater than waist-to-hip ratio		Participants No.15 Waist: 88.3cm Hip: 98.4cm Bust: 99.8cm 164cm Bust-waist: 11.5cm Hips-waist: 10.1cm	H Shape Features: Waist-to-hip ratio and chest-to-waist ratio are similar in value
	Participants No.17 Waist: 80.5cm Hip: 103.8cm Bust: 90.6cm 167cm Bust-waist: 10.1cm Hips-waist: 23.3cm	A Shape Features: The waist-to-hip ratio is larger than the chest-to-waist ratio		Participants No.14 Waist: 88.1cm Hip: 103.7cm Bust: 100.2cm 165cm Bust-waist: 12.1cm Hips-waist: 15.6cm	X Shape Features: The difference between waist-to-hip ratio and chest-to-waist ratio is very large

Based on the BSAS classification, I've identified four body types: T-type (waist-to-hip ratio smaller than chest-to-waist ratio), H-type (waist-to-hip ratio similar), A-type (waist-to-hip ratio larger than chest-to-waist ratio), and X-type (both waist-to-hip ratio and chest-to-waist ratio are large). Comparing the avatars selected by FFIT, I found that visual selection can be somewhat inconsistent. When visually inspecting, I tend to focus on shoulder-to-body proportions. However, for general clothing design, chest circumference is a more accurate indicator of upper torso width. Therefore, I abandoned the FFIT as a reference and ultimately relied on the BSAS body type classification results.

4.3 Final Avatar



H shape T shape A shape X shape

I found that participants with H, A, and T-shaped body types exhibited relatively standard and easily identifiable body contours in the scans; while those with X-shaped body types, who should have a distinct waistline, were closer to H-shaped in actual measurements. The main reason for this phenomenon is that as women age, the distribution of fat in the waist and abdomen changes, and the waistline gradually becomes less defined, weakening the X-shaped characteristics. However, the X-shaped body type is still retained because it has clear characteristics in traditional body type classifications and is an important benchmark for assessing changes in body shape. Comparing it with H, A, and T-shaped body types helps to more clearly observe the trajectory of morphological changes with age and provides a more comprehensive reference for body differences in subsequent clothing pattern research.

5.7 Range Plan

SS26DS01 100%LINEN
PEPLUM DRESS
S,M,L
DARK BROWN

SS26TOP01 100%LINEN
TIE-FRONT TOP
S,M,L
OFF WHITE

SS26SK01 100%LINEN
A-LINE SKIRT
S,M,L
OFF WHITE

SS26JK01 100%LINEN
SHORT JECKTET
S,M,L
DARK BLUE

SS26TS01 100%LINEN
CURVED JEAN
S,M,L
DARK BROWN

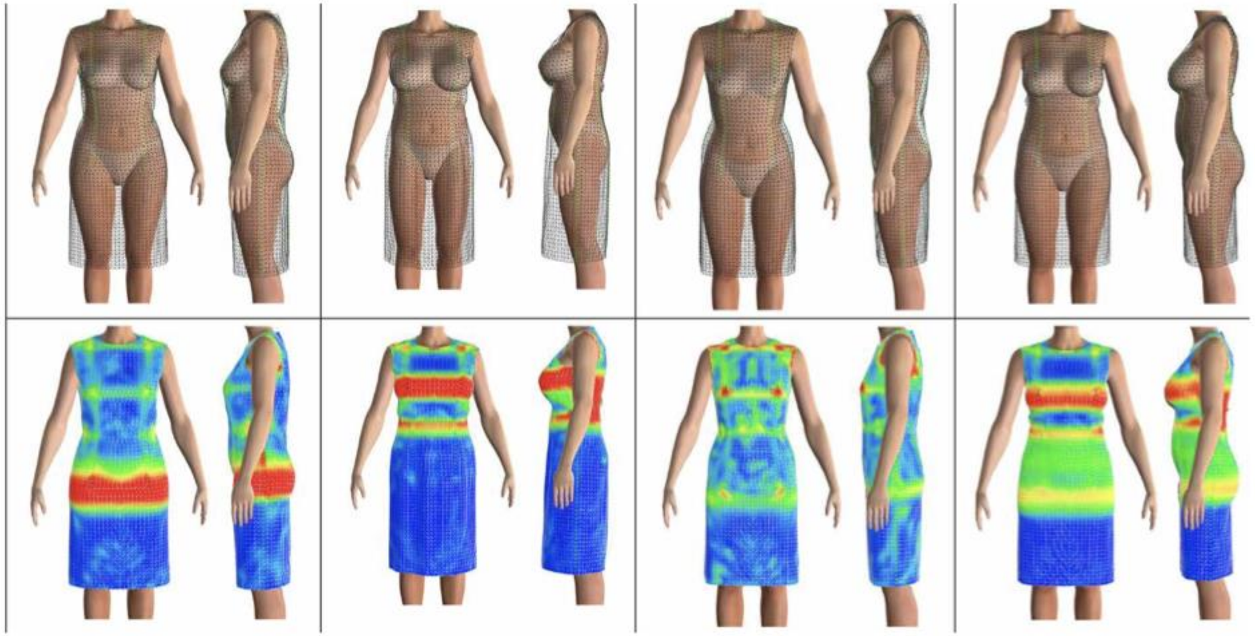
6.1 Stress Test Research

Based on 3D body scan data of middle-aged women, I created four representative virtual models (A-type, H-type, T-type, and X-type). I then designed clothing using CLO software and tested each design on four avatars. The aim of this approach was to ensure that the final clothing accommodated the realistic diversity of body types in middle-aged women.

Factors such as increased waist circumference, changes in posture, and variations in body fat distribution lead to significant differences in body shape. Relying solely on a single virtual model would result in clothing designs that only fit one body type, limiting their practicality in real-world applications.

Designs that only fit one body type are not practical for the target audience(Penko and Rudolf, 2025). Ensuring clothing is compatible with all four body types allows the brand to serve a wider customer base, improves sizing inclusivity, and reduces returns due to sizing issues.

If a garment performs consistently on all four virtual avatars, it indicates that the selected body type effectively represents the major body shape differences identified among the scanned participants.



A defined fit between a woman's dress and her body shape.

6.2 Clo3D Process and Stress Test


Shape H


Shape A


Shape T


Shape X

When comparing the garments on different bodies, I found that the most noticeable fitting issues appeared around the underarm structure, where pulling or gaping was common. Because the waistline of this series uses an elastic band, it can naturally adjust to different waist measurements. Therefore, the waist area did not need to be prioritised during the initial pattern modifications.

Next, I conducted a pressure analysis (Pressure Map) in CLO3D. The results showed that the chest area had the highest pressure values and was the least well-fitted. This aligns with both the scanning and interview data: many middle-aged women have varying degrees of bust fullness and chest shape changes, making the original chest volume insufficient.Based on these findings, I focused on increasing the chest allowance during the pattern adjustment stage to create more space and improve mobility. At the same time, I adjusted the surrounding pattern pieces according to the pressure distribution to achieve a more balanced shoulder-to-bust proportion and reduce stress under the arm and across the front chest. Through these data-driven, simulation-based iterations, the final pattern became more suitable for a wide range of middle-aged female body shapes.

5.8 CLO3D Line up