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The Fabrics Design Influence in Real and Simulated Drape of Clothing

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Abstract

This research work aims to study the influence of the fabrics in the wear performance of clothing. For this, an experimental work was developed with two fabric samples having the same weight/m2, one single and another double, and a jacket prototype. Through a comparative analysis of the mechanical properties, very interesting results was obtained in the evaluation and characterization of the two fabrics performance in designing the same jacket, namely the drape and the corresponded aesthetic fabrics behaviours during wear. The structural characteristics and mechanical properties of each fabric were introduced into Marvelous Designer Version 8 software to simulate the virtual draping of fabrics in a skirt. The analysis of the drape profile of each fabric given by the software and the drape of the real fabrics evaluated in laboratory indicates, coherently, that the double fabric falls less than the single, but in a more harmonious way, what evidence the close links between technology and design of fashion products.

Keywords: Fabrics design, Fabrics mechanical properties, Clothing drape, Real and simulated drape

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1. Introduction

The clothing conception (and its components) is a special case of involvement design in the project of products. This peculiarity arises from the importance that clothing has for the physical and psychological human well-being, since people lives in a constant relation with garments. The fabric, as raw material for clothing, has a huge relevance in aesthetic and functional components of clothing design project [1].

Regarding clothing, fabrics must answer primarily to two factors: the functional and the aesthetic. It is essential to the fabric to be functional in order to be able to meet the basic needs of protection and comfort. The aesthetic component of the fabric is related to the colour and harmony of colours in patterns, the weave and the relationship weave/pattern, the drape or fluidity of the fabrics and the overall look that is still influenced by the raw materials and finishing. The domain of these parameters by designers allows introducing the differentiation, leading to consumer satisfaction when they wear certain products. These two factors, functional and aesthetic, are critical in conception of a fabric design project aiming its success in response to market, embedded in a logic of constant demand by designers, as an integral part of the design process, creativity and innovation [1].

Generally, fabric drape determines the sensory comfort and aesthetics that fabrics give to garments. The more fluid or more stiff shape, that is, with more volume, as the garment having a good drape, according to the aesthetic the designer intends for his garment, is related to the bending and shear rigidities of the fabric that makes the garment, including the ability of fabric to adapt to the three-dimensional shape of the garment [2].

1.1. Historical importance of fabric drape

Historically speaking, draping and fabric flowing is usually related to the Ancient Greece. However, in this context, military costumes are not considered, since their adornments and specific materials, such as leather and metal cannot be considered in this study. Therefore, it is important to look at the everyday costume of men and women of this era, since their outfits were made from different large tunics, like the palla or the peplos, cut out from very light fabrics and simply embroidered [3]. This simple yet comfortable way to drape fabrics on the body would create simple silhouettes, very similar from gender to gender.

The Japanese fashion design has explored in an interesting way the fall of fabrics. Since Kansai Yamamoto's approach on fabric and flowing silhouettes for David Bowie's Ziggy Stardust Tour in 1973, Japanese designers have showed their approach to fabric draping and use of flowing fabrics to create new dynamics and silhouettes, conflicting the western tradition and forms [4, 5]. Their approach on weaving and its direct relation to the flowing of the garments has changed the western designers' approach. Textile designer Yoshiki Hishinuma is one of these examples, after created revolutionary designs for Issey Miyake and further developing chiffon and other fabrics, thus "pushing the practical and aesthetic boundaries of material" [5].

Balenciaga and Dior were creators known for their attention on fabric drape detail. Cristobal Balenciaga is considered a purist of his era, erasing all artifices from the silhouettes he created since the 1950's, by simply manipulating different fabrics, and letting them flow and drape on their own, creating the so-called "sack line" [6]. In the four-horn dress in black gazar, 1967, Balenciaga interprets the geometric trends of the time through the drape of the fabric. Years earlier, Christian Dior would present his "New Look" parade, in 1947, showing a new silhouette, where the skirt flows completely from the volume created in the bosom, remembering the organic form of a flower [5].

1.2. Fabric parameters influencing drape

The drape of fabrics is influenced by the type of fibres in the composition and by the technical construction of the yarns and the fabrics themselves. The mechanical properties of fabrics are determinant of drape behaviour, in particular bending and shear rigidities. In turn, these properties of fabrics depend on their technical construction, namely the thickness, the weave, the covering factor and the weight/m^2. The bending rigidity expresses the greater or lesser difficulty that fabrics undergo when subjected to a bending force, even if that is their weight itself. The shear rigidity expresses the greater or lesser difficulty that fabrics undergo to undo the perpendicular shape between warp and weft, in the plane of the fabric, when subjected to a force. The thickness of the fabric is very important in the bending rigidity and the weave and the covering factor are decisive for the shear rigidity. Thicker fabrics usually show higher bending rigidities, are more compact and have higher shear rigidities.

The mechanical behaviour of fabrics, especially the ones that determines their drape, can be evaluated in laboratorial equipment that measures the mechanical parameters when the fabrics are submitted to low stresses, similar to those that they experience in the daily use, as its own weight. Of particular note are KES-F (Kawabata Evaluation System - Fabrics) (Figure 1) and FAST (Fabric Assurance by Simple Testing) equipment. The first evaluates the extensibility in the warp and weft and in bias direction; the bending; the compression (thickness) and the surface texture of fabrics, with very precise laboratory tests. FAST evaluates the same parameters with the exception of texture, with simpler and less stringent tests.

1.3. 3D garment simulation considering fabric drape

Following a trend, based on technology, for a real virtualization, favouring decision making, whether for issuing production orders or for buying decisions, whether in B2B or B2C, the 3D simulation of clothing has been studied, resulting in several software applications in which fabric drape is a central element. One of them is the Lectra Modaris

Figure 1: Partial view of the Kabawata KES-F system installed at the Textile Department of University of Beira Interior showing compression and surfaces modules at bottom of the image (Source: Authors)

3D Prototyping that simulates garments in a very close way that garment makers do in a real situation [7].

Another computer application is the CLO3D's patternmaking and 3D rendering software called Marvelous Designer that has improved a lot since its first launch, as the company released their 8th version of the software [8]. The software enables an entire control panel of fabric physical properties, in order to reach the best quality when rendering the garments in 3D. The user can also tuck the fabric and use virtual pins in order to create draping effects, just like designers do on their mannequins. Physical properties such as the elasticity of the fabric, its density, shrinkage and thickness are some of the functionalities made possible by the program. Of course, other programs like Autodesk's Maya and 3DS Max provide high-quality renders for any object modelling, however, in terms of fabric mimicking, they cannot surpass the high quality and realism of Marvelous Designer and Lectra 3D Prototyping.

2. Experimental Work

To demonstrate the importance of fabric's drape parameters in the clothing fashion design, in the experimental methodology, two fabrics and two garment projects were developed, which gave rise to so many prototypes aiming to evaluate and compare the aesthetic and functional behaviour of single and double fabrics during wear [9].

It was taken into account that the two fabrics should have the same composition, the same type of yarn, the same weight/m^2 and the same finish so that the application could be the same, although their behaviour with regard to drape would necessarily be different. For this, a single and double fabric was developed [9]. Double fabrics are those consisting of two warps and two wefts, creating a woven fabric composed of two juxtaposed single fabrics. The production technology of double fabrics is used in conventional fabric weaving, depending on the weave and yarn densities, being used when it is intended to obtain heavier fabrics, while avoiding the increase of rigidity caused by increasing the yarn densities, thus keeping the flexibility at satisfactory levels. On the other hand, double fabrics, because they are made of two single ones, allow a range of appearance and function between their two sides, in terms of colours, patterns and types of yarns, including raw materials. The structural characteristics and performance properties of the two fabrics were laboratory tested. Also, some structural and mechanical properties of the two fabrics were measured with the Kawabata KES-F system. Draping behaviour was assessed in laboratory [9] and through Marvelous Designer V8 software.

2.1. Materials and methods

The development of the technical fabrics project started by defining the weight/m^2 considering fashion trends and the intended application for the fabrics: winter coats and skirts for women. In this definition and considering that both single and double fabrics must have the same weight/m^2, it was also considered the compatibility between weight/m^2, yarn count, weave, cover factor and fabric type - double and single. Thus, it was considered for both fabrics a weight/m^2 of 340g/m^2, as well as the use of siro-spun dyed yarn, having a 2/50 Nm count for the double fabric and, twisted to give a 4/50 Nm count, for use in the single fabric. The weave was a balanced twill 2/2. In the UBI workshops the project was materialized into two prototypes, a double and a single fabric, with the same regular woollen finish [9] (Figure 2).

In order to evaluate the drape of single and double fabrics in their final applications and during wear, the development and prototyping of garments was analysed starting from fabrics. The garment chosen for the implementation of the prototype was a short coat for winter in a casual style [9] (Figure 3) and for computer simulation a skirt was taken (Figure 4). The choice of these typologies was due to the fact that it is a propitious shape to highlight the fabric drape, having no lining and non-conventional reverses. The technical worksheet of prototypes to be produced was developed – two equal women's coats, one for each fabric, single and double. The prototyping of the coats was made in the Clothing Workshop of the Textiles Department of UBI, having the type of fabric as the only differentiating variable between coats [9].

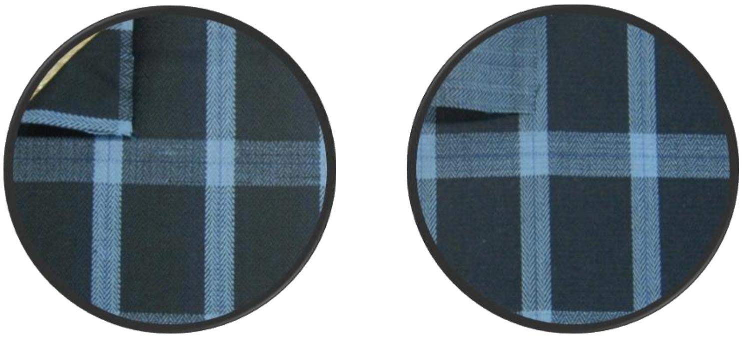

Figure 2: Representation of single (left) and double (right) fabrics Source: [9]

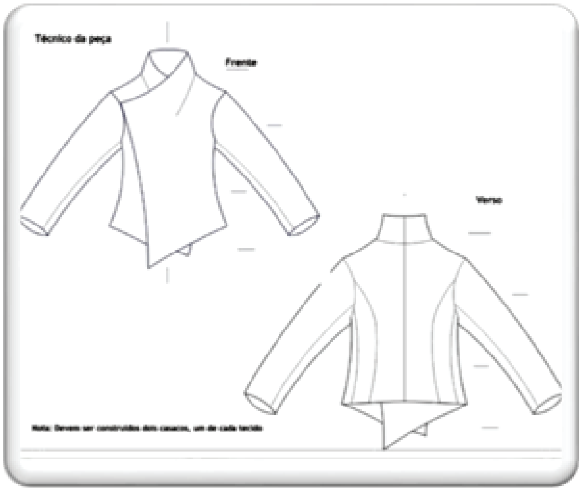

Figure 3: Coat technical drawing sheet. Top left front view and bottom right back view Source: [9]

2.2. Virtual fabric drape simulation

Through Marvelous Designer software the 3D shape of the skirt was built from the 2D patterns. Simulating the drape of the same skirt with the two fabrics, single and double face, from the introduction in the software of the structural characteristics and the Kawabata mechanical properties of each fabric (Figure 4).

2.3. Laboratory evaluation of fabric drape

The drape of both fabrics was evaluated in the Cusik Drape Tester laboratory apparatus. The principle of operation of the apparatus is from a sample of fabric with 40cm in diameter, provoking the lack of support of the external circular crown of the sample, allowing the fabric to fall in all directions, maintaining the central circle supported during the test. The falling behaviour will be different from fabric to fabric, and is thus characterizing the drape. With the aid of a spotlight, the shadows of the image generated is projected onto a sheet of paper, which allows the shaded area to be

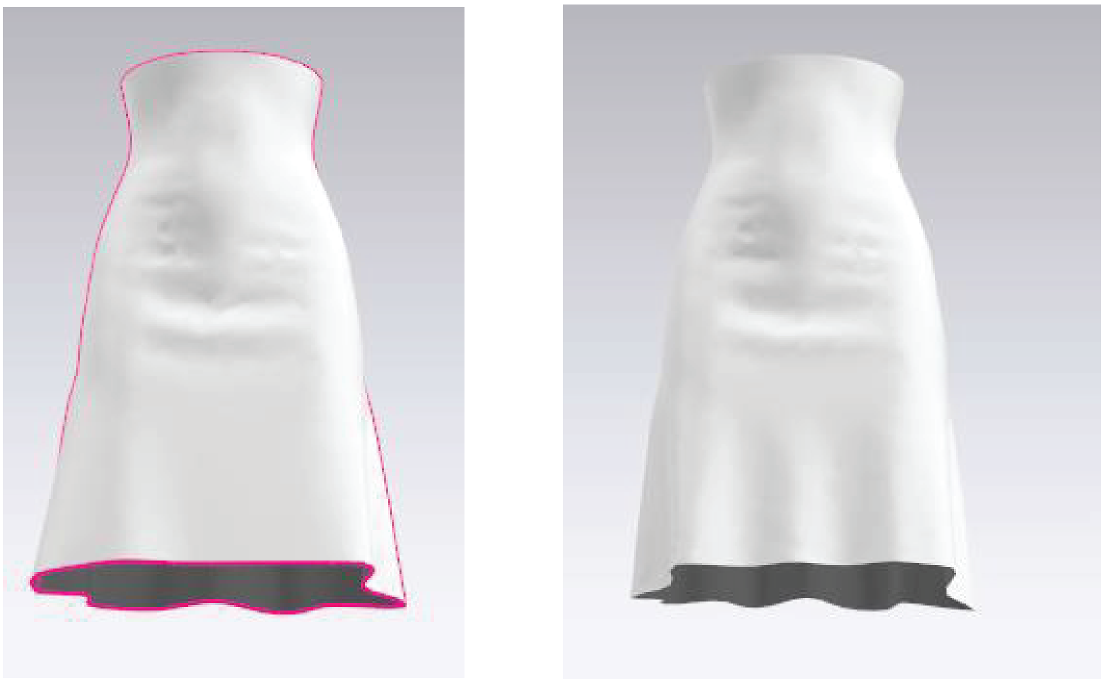

Figure 4: Upright skirt simulation view. Left: Single fabric skirt; Right: double fabric skirt Source: Authors

related to the initial area, giving an objective measure of the drape of the fabric. If the shaded area corresponds to the initial area, it means that the fabric does not fall and its value is 100%. Virtual draping behaviour was assessed through Marvelous Designer V8 software.

3. Results and Discussion

Very interesting results in terms of technology of fabrics and the interaction between technology and design were obtained. The results of laboratory tests, shown in Table 1, reveal significant differences between the performance of single and double fabrics, even having the same composition, yarn and weight/m^2. In this table we can observe the results of the mechanical properties tests as well as of the properties of comfort (air permeability, water vapour permeability and thermal behaviour) that are related to the structural characteristics of each fabric, which also effect the mechanical properties that influence drape [1, 9].

For the group of properties related to comfort, the two fabrics have different behaviours. The double fabric is more permeable to air (472l/m/s) and water vapour (6.8%) and more insulating to heat (17.2 m^2.K/W) than the single fabric (84.7 l/m^2/s, 7.5%, 10.4 m^2.K/W).

Table 1: Influence of characteristics and properties of fabrics in fashion design Source: [1, 9]

Characteristics and properties of fabrics					Constraints and influence in fabrics and clothing design
	Single Fabric		Double Fabric		
Air permeability ($l/m^2/s$)	84.7		472.0		Application, comfort
Water vapour permeability (Permetest method) Coefficient of variation – CV% (Reference CV=5%)	7.5		6.8		Application, comfort
Thermal resistance (Alambeta method) – r (m^2.K/W)	10.4		17.2		Application, comfort
Fabric drape (Cusik Drape Tester) (%)	33.9		48.3		Sensorial comfort, look
Surface properties Kawabata KES-FB4 system Roughness SMD	3,642		6.855		Application, look, touch
FAST parameters	Warp	Weft	Warp	Weft	
Bending length (mm)	4.4	4.8	5.7	4.8	Sensorial comfort, drape, adaptation of garment to the 3rd dimension
Bending rigidity (uN.m)	0.3	0.4	0.6	0.4	
Shear rigidity (N/m)	37		20		Sensorial comfort, drape, garment fit to 3rd dimension
Compression - Thickness (mm) Under 2g (T2)	0.767		1.162		Application, look, comfort – thermal behaviour
Compression - Thickness (mm) Under 100g (T100)	0.641		0.857		
Compression - Thickness (mm) Surface thickness (ST)	0.126		0.305		

The double fabric has the same weight/m^2 than the single one at the expense of the increased thickness formed by the two overlapping single fabrics, but also due to the use of thinner and more widely spaced yarns. For this reason, the spatial geometry of the double fabric is more porous as compared to the single one, favouring the air and water vapour permeability. It is also because it has a greater thickness and the corresponding air content, that the double fabric is more heat insulating than single fabric. Considering the weight/m^2 of fabrics, the application of both is in winter clothing, the double fabric being the one that best meets the weather requirements, with the exception of being more uncomfortable than the single fabric on windy days [1].

Concerning the mechanical behaviour of fabrics, including the bending and shear rigidities, both fabrics show also differences in their behaviour. The double fabric has a smaller drape (48.3%) in the Cusik Drape Tester than the single fabric (33.9%). In the

FAST system, the weft bending rigidity is equal for both fabrics (0.4uN.m), while for the warp is higher in the double fabric (0.6 uN.m) than single (0.3 uN.m). These results of the bending rigidity are concordant with the drape measured using Cusik Drape Tester. The ability of fabrics to adapt to the three dimensions of the garment is higher in the double fabric than in single one, according to the respective values of shear rigidity (20N/m and 37N/m). Indeed, in the double fabric yarns are less compressed and thus have a greater freedom of movement, presenting therefore lower shear rigidity [1].

Table 1 also shows the influence of the characteristics and properties of fabrics in the design of fabrics and garments made with them. The results are also very interesting. As it can be seen, all the technological fabrics parameters have some influence on design, either in surface appearance, either in the fabric drape and touch. The performance level of some parameters influence the use of fabrics, although in the cases studied it appears that fabrics are suitable for the manufacture of coats chosen [1].

The study shows that the fabrics roughness, measured with a surface analysis test, has a direct relationship with the look and touch, conditioning the application. Indeed, the double fabric has a higher roughness (6.855) than the single (3.642), since yarns are packed in the single fabric. In the double, the yarn densities of the component fabrics are more open and the three-dimensional effect causes greater yarn positional freedom to floats, favouring increased irregularity of fabric surface and the gain of a textured look, so suitable to casual applications. In this perspective, the double fabric showed the best fit to the coat chosen, considering its casual cut [1].

The relationship between the drape of the fabrics, their bending and shear rigidities and the aesthetic aspect of the drape of coats is very interesting to discuss. Figure 5 - right shows the shape of the drape of double fabric, i.e., in all directions at once. There is a regular shape with seven pleats less pronounced than on the single fabric (Figure 5 - left) that shows a less regular contour with six pleats. These results indicate that the double fabric has a more harmonic drape but with more volume. The volume is noticed by the drape value given by the Cusik Drape Tester test and is due to the higher thickness (1.162 mm and 0.767 mm) and to the three-dimensional structure of the double fabric [1].

The greater volume of the double fabric is noted by the increased drape measured by Cusik Drape Tester and by the higher bending rigidity given by the FAST system (0.6uN.m and 0.3uN.m). The lower shear rigidity of the double fabric contributes to the increased number of pleats formed in Cusik Drape Tester test and to the uniformity and naturalness of fabric and coat drape. Figure 6 show the two coats in actual wear. Figure 6 - right shows the coat constructed with the double fabric, being easy to observe what

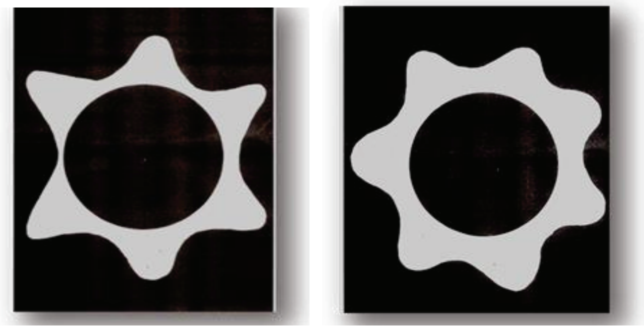

Figure 5: Fabric drape using Cusik Drape Tester. On left, single fabric and on right, double fabric Source: [1, 9]

was proved by the technological parameters results, i.e., a more voluminous and natural drape than the in the coat built with the single fabric shown in Figure 6 - left. Also, in the aesthetic point of view, the double fabrics offer two sides, which may be distinct, to the designer's creativity [1].

Figure 6: View of coats made with single fabric (left) and double fabric (right) Source: [1, 9]

To better understand the drape behaviour of both fabrics and also to relate the fabrics real drape and virtual simulations through a software, a skirt was simulated with the Marvelous Designer V8 having a 26cm waist, 68cm length and a round contour at the bottom of 60,5cm. The software parameters of the studied single and double fabrics, required for the corresponding virtual simulations, was measured with the Kawabata Evaluating System for Fabrics [10, 11] shown in the Table 2.

The Figure 7 represents the cross sections of this skirt, considering the single and double fabrics, obtained on Marvelous Designer V8 by a horizontal plane, which intersects the very bottom of the skirt. The vertical position of the intersecting plane was the same for the single fabric skirt and for the double one.

The analysis of the skirt cross section at bottom, considering the single and double fabrics, shown in Figure 7, allowed to elaborate the Table 3 with the comparison of measurements of real and simulated skirts with single and double fabrics. The lengths

Table 2: Kawabata KES-F parameters [10, 11] for single and double fabrics, required for the virtual simulations Source: Authors

	Single fabric		Double fabric	
KES-F Parameters	Warp	Weft	Warp	Weft
Bending rigidity, B (10^{-6}N.m)	16.01	14.03	36.36	23.16
Extensibility, EMT (%)	5.30	5.10	4.92	4.24
Curve linearity, LT	0.93	0.72	0.84	0.83
Stress energy, WT (N/m)	23.81	23.12	25.98	22.26
Shear rigidity, G (N/m.degree)	0.79	0,79	0.40	0.44
Thickness, TM (N/m)	0.34		4.27	
Friction coefficient, MIU	0.15	0,21	0.19	0.33
Fabric weight, W (Kg/m^2)	0.34		0.34	

and areas were calculated by a cross section plane at waist and the bottom of the skirt using the software Sketcandcalc, trial version [12]. Simulated values were determined after skirt being dressed and draped on an avatar using the Marvelous Designer V8 program.

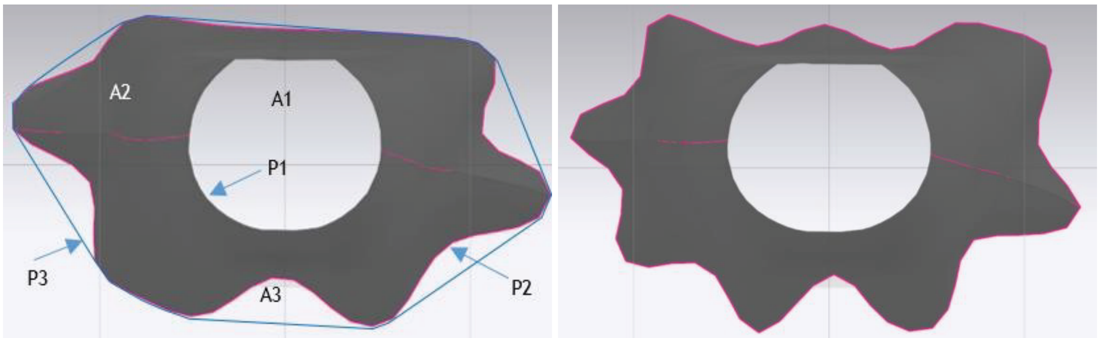

Figure 7: Skirt cross section at bottom. Left: Single fabric skirt; right: Double fabric skirt. Lines shown: Inner line – waist of mannequin; outer line - draped skirt fabric at bottom (A1 - Waist area; A2 - Area at bottom (pleats); A3 - Contour area at bottom; P1 - Waist perimeter; P2 - Perimeter at bottom (pleats); P3 – Contour perimeter) Source: Authors

A similarity can be drawn between the images of the profile of the pleats resultants from the fabrics drape, measured by the Cusik Drape Tester (Figure 5) and simulated by Marvelous Designer V8 program (Figure 7). The area at bottom (pleats) of the double fabric skirt (704.87cm^2) is greater than the same area of the single fabric skirt (639.05cm^2), which leads to consider that the double fabric gives the skirt a drape with higher volume. On the other hand, the virtual drape of the double fabric skirt features a higher number of pleats than the virtual drape of the single fabric skirt, which allows to conclude that the double fabric gives the skirt a more harmonious and natural drape.

Table 3: Comparison of measurements of real and simulated skirts with single and double fabrics. (Source: Authors)

Real and simulated skirt measurements (lengths in cm; areas in cm^2)			
Waist perimeter		52.00	
Perimeter at bottom		121.00	
Waist area		215.30	
Contour area at bottom		1165.80	
Single Fabric Skirt Simulation		Double Fabric Skirt Simulation	
Waist perimeter	51.74	Waist perimeter	52.25
Perimeter at bottom (pleats)	124.74	Perimeter at bottom (pleats)	119.88
Waist area	213.93	Waist area	216.67
Area at bottom (pleats)	639.05	Area at bottom (pleats)	704.87
Contour area at bottom	825.55	Contour area at bottom	833.78

4. Conclusions

The purpose of this study was satisfied. The importance of knowledge of technological parameters in the engineering design of fabrics and clothing was emphasized, taking into account the functional and aesthetic performance. Very interesting results in the comparative analysis of two fabrics with the same weight/m^2, a single and another double, with regard to its aesthetic and technical performance in clothing were obtained. It has been shown that the double fabric, relative to the single, gives clothing a more voluminous, harmonious and natural drape due to its structural construction: two-layer fabric (greater thickness and greater bending rigidity) and greater yarn mobility in the structure (lower shear rigidity). These results were obtained in laboratory with the Cusik Drape Tester and proven through virtual simulation with the Marvelous Designer V8 program. Also, for application in casual winter coats the double fabric showed better performance with the exception of the air permeability behaviour.

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