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Research Article

Master block pattern development for fit evaluation based on adult female anthropometric data and body shapes using Telestia-AB patternmaking system

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ABSTRACT

Developing well-fit garments is relevant in the garment industry, especially to achieve the quality of corporate uniform wear. A garment that looks good must also fit the body. The first process for garment fitting is to develop the body pattern that acts as the form for body shape before translating it to the desired garment design. Thus, the focus of this study is to construct a good master block pattern that fit the body well. Size, shape, and proportions are considered factors that contribute to a well-fitted garment. This study involves anthropometric study, master block development, pattern assembly onto fabric, basic garment constructions, and fitting analytics. The fit analytics are a relevant part of a fit evaluation to model the best method to develop body patterns and wear analysis for each individual for better-fit garment consumption. The conclusion showed that using sophisticated Telestia-AB tools and Telestia body key dimensions expedites the process of body block pattern for fit evaluation. The wear trial process is to determine how the bodice block fits before transforming it into the design pattern for corporate wear. This research concludes that developing a proper body pattern based on the anthropometric data is crucial as the fit of the garment is achievable with the right pattern-making system and skillset.

Keywords: *Anthropometric Data; Upper and Lower Body Measurements Tables; Body Shape Analysis and Size Cluster*

1. INTRODUCTION

Anthropometric research for clothing sizing systems for better fitting garments has been explored for many decades, dating back to 1921 (1-3). Different lifestyles, cultures, and geographical areas lead to a wide variety of body shapes and sizes among the world's populations. Moreover, having the correct skill sets and techniques to translate an understanding of particular body sizes and shapes into a good fit body pattern is essential (4). Before the design of the garment is produced, the body pattern goes through first fitting evaluation process for a wear trial to determine a good fit. This research explored the required skills for body pattern development based on different body shapes. This research explores the skills needed for body pattern development based on the various body shapes observed in 21 adult females in Malaysia. As a result, the body pattern is developed using

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the accredited Telestia system, for each pattern piece is worn by each female for wear trial fit analysis.

For hundreds of years, tailors, designers, dressmakers, and seamstresses have created clothing. Fitting issues have been identified as one of the major causes of low-quality garments, which are influenced by a variety of factors such as technical product development, vocational garment making skills, body size and shape evaluation, fitting evaluation technique, and patternmaking system use (5-7). To ensure a high level of comfort for the wearer as well as aesthetic purposes, quality garments must begin with an understanding of different body sizes and shapes that relate to a good fit. Good fit is another term for perfectly fitted garments with nice trim, which is determined by the wearer's size measurement, body shape, fit, and proportion (5, 8).

Because there are limitations in the suitability of free-size garments with the actual wearer, the concept of good fit in garment engineering contradicts the concept of free-size garments in textile markets. This could be attributed to the concept of size, fit, and proportion, because while everybody wears the same sizes, no one has the same shape, fit, and proportion, which distinguishes an individual's features (9). The main goal of a successful corporate worker is to wear good clothing that fits well and is appealing in that particular market (10). The market for corporate women is enormous because they are regarded as the largest group of people who always want to look good in their clothing. They are also the group that goes through a variety of body changes based on age, rites of passage, and various biological and emotional changes. Besides that, fit issues can arise during clothing production because producers lack the skills to produce good body patterns, especially when clothing sizes are not based on national anthropometric data.

1.2. Statement of the Problem

Corporate consumers in Malaysia can easily get their garments tailored, either through established tailoring companies or at home-tailors nearby. Corporate uniform wear is also available from many ready-to-wear clothing companies, which sell the garments in a variety of sizes. Nonetheless, female corporate consumers continue to face difficulties in obtaining well-fitting corporate uniforms because Malaysia lacks standard clothing sizes based on national anthropometric data. Females have a unique figure variation with different curves and bulges, making it more difficult to fit than males. The challenge of developing quality clothing that fits well is high without a proper understanding of the shapes and sizes, as well as the proper technique of body measurements and patternmaking skills.

2. LITERATURE REVIEW

In this section, three main topics that describes the relevant topics to the research are introduced. The first section is understanding the body size, shape and proportions. The next topic is the pattern making for garment construction and lastly the quality of garment based on fit evaluation.

2.1. Understanding Body Size, Shape and Proportions

Body measurements are a useful resource for many fields of science and design applications. Anthropometric studies are conducted all around the world to comprehend the diversity of body types and shapes that resulted in the creation of a standardised size system in one country (11, 12). The sizes, dimensions, and proportions of the forms that make up the human body vary according to a person's diet, way of life, culture, and geographic location. An anthropometric research compares the sample to the appropriate size and form by measuring various aspects of the human body. Manufacturers cannot create clothing that fits their population well without knowledge of the national anthropometric data (9, 13). Body size and shape are key attributes in the apparel industry since they are directly related to the wearer's physical comfort and how the clothing appears on others after it has been worn. This will have an impact on the wearer's body image and self-confidence (14).

A corporate uniform is a basic work requirement that staff or workers at a specific company must wear. Corporate employees must wear that garment at one particular time; whether at work or on duty outside of the workplace. A corporate uniform's purpose is to represent the uniformity of a company while also reflecting the wearer's intelligence. Thus, the goal of corporate uniform design is to make people wear garment that is comfortable for their body size. The foundation of the garment should be body size and shape detailing that will satisfy the wearer (15).

The significance of conducting sizing studies is to be able to design clothing that corresponds to body shapes and to obtain feedback from customers on the fit of their clothing. When it comes to female size and shape, the study is more relevant. Many studies have shown that women go through many different life stages that result in various body changes. Fit is the analysis of the interaction between garment sizes and body shapes (13). Female body shape is the sum of skeletal structure, fat distribution, and muscle mass, which can be determined visually using a shape representation (16). Traditional body shapes include pear, apple, straight, and hourglass (17). Body shape frequently describes an individual's overall shape, there are many references to define body shapes such as these 7 types of female body shapes which were classified into triangle body shape, inverted triangle, rectangle, hourglass, full hourglass figure, oval or apple and diamond body shape as shown in Fig. 1.

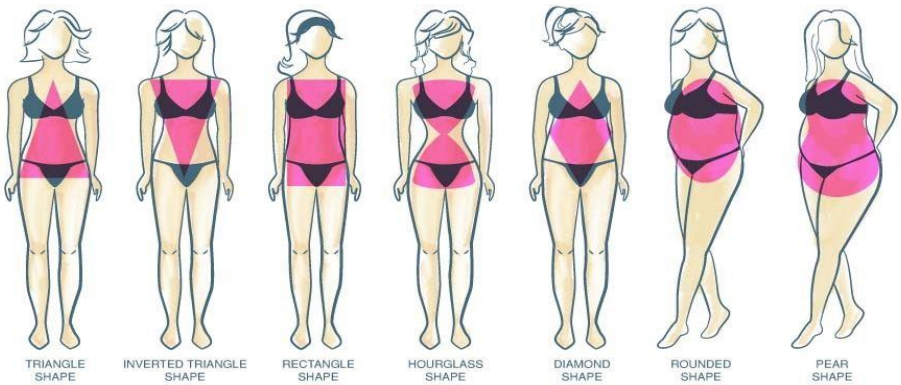


Fig. 1. Classification of female body shapes (17)

Each body shape refers to the accumulation of fat or muscle formation in a specific area, such as the bust, hips, and waist. A pear body type, for example, may have hips that are larger than their bust, whereas an hourglass body type may have a bust that is larger than their hips and a well-defined waist. Thus, these differences must be considered when classifying females into their correct body shapes, so that when sizing is developed, females are divided into two categories: sizes and shapes, for better fit. Table 1 showed the formulation for body shape classifications, which are used to determine the body shapes of the sample population (18). Whereas, Fig. 2 showed the description of each body shapes (19)

Table 1. Body shapes categories (18)

Hourglass If (bust - hips) ≤ 1" AND (hips - bust) < 3.6" AND (bust - waist) ≥ 9" OR (hips - waist) ≥ 10"
Bottom hourglass If (hips - bust) ≥ 3.6" AND (hips - bust) < 10" AND (hips - waist) ≥ 9" AND (high hip/waist) < 1.193
Top hourglass If (bust - hips) > 1" AND (bust - hips) < 10" AND (bust - waist) ≥ 9"
Spoon If (hips - bust) > 2" AND (hips - waist) ≥ 7" AND (high hip/waist) ≥ 1.193
Triangle If (hips - bust) ≥ 3.6" AND (hips - waist) < 9"
Inverted triangle If (bust - hips) ≥ 3.6" AND (bust - waist) < 9"
Rectangle If (hips - bust) < 3.6" AND (bust - hips) < 3.6" AND (bust - waist) < 9" AND (hips - waist) < 10"

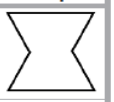
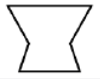
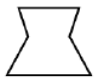
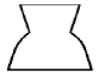
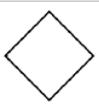
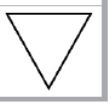
Body Shape	Definitions	Shape
Hourglass	A very small difference between bust and hip circumferences The ratios of bust-to-waist and hips-to-waist are about equal and significant	
Top hourglass	A larger bust circumference than hip circumference The ratios of bust-to-waist and hips-to-waist measurements are significant enough to produce a definite waistline	
Bottom hourglass	A larger hip circumference than the bust circumference The ratios of bust-to-waist and hips-to waist are significant enough to produce a definite waistline	
Spoon	A larger circumferential difference in hips and bust The bust-to-waist ratio is lower than the hourglass shape The hip-to-waist ratio is high	
Triangle	A larger hip circumference than that of the bust The ratio of hip-to-waist was small Larger in the hips than in the bust without having a defined waistline	
Rectangle	Bust and hip measurement fairly equal Bust-to-waist and hip-to-waist ratios are low There is not a clearly discernible waistline	
Oval	The average of the stomach, waist and abdomen measurements is less than the bust measurement	
Diamond	The average of the stomach, waist, and abdomen measurements is more than the bust measurement	
Inverted Triangle	A larger bust circumference than that of the hips A small bust-to-waist ratio	

Fig. 2. Body shapes descriptions (19)

2.2. Garment Pattern Development

The process of garment making is consolidated with two important features in this study, which are the identification of body shapes for each individual and the development of body patterns for fit evaluation. Garment development is critical because the garment must be transformed to fit the wearer's size and shape (20). Thereby, the patternmaking method is seen crucial to address the various changes in the design and silhouette, which later becomes significant for a well-fitted garment. It is also acknowledged that the skill for garment pattern maker is still scarce globally, as not all designers who can design well can create a good pattern to meet the needs of the designs (4).

As measurement skills are transformed into a fundamental body form, patternmaking techniques should start with the body pattern (21). This is the skill of creating a basic, well-fitting body template using a person's body form, including sizes, shapes, and proportions. Because manual patternmaking is more affordable to start with before moving on to a technology-based pattern making system, mastering it has shown to be advantageous. Before moving on to the next stage of digital patternmaking using the Telestia-creator CAD system, students must first master the art of body patternmaking using the Telestia-AB trainer system.

Pattern construction is the foundation of garment making and fashion design. It is the blueprint or template used to cut out fabric for the construction process (21). It is thus at the heart of manipulating and moulding a flat fabric to correspond to the curves and bulges of the human figure, particularly in the case of adult female figures. Fitting an adult female figure presents unique challenges when compared to any other target market. The foundation of patternmaking begins with a body block pattern and fitting evaluation before the basic pattern is transformed into the design pattern desired by the wearer (22, 23). The basic pattern is the transformation of the body form into one that is well suited to the wearer, so that when it is made into the corporate uniform, it fits well.

The process of developing a Telestia-AB body pattern started with measurement training. An emphasis on the anatomical body landmarks is supplied through the meticulous analysis of the landmarks, together with practical, hands-on training on how to identify the main body proportions. Following the conclusion of the body measurement procedure, a ruler-based size identification technique is shown. Consequently, the body size based on the key dimension is recognised without having to perform any calculations because the formulation has already been inferred from the ruler. Body pattern formation becomes a quicker and more efficient procedure. The capacity to shift from the current patternmaking process to a speedier pattern mastery skill set, which is required in the manufacture of garment products, is the most crucial talent associated to this novel Telestia body pattern making approach. Making correct garment pattern is particularly important for producing garment that fit. Fit for clothing is a key element for wearing satisfaction (5). It is also mentioned that in order to assess fit, garment patterns should be created using knowledge of body shapes (14).

2.3. Fit Evaluation

Physical try-on applications on actual living beings are strongly advised to provide unbiased feedback based on the wear trial (5). For the participants to anticipate positively, the features to be evaluated must be given clearly to the participants for positive anticipation. They shall be guided to a fully accurate evaluation of garment fit with actual try-on experience. The fit analysis will be based on two parameters: body shape and pattern development. The success factor of fit evaluation is examined using these two metrics in order to make additional advancements. However, the two fit level analytics can be combined with the product development process from anthropometric data, collection to the development of body pattern. In any case, these parameters are sufficient to determine what should be avoided or changed to improve analysis for future investigations.

To be properly fitted, clothes must be large or small enough to accommodate the wearer's shape and size (7, 24). It can also be used to create clothing that fits three-dimensional human body figures. For the enjoyment of the human body, a well-fitting garment is crucial. When a garment lacks security, is poorly constructed, has poor dressing and cutting techniques, and wastage of resources due to negligent design and bad construction. These factors, which include grain, set, line, balance, and ease, are used to assess fitted clothing (25, 26). Garments made of grain hang evenly and seem symmetrical. If the fabric is against the grain, the garment won't hang straight, referring to a very smooth fit without of any unwanted creases. Because of how the garment fits the person, wrinkles brought on by faulty sewing cannot be removed with ironing. When a consumer wears a garment, it hangs or sags and causes set wrinkles, which usually happen because the garment is too big or small for the wearer (27, 28). In order to accommodate the typical human body while walking, sitting, riding, and even breathing, a garment needs to have enough ease beyond the wearer's actual size (24,26, 29). Fitting ease is the term used to describe easiness in this context. The additional flair, such as fullness, that is added to the fitting ease is known as design ease . All of the clothing has ease of fitting, although ease of design is not required because it is added solely for aesthetics and to give the clothing its styles (30).

3. METHODOLOGY/MATERIALS

This study is conducted to model the fit analytic process. The process involved three steps (as shown in Fig. 3) which are the anthropometric survey, master block development and fit assessment. The end result of this study will establish the process of master block patternmaking using the key dimensions allocated by an established accredited Telestia Technology system according to the nation’s female body shapes where the research are carried out.

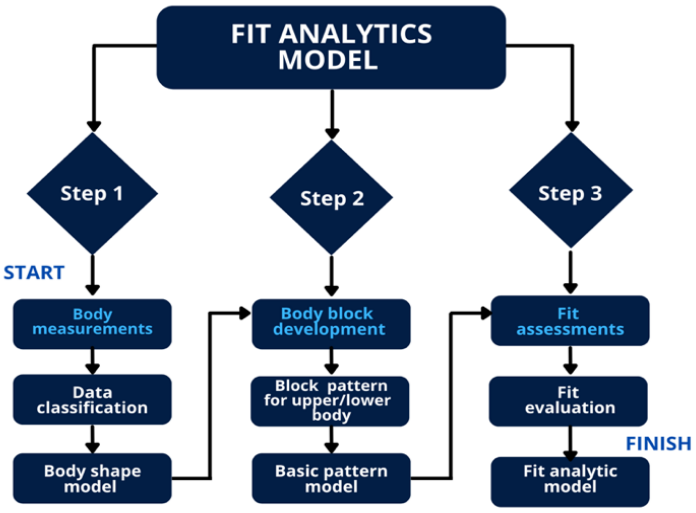


Fig. 3. Fit analytic process

3.1. Participants

In this study, 21 adult females between the ages of 18 and 47 volunteered to participate in the in-depth fit analytics process and selected from the 200 sample population. The fit assessment questions were self-administered by each participant after they put on the basic bodice for the upper body. The fit observation was also carried out concurrently during this session by the trained measurer. The participants self-rated their levels of fitness at the initial screening. Each participant acknowledged that they wore the identical upper bodice at least twice throughout the session in response to the degree of fit assessments. The body measurement protocol adheres to accredited Telestia-AB Trainer patternmaking system.

3.2. Study Design

This study explored the readiness of technical skills and defined the process of garment making. This process includes body measurement, pattern drafting and assembly, lay planning, sewing, and fitting. The development of the master bodice block is for fit evaluation of the basic garments for Malaysian female adults with various body shapes. Measurers learned how to identify the location of each body dimension before they were allowed to take measurements of the sample female subjects. The process divides into the following three sections:

3.2.1. Section 1: Anthropometric survey for body shape classification

This research conducted an anthropometric survey which involved measuring identified body dimensions of each sample. The body measurement process were conducted using manual measurement techniques by two trained measurers. The training were conducted before the measurers carried out the field work to minimise human error in measurements. The body measurements only involved body dimensions (from Table 2 below) taken from the accredited Telestia -AB patternmaking system so that these measurements can be

used for body and design pattern development. The body dimensions is used for the upper and lower patterns development.

Body measurement methodology includes the identification of anatomical body landmarks, which is essential for the accuracy of measurements into well-fitting body patterns. The body measurement training starts with the introduction of the 13 main body dimensions and anatomical landmarks.

Table 2. Description of body dimensions for Telestia-AB patternmaking

Chest circumference	The chest measurement was taken using a measuring tape by allowing it to rest on the body at underarm level (See Fig. 4)
Bust circumference	The measuring tape was securely held at the chest level at the back and at underarm position. The front tape was lowered at the front to measure the bust at its fullest level (See Fig. 5)
Waist circumference	The slimmest waist area was measured where the indented position is found at the waist
Upper hip circumference	10 cm lower from the waistline was measured to get the upper hip position
Hip circumference	The hips are measured at its most prominent point (17 cm from the waistline). The measuring tape was ensured to be at an even level to avoid getting awkward full pattern.
Bust distance	The bust was measured from one bust point to the other bust point
Front shoulder	The landmark from shoulder bones were measured from one side to the other side
Back shoulder	The landmark from shoulder blasé were measured from one side to another
Bust length	Measurement taken in vertical from the shoulder to the most prominent bust point
Total bodice length	Tie the string to the waist level to mark the waist line. Start positioning the measuring tape from the back waist line, passing over the highest shoulder point and continue over greatest bust point to front waistline
Arm Length	The measurement taken from the lowest shoulder point to the wrist with the arm bent
Knee Length	The measurement taken from the waist to the knee for skirt length
Ankle length	The measurement taken from waist to the ankle for trouser length

The measurement technique is more accurate and precise when the specific bones or landmarks are identified. One of the abilities required in an anthropometric survey to guarantee accuracy and effectiveness of the measurement process is landmark identification. After the survey, the data collected is analysed according to body shape classification according to Table 1 to explore the existence of body shape variations among adult females in Malaysia. The analysis of this body measurement data resulted in the first model of size cluster based on body shape descriptions (shown in Fig. 2) for clothing sizes development.

In addition, the method for measuring the bust circumference that accounts for the variances between the bust and chest is one of the Telestia-AB distinctive breakthroughs. The measurement method is demonstrated in Fig. 4 and Fig. 5 below. For the chest measurement, the measuring tape were put on the chest circumference line wrapping the front and back bodice at the same position (Fig. 4). While for the bust measurement, the measuring tape is position at the chest line at the back body. For the front body, the tape is pulled down chest line to the bust apex line (green line) to cover the differences of chest and bust as shown in Fig. 5 with the red arrow.

Fig. 4. Chest measurement (front and back same position- red line)-Telestia-AB system

Fig. 5. Bust measurement (back same as chest position, front chest position tape is pulled down to bust point -green line)-Telestia-AB system

3.2 SECTION 2: MASTER BLOCK DEVELOPMENT USING TELESTIA-AB SYSTEM

Thirteen measurements are required in the master block development procedure to create a well-fitting body pattern before modifying it into different design patterns. Fig. 6 below depicts the development of a standard garment.

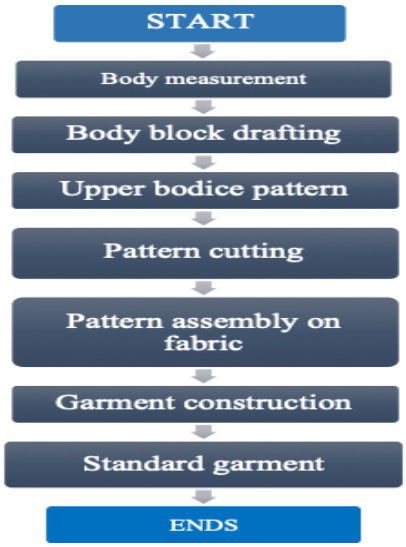


Fig. 6. Process for garment development

The final goal of this process is to make sure the measurer acquires the skill abilities necessary to comprehend the anatomical landmark and the proper technique for taking accurate body measurements. The 3D bodily form will eventually be translated through this method into 2D paper-based patterns. The Telestia-AB system makes use of advanced tools and interactive patternmaking software. It also provides instructions for creating simplified body patterns. Block, curve, long and flexible rulers are the four fundamental patternmaking tools for pattern drafting. Structured software step-by-step instruction must be followed (as shown in Fig. 7).

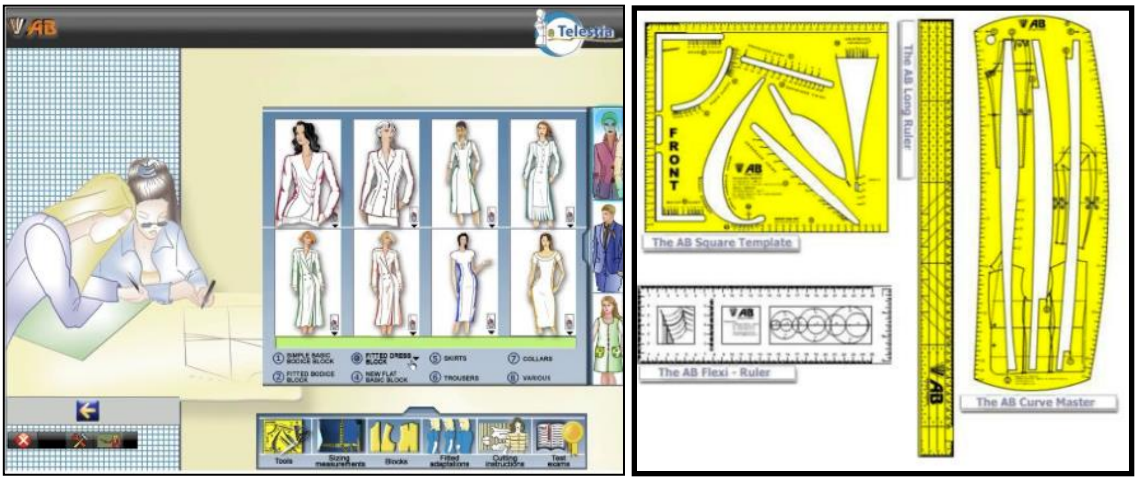


Fig. 7. Telestia patternmaking system- structured learning and tools

3.4. Section 3: Wear Trial Fit Analytics

Women who agreed to participate for fit analytics are required to do wear trial. Basic garment for the upper body is made from the master block pattern for the upper bodice. Physical fit assessment and fit observation activities are carried out on live models. Participants in this study were instructed to try the garment twice and describe their findings about fit. 21 females out of 200 females volunteered to perform the fit analysis based on the three criteria listed in Table 3 below. The fit analytic model that were developed consist of these three elements ; fit dimension, fit assessment and fit evaluation. The area of the body where the fit is evaluated would be the fit dimension. The participants' appraisal of fit (tight, well, large etc) along the fit dimension are what make up the fit assessments. The fit assessment was conducted using 5 point-Likert. Lastly, is the fit evaluation that we observe on each participant when they wear the garment. We observe the lines and wrinkles that are visible at the bust line which includes the bust circumference, bust distance and bust length.

Table 3. Fit Analytic model

Body shape	FIT analytic model		
	FIT dimension	**FIT assessment**	**FIT evaluation**
Hourglass S Spoon Top hourglass	• Bust line	• Very tight • Tight • Well • Large • Very large	• Lines • Wrinkle

4. RESULTS AND FINDINGS

This section records the findings of the three steps of methodology as follows:

4.1. Section 1: Body Measurements using the Telestia-AB System

All female samples were measured by the trained measurers. The measurers had training to acquire the scientific skill to conduct the anthropometric procedure. The thirteen dimensions on the body according to Telestia measurement system were followed accordingly. The results of the anthropometric data are shown in Table 4 and 5 below. Table 4 described the reading of the measurements in cm rounding to the nearest two digits. After obtaining the anthropometric data, the body shapes of each sample is calculated using the formulation table (shown in Table 1).

Table 4. Participant measurement data and body shape classifications

Body dimensions (cm)	Chest	Bust	Waist	Upper Hip	Hip	Front Shoulder	Back Shoulder	Bust length	Bust distance	Total body length	Sleeve	Knee length	Ankle length	Body shape
Case														
1	78	74	69	86	90	31	39	27	17	86	58	56	87	Spoon
2	92	105	87	100	106	32	39	28	18	92	58	53	84	Hourglass
3	78	85	74	88	91	31	36	26	18	89	59	56	85	Spoon
4	72	74	72	84	86	33	39	23	16	93	58	51	85	Spoon
5	97	110	103	109	110	34	39	32	21	94	60	54	87	Hourglass
6	73	81	74	89	92	30	35	22	16	89	58	54	85	Spoon
7	74	87	75	87	92	33	34	27	18	88	58	51	85	Spoon
8	81	85	83	92	94	36	38	25	19	93	58	58	92	Spoon
9	86	92	77	93	95	35	35	26	16	86	62	64	93	Hourglass
10	90	94	93	97	103	35	38	27	19	87	57	57	93	Spoon
11	91	110	85	97	103	32	39	30	20	83	57	53	86	Top Hourglass
12	92	100	83	97	97	35	39	28	19	75	59	59	91	Top Hourglass
13	89	92	81	98	100	33	40	26	20	87	63	60	95	Spoon
14	86	93	80	95	93	34	38	28	20	79	59	58	87	Hourglass
15	95	103	84	104	106	35	39	27	20	81	64	59	94	Hourglass
16	77	81	72	89	93	35	39	24	17	87	59	58	91	Spoon
17	103	111	96	111	112	36	36	28	20	91	60	56	88	Hourglass
18	79	84	84	98	105	31	36	25	18	90	59	53	86	Spoon
19	104	111	96	113	111	37	43	28	19	93	65	53	91	Hourglass
20	84	90	70	87	94	34	38	26	19	80	56	58	91	Spoon
21	89	94	83	95	98	31	36	26	18	90	61	58	93	Spoon

Table 5 described the results of the body shapes according to the different classifications.

It was found out that the 21 adult females volunteers are only clustered into three main body shapes which are hourglass, top hourglass and spoon shapes. Seven was classified to hourglass shape, twelve as the spoon shapes and only two belong to the top hourglass shape.

Table 5. Result of body shapes according to total sample population (n=21)

	Frequency	Percent	Cumulative Percent
Hourglass	7	33.3	33.3
Spoon	12	57.1	90.4
Top Hourglass	2	9.5	99.9
Total (N)	21	100.0	100.0

4.2. Section 2: Master Body Block Development using Telestia-AB system Results

All participants were very corporative in getting their bodies measured for the development of body block pattern. For this study, we start with the development of upper bodice first considering the fit areas of bust and waist circumference. Table 4 shows the anthropometric measurement data of 21 adult female for fitted bodice pattern production. The volunteers were told to wear the constructed bodice garment for wear trial analysis. In Telestia-AB system, the key to make the body block is to identify the sizes of the wearer. For upper body, the size of the block pattern is based on the chest measurement while for lower body the size is determined by the hip measurement. The size is calculated by looking at the key dimensions for each person and the selection of the size determines the fit. For example: The upper bodice part was at personal size of 42 for CASE 20 while CASE 19's personal size was 52. The personal size was retrieved from the chest measurement divided by 2 as shown in Fig. 8. Meanwhile for skirt and trousers, the sizes were obtained from hips size divided by 2 which resulted in size 47 for CASE 20 and size 55 for CASE 19.

Fig. 8. Basic garments using Telestia-AB trainer tool

4.3. Section 3: Wear Trial Fit Analysis

As can be seen from Fig. 9, the wear trial is tested and observed at the front, side and back position of the wearer's body. Each wearer was subjected according to cases and was labelled as Case 1 until Case 21 (as shown in Table 4). The garments were marked beforehand to properly position the important lines on body form such as the bustline, princess line and waistline. Bustline should be positioned on the highest point on the bust apex. The princess line connects the bustline and waist line while the waistline should be positioned at the narrowest part of the torso. Fig. 9 below recorded the fitting session for the first wear trial conducted on ten persons who gave the permission to take pictures. The fit observations were based on the criteria on Table 3.

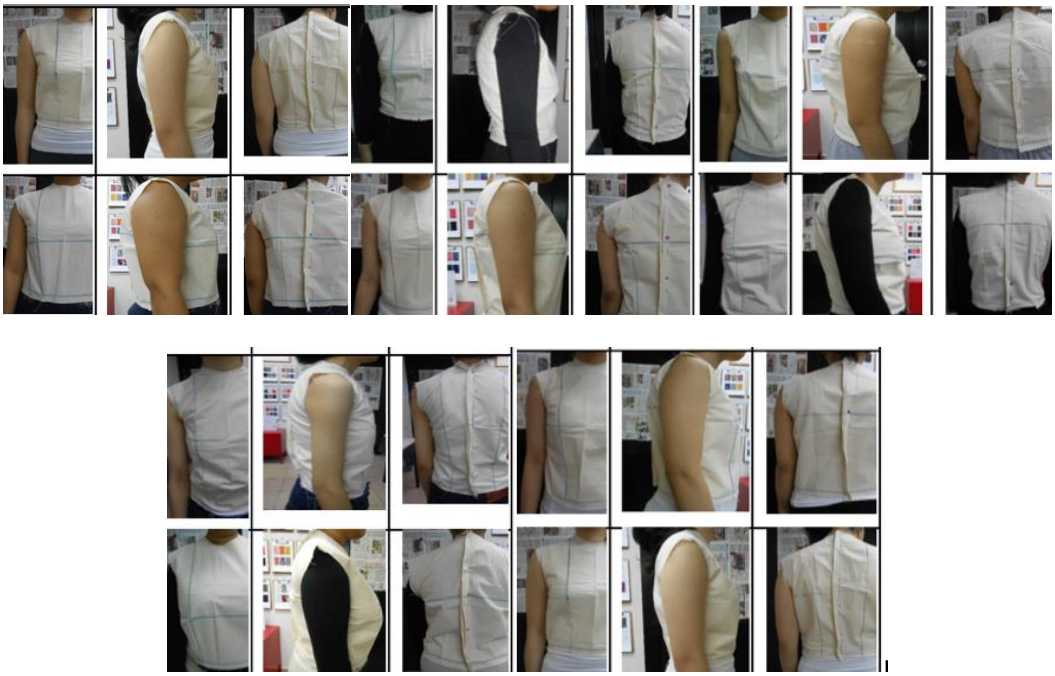


Fig. 9. Garment Fitting (Wear Trial)

The total fit analysis results are seen in Table 6 below. The fit observations are obtained for each individual according to spoon, top hour glass and hourglass for upper body focusing on the bust line area. It can be seen that although the person has the same body shapes, but the fit result can differ. The fit factors lie in three elements namely the size, shape and proportion. Thus, taking into consideration of these elements, the fit might not be good as the definition of fit is "well" due to different sizes and proportion although they can have the same body shapes. There were 21 female participants in the wear trial analysis. Thirteen participants said that their bodice blocks suited them well, according to the wear testing data. They are a part of six spoon body shapes, two top hourglass shapes, and five hourglass shapes. The bodice block did not fit eight additional participants well. Seven of the eight participants had spoon-shaped bodies, whereas just one had an hourglass body type. All of the ill-fitting clothes had creases and lines because they did not adhere to the body's curves, according to the fit evaluation.

Table 6. The fit analytics modelling

Measurement (cm)	Body shape	Fit dimension	Fit assessment					Fit observation	
Case		Bust line	Very tight	Tight	Well	Large	Very large	lines	wrinkle
1	Spoon								
2	Hourglass								
3									
4	Spoon								
5	Hourglass								
6	Spoon								
7	Spoon								
8	Spoon								
9	Hourglass								

Measurement (cm)	Body shape	Fit dimension	Fit assessment					Fit observation	
Case		Bust line	Very tight	Tight	Well	Large	Very large	lines	wrinkle
10	Spoon								
11	Top Hourglass								
12	Top Hourglass								
13	Spoon								
14	Hourglass								
15	Hourglass								
16	Spoon								
17	Hourglass								
18	Spoon								
19	Hourglass								
20	Spoon								
21	Spoon								

For the second analytical test, the measurers were asked to verify the fit analytic model's protocol on those wearing ill-fitting clothing. The body measurement procedure was discovered to be the root of the fitting problems after reviewing the previously collected data and taking new measurements of the participants. The errors committed by the measurers were subsequently disclosed to them. A newly altered pattern was created for those who had eight fit difficulties after they were asked to identify the bust line trouble region. Body measurements were checked and body measuring were conducted once more on all eight participants. The body pattern were drafted. The body pattern can become inaccurate if the measurement is not obtained accurately, leading to the selection of the incorrect pattern size for body block creation. After the body pattern is adjusted and the size measurements are corrected, the wrinkles and drag lines is reduced. The sample garment passed the second round of testing on the same volunteers with good results, demonstrating that they fit the person well.

5. CONCLUSION

This is the first study in Malaysia to define female body shapes for the creation of body patterns and to comprehend the process of evaluating fit. The goal of collecting body measuring data for data analytics is to comprehend the current female body shapes in Malaysia, to convert each body shape into a body pattern, and to evaluate the fit of the essential bodice. The females' body measurement data are classified into their own body shapes using a formula. This novel method of body shape classification from the previous research helped extract features which characterise an individual’s body shape. This characterization of shape contains information that is absent from measures used in current anthropometric practice. In addition, these identified shape features can complement traditional anthropometrics when explaining variations in quantities of shapes and sizes.

A structured pattern making methodology following the Telestia-AB system gave the measurers a simplified process that identified the body landmark correctly, making the

measurement process precise and efficient. The anatomical landmarks of key areas are identified so that they can easily be measured on one's body.

When fit assessment and observation are carried out on the fit dimension, which is the bust line, different findings are found for each individual, although they have the same body shape. The findings of this study indicate that, in comparison to other body shapes, people with spoon-shaped bodies experience the issues with fitness. The fit problem in this instance can be traced to either a problem with practical measuring ability or improper measurement technique. It may also be connected to the fact that different body parts with the same body shape have different proportions and sizes, which leads to fit issues and necessitates more modification and investigation to resolve.

As a result, this fit analytic model is created to establish a quality control procedure for the development of body pattern. This step is essential to ensure that each body form is accurately translated onto the paper to serve as a blueprint for the development of each garment. This study's findings suggest that this fit analytical approach may one day serve as the Malaysian standard for evaluating fit based on female shapes. Recognizing the variations in female body forms within a single country is essential because there are many elements that contribute to non-fitted apparel. In all nations and among all racial groupings, the study of female body forms is crucial. Understanding one's dimensions, forms, and proportions let fit experts make better judgments, which led to better-fitting clothing.

This fit analysis model has a significant effect on the apparel industry. A continuous process link can be given for the garment firms to provide better fitting apparel by integrating this entire process within the businesses. In order to establish a deeper methodology for this drawn-out process, we combined three pertinent approaches used in this fit analytic model: the specific body measuring protocols; the streamlined body pattern procedure using the Telestia-AB specialised tools; and the critical fit evaluation component. It was discovered that the technical protocol of developing body block pattern can be expedited using specialized tool that makes the procedure more efficient and effective in translating body measurements into body pattern.

In subsequent studies, it would be meaningful to investigate more female samples in Malaysia to explore additional body shapes from representative national population. Future research will use a large cohort of thousands of participants to apply the suggested methods, identifying the distinctive shape pattern of variation across a wider range of body shapes, and further explore the connection between shape features and body block pattern garment development for better fitting clothing.

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Reference:

1. Balach, M., Lesiakowska-Jablonska, M., & Frydrych, I. Anthropometry and Size Groups in the Clothing Industry. Autex Research Journal. 2020;20(1):56–62. https://doi.org/10.2478/aut-2019-0001
2. Zakaria N, Gupta D. Apparel sizing: existing sizing systems and the development of new sizing systems. InAnthropometry, apparel sizing and design 2014 Jan 1 (pp. 3-33). Woodhead Publishing. https://doi.org/10.1533/9780857096890.1.3.
3. Zakaria N, Gupta D, editors. Anthropometry, apparel sizing and design. Woodhead Publishing; 2019 Oct 5. https://doi.org/10.1016/C2017-0-01616-6
4. Ramly NM, Shaari N. The Effectiveness of Apparel Pattern Drafting in Manual System for Tvet Fashion Program. PalArch's Journal of Archaeology of Egypt/Egyptology. 2020 Nov 2;17(9):3062-70.
5. Tama D, Öndoğan Z. Fitting evaluation of pattern making systems according to female body shapes. Fibres & Textiles in Eastern Europe. 2014.
6. Tanjibul, M., Sajib, H., Islam, A., Eanamul, M., & Nizam, H. Development of Basic Pattern Blocks for Men's Wear Applying 3D Body Scanning Technology. 2018. www.symbiosisonline.orgwww.symbiosisonlinepublishing.com
7. Zhu, Y., & Peng, Y. Fit Evaluation during Repetition Interaction in Garment Pattern Design. Mathematical Problems in Engineering, 2019. https://doi.org/10.1155/2019/3901582
8. Scott, E., Gill,S., & McDonald, C. Novel Methods to Drive Pattern Engineering through and for Enhanced Use of 3D Technologies. 2019:211–221. https://doi.org/10.15221/19.211
9. Hackett, L. J., & Rall, D. N. The size of the problem with the problem of sizing: How clothing measurement systems have misrepresented women's bodies, from the 1920s to today. Clothing Cultures. 2018:5(2). https://doi.org/10.1386/cc.5.2.263_1
10. Yin, L., & Annett-Hitchcock, K. Comparison of body measurements between Chinese and U.S. females. The Journal of The Textile Institute. 2019:110(12);1716–1724. https://doi.org/10.1080/00405000.2019.1617531
11. Petrak, S., & Mahnič Naglic, M. Dynamic Anthropometry – Defining Protocols for Automatic Body Measurement. TEKSTILEC. 2017:60(4);254–262. https://doi.org/10.14502/Tekstilec2017.60.254-262
12. Zakaria, N., Taib, J. S. Mohd. N., Tan, Y. Y., & Wah, Y. B. Using data mining technique to explore anthropometric data towards the development of sizing system. Proceedings - International Symposium on Information Technology 2008, ITSim. 2008:2. https://doi.org/10.1109/ITSIM.2008.4631721
13. Ashdown, S., & Loker, S. Mass-customized Target Market Sizing: Extending the Sizing Paradigm for Improved Apparel Fit. Fashion Practice. 2010:2(2);147–173. https://doi.org/10.2752/175693810X12774625387396
14. Kim, H., & Damhorst, M. L. The Relationship of Body-Related Self-Discrepancy to Body Dissatisfaction, Apparel Involvement, Concerns with Fit and Size of Garments, and Purchase Intentions in Online Apparel Shopping. Clothing and Textiles Research Journal. 2010:28(4);239–254. https://doi.org/10.1177/0887302X10379266
15. Yu, M., & Kim, D. E. Body shape classification of Korean middle-aged women using 3D anthropometry. Fashion and Textiles. 2020:7(1). https://doi.org/10.1186/s40691-020-00223-8
16. Kasambala J, Kempen E, Pandarum R. Female consumers' perceptions of garment fit, personal values and emotions considering their body shapes. The Retail and Marketing Review. 2014 Jan 1;10(1):95-108.

17. Kausher, H., & Srivastava, S. A review on sizing systems for readymade garments in India and different types of body shapes of females. International Journal of Home Science. 2016:2(3);136–138.

18. Yim Lee, J., Istook, C. L., Ja Nam, Y., & Mi Park, S. Comparison of body shape between USA and Korean women. International Journal of Clothing Science and Technology. 2007:19(5);374–391. https://doi.org/10.1108/09556220710819555

19. Vuruskan A. & Bulgun E. identification of body shapes of female body shapes based on numerical evaluation. International Journal of Cloth Science and Technology. 2010:23(1);46–60.

20. Hong, Y., Bruniaux, P., Zeng, X., Liu, K., Curteza, A., & Chen, Y. Visual-Simulation-Based Personalized Garment Block Design Method for Physically Disabled People with Scoliosis (PDPS). Autex Research Journal. 2018:18(1). https://doi.org/10.1515/aut-2017-0001

21. Sakata Y, Kim K, Takatera M. Development of a measuring garment for a woman's upper body shape. In International Symposium on Affective Science and Engineering ISASE2021 2021 (pp. 1-2). Japan Society of Kansei Engineering. https://doi.org/10.5057/isase.2021-c000016

22. Guo S, Istook CL. Evaluation of 2D CAD Technology for Garments Customized for Body Shape. Fashion Practice. 2021 Sep 30:1-27. https://doi.org/10.1080/17569370.2021.1987647

23. Santesteban, I., Otaduy, M. A., & Casas, D. Learning-Based Animation of Clothing for Virtual Try-On. Computer Graphics Forum. 2019:38(2). https://doi.org/10.1111/cgf.13643

24. Liu, K., Wu, H., Zhu, C., Wang, J., Zeng, X., Tao, X., & Bruniaux, P. An evaluation of garment fit to improve customer body fit of fashion design clothing. International Journal of Advanced Manufacturing Technology. 2022. https://doi.org/10.1007/s00170-022-08965-z

25. Shin, E., & Lorenz, F. Exploring consumers' fit perceptions and satisfaction with apparel fit in general. Master's thesis. Iowa State University, USA. 2013.

26. Shin, E., Niehm, L., Russell, D., & Laczniak, R. The role of fit information in consumer online reviews and individual characteristics in consumer's online purchase decisions. Doctoral dissertation, Iowa State University, USA. 2016.

27. Jiang B, Zhang J, Hong Y, Luo J, Liu L, Bao H. Bcnet: Learning body and cloth shape from a single image. In Computer Vision–ECCV 2020: 16th European Conference, Glasgow, UK, August 23–28, 2020, Proceedings, Part XX 16 2020 (pp. 18-35). Springer International Publishing. https://doi.org/10.1007/978-3-030-58565-5_2

28. Jiang, L., Ye, J., Sun, L., & Li, J. Transferring and fitting fixed-sized garments onto bodies of various dimensions and postures. CAD Computer Aided Design. 2019:106. https://doi.org/10.1016/j.cad.2018.08.002

29. Lin, Y. L., & Wang, M. J. J. The development of a clothing fit evaluation system under virtual environment. Multimedia Tools and Applications. 2016:75(13). https://doi.org/10.1007/s11042-015-2681-7

30. Scott, E. & Sayem, A. S. M. Landmarking and Measuring for Critical Body Shape Analysis Targeting Garment Fit. 2018:222–235. https://doi.org/10.15221/18.222