IMPACT OF AVATAR TYPE AND SURFACE CHARACTERISTICS ON GARMENT FIT IN 3D SIMULATION

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Abstract: *The development of digital technologies has enabled the analysis of the behavior of clothing products in a virtual environment using 3D simulation. One of the important factors in these simulations is the digital avatar, whose characteristics can affect the interaction between clothing and the body. The aim of this work was to examine the influence of the avatar type and its surface characteristics on the clothing fit and stress distribution during 3D simulation. The simulation was conducted in the Browzwear V-Stitcher software on a dress model made of 100% cotton rib knit (2×2 rib) and interlock. The analysis included two types of avatars (hard and soft Olivia) and three types of avatar surfaces (human, plastic and fabric). The results show that the highest stress values are recorded in the chest area, while the differences between the avatar surfaces are relatively small. At the same time, it was observed that the deformability of the soft avatar affects the contact between clothing and the body and allows for a more natural fall and draping of the material compared to a rigid avatar.*

Key words: 3D clothing simulation, digital avatar, fitting, tension map, knitwear.

UTICAJ TIPA AVATARA I KARAKTERISTIKA POVRŠINE NA PRISTALOST ODEĆE U 3D SIMULACIJI

Apstrakt: *Razvoj digitalnih tehnologija omogućio je analizu ponašanja odevnih proizvoda u virtuelnom okruženju korišćenjem 3D simulacije. Jedan od važnih faktora u ovim simulacijama je digitalni avatar, čije karakteristike mogu uticati na interakciju između odeće i tela. Cilj ovog rada bio je ispitivanje uticaja tipa avatara i njegovih površinskih karakteristika na pristalost odeće i raspodelu naprezanja tokom 3D simulacije. Simulacija je sprovedena u softveru Browzwear V-Stitcher na modelu haljine od rebraste pletenine (rebro 2×2) i interloka od 100% pamuka. Analiza je obuhvatila dva tipa avatara (čvrsta i meka Olivija) i tri tipa površina avatara (ljudska, plastična i platnena). Rezultati pokazuju da su najveće vrednosti naprezanja zabeležene u predelu grudnog koša, dok su razlike između površina avatara relativno male. Istovremeno, primećeno je da deformabilnost mekog avatara utiče na kontakt između odeće i tela i omogućava prirodniji pad i drapiranje materijala u poređenju sa čvrstim avatarom.*

Ključne reči: 3D simulacija odeće, digitalni avatar, pristajanje, mapa zatezanja, pletenina.

1. INTRODUCTION

The development of digital technologies has significantly changed the process of designing clothing products. Software for 3D design and simulation of clothing allows designers and engineers to visualize and analyze cut patterns, fit and behavior of textile materials on digital avatars before physical prototyping. In this way, the need for physical samples is reduced, the product development process is accelerated and production sustainability is contributed [1-5].

One of the key factors that affects the accuracy of 3D simulation is the model of the digital avatar. An avatar is a virtual model of the human body on which the behavior of the garment is simulated. However, different types of avatars can have different mechanical characteristics, such as strength or surface deformability, which can affect the way the material is arranged, stretched or draped [2,3].

In modern 3D clothing modeling systems, it is possible to use different types of avatars, such as standard humanoid avatars, plasticized avatars or avatars with textile properties, as well as different levels of softness of the avatar surface (soft, medium soft and firm). These characteristics can significantly affect the simulation of body-clothing contact, as well as the stress distribution and draping of the material [4-12].

The aim of this paper is to examine the influence of digital avatar characteristics on the behavior of a garment in a 3D simulation, with a particular focus on stress distribution and model fitting. The analysis includes a comparison of a solid and a soft avatar, as well as different avatar surface characteristics (human, plastic, and cloth).

2. MATERIALS AND METHOD

2.1 Garment model

In the research, a model of a tight long-sleeved dress that follows the body line in size M was used. The model was constructed in a 3D CAD environment and simulated on a digital avatar of standard female body measurements in the Browzwear Vstitcher program (Figure 1). The dress is modeled so that it has contact with the body and the cut is adapted to knitted materials, which allows a clearer observation of the differences in fitting and stress distribution.

Figure 1: Simulation of used model for expirement (photo made by authors)

Visual representations of the dress simulation on different avatars are shown in the work through front, side and back views.

2.2. Digital avatars

The research used two basic types of digital avatars available in the Browzwear V-Stitcher software: Solid Olivia avatar and Soft Olivia avatar.

The Solid Olivia avatar is a parametric digital model of the human body that enables the adjustment of various anthropometric and morphological parameters. With this type of avatar, it is possible to change the size, body measurements, body posture, pose, and body shape through parametric controls [3].

On the other hand, the Soft Olivia avatar is a deformable avatar whose surface simulates the elastic properties of the human body. Unlike the parametric avatar, with this type of avatar it is not possible to change the basic anthropometric measurements, but a predefined body model is used. However, its surface reacts to contact with clothing during the simulation, allowing body deformation under the influence of material pressure, thus achieving a more realistic interaction between clothing and body. Three levels of softness of these avatars, Soft, Medium and Firm, were used in the work [3].

In order to analyze the influence of the interaction between the material and the surface of the avatar, the friction parameter was changed for both types of avatars. This parameter defines the degree of friction between the surface of the avatar and the textile material, that is, it determines to what extent the fabric slides on the surface of the body or "sticks" to it during the simulation. For both types of avatars, three different characteristics of the avatar surface were used: human, plastic and cloth. These variants represent different models of interaction between the material and the surface of the avatar, thus simulating different contact conditions between the body and the garment during the 3D simulation.

2.3. Material

A ribbed knitted material (rib 2×2) and interlock was used for the simulation. Both fabrics were 100% cotton.

The mechanical properties of the fabrics were defined within the Fabric Physics module of the Browzwear V-Stitcher software. This module enables the simulation of the mechanical behaviour of textile materials through parameters describing mass, thickness, bending, stretching and shearing of the material. The parameters used in the simulation are presented in Table 1.

Table 1: Mechanical parameters of ribbed knitted material (rib 2×2)

	Rib 2x2	Interlock	
Parametar	**Vrednost**	**Vrednost**	**Jedinica**
Mass	270	250.9	g/m²
Thickness	1.62	1	mm
Friction	0.2	0.2	–
Bend (W)	30.93	72.47	dyn·cm
Bend (L)	125.71	225.62	dyn·cm
Stretch (W)	10	35.24	N/m
Stretch (L)	212.49	331.6	N/m
Stretch Linearity (W)	5	39.23	%
Stretch Linearity (L)	18.08	0	%
Shear	13.94	45.65	N/m
Shear Linearity	29.46	50.94	%

2.4 Avatar parameters

Avatar dimensions are adjusted to standard female measurements that include neck, shoulder, chest, waist, and hip measurements, as well as arm and torso dimensions corresponding to a size M. Adjustments are made within avatar parameters within the simulation software. The anthropometric dimensions of the avatars are shown in Table 2.

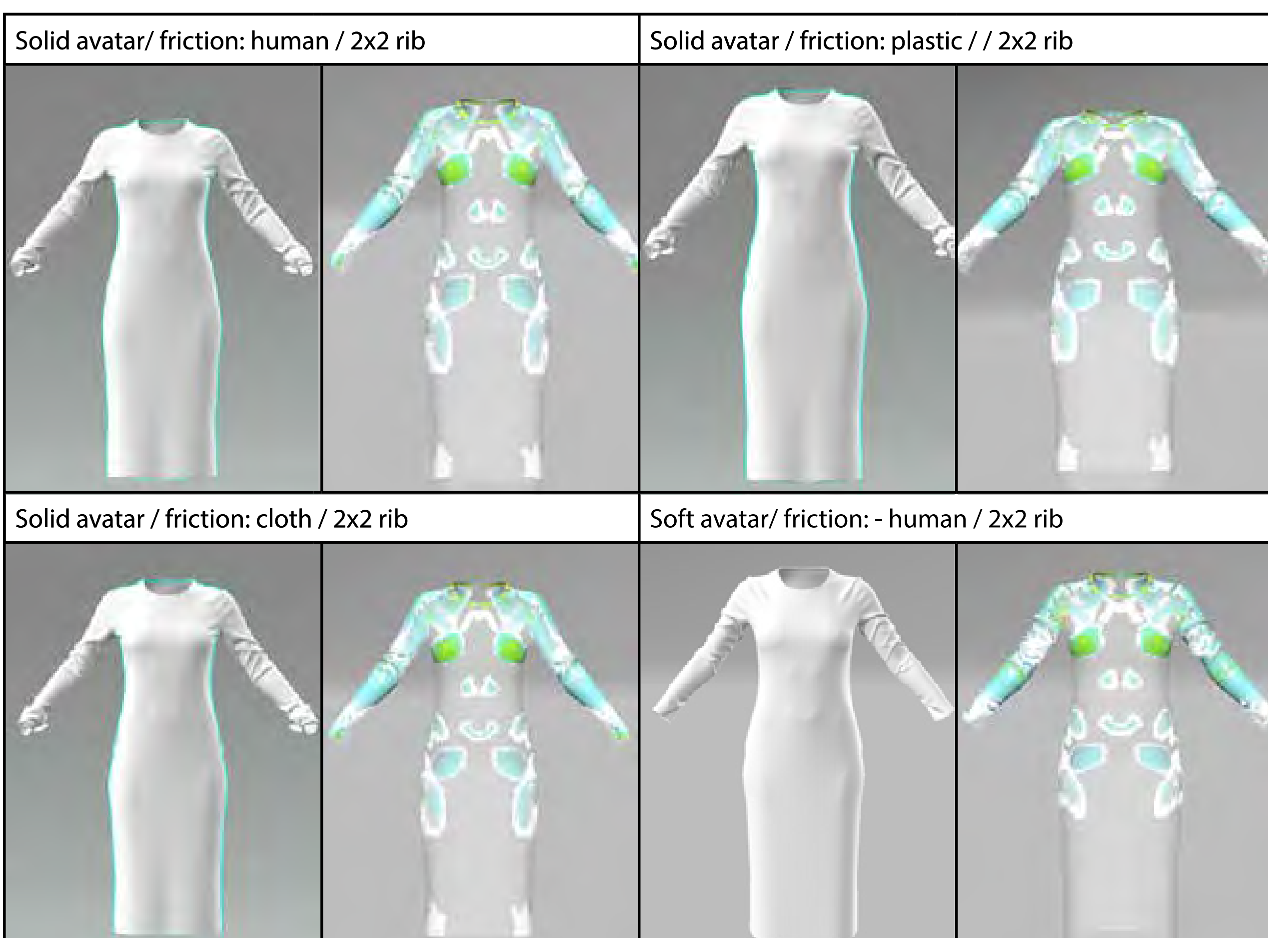
Table 2: The anthropometric dimensions of the avatars

Parameter	Value
Height	167 cm
Chest	89 cm
Waist	69 cm
Hip	95 cm

3. RESULTS AND DISCUSSION

The simulation results shown in Figure 2 and the results of the tension maps shown in Table 3 enable the analysis of material stress distribution for two types of knit fabric (rib 2×2 and interlock) and two types of digital avatar (solid and soft).

The analysis were carried out for three different characteristics of the avatar surface (human, plastic and cloth), where the stress values were observed in the characteristic zones of the body: chest, hips, waist and shoulders, as well as in the direction of length (L) and width (W).



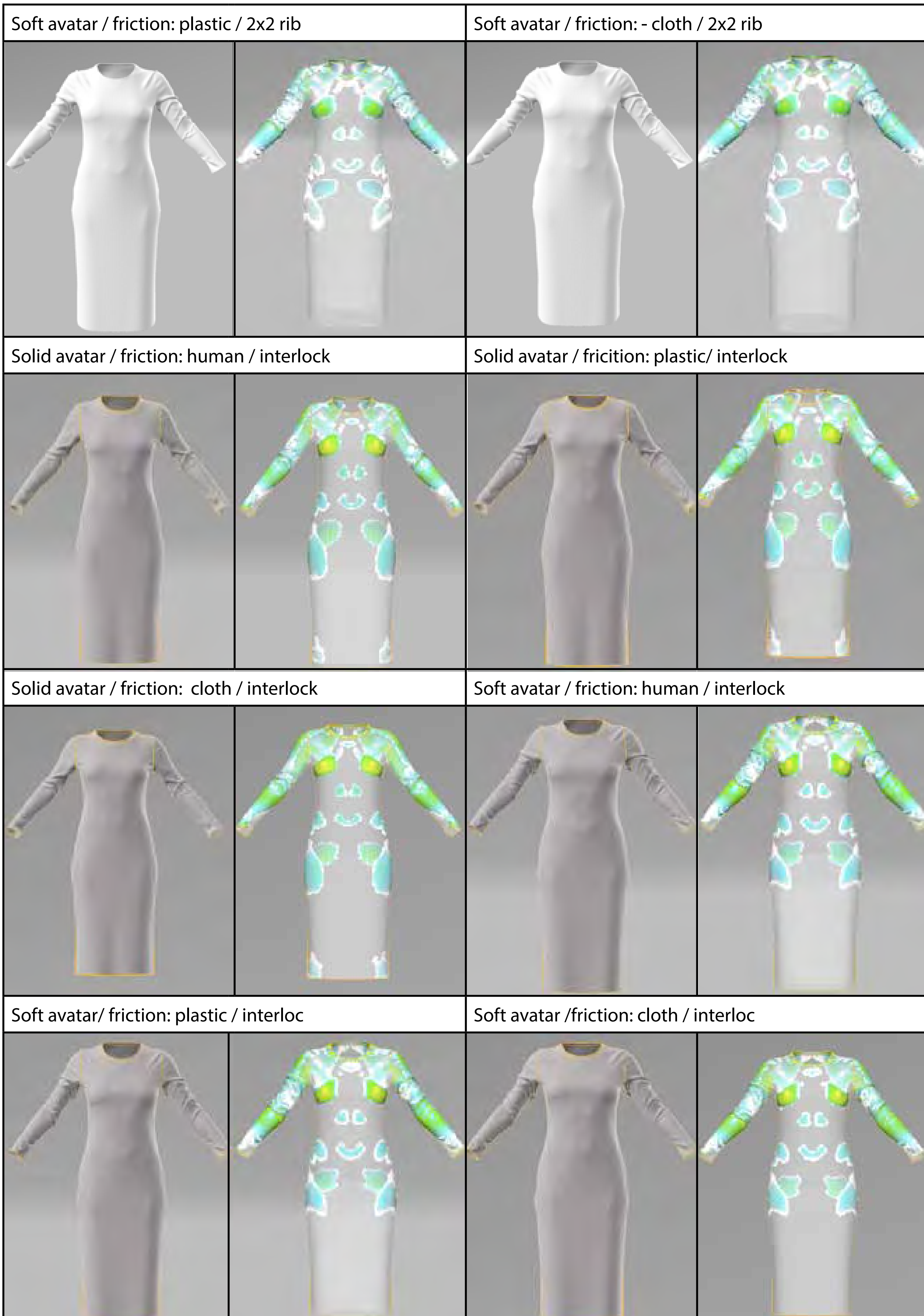


Figure 2: The simulation results

The results show that in rib knit, the highest stress values were recorded in the chest area. In the case of solid avatars, the elongation values in the length direction range between 3.6 and 3.7, while in the width direction they reach 19.8–21.4, which indicates a significant deformation of the material in this area. This result is expected considering that the chest area has the greatest contact between the body and the garment.

In the hip and waist area, stress values are significantly lower and relatively uniform. The elongation in the lengthwise direction is between 0.4 and 0.7, while in the widthwise direction it is between 2.5 and 4.3. In the shoulder area, stretching in the lengthwise direction was not recorded, while in the widthwise direction there were values between 10 and 11.6.

With the soft avatar, a slight decrease in stress in the chest area in the length direction (2.4–2.7) is observed, which indicates that the deformable surface of the avatar enables partial deformation of the body under the influence of the material and a more natural distribution of stress. In other zones, the differences between solid and soft avatars are minimal.

Table 3: Results of the tension maps

Solid avatar				
2x2 rib Human		Friction: (%)		
		Plastic	Cloth	
Chest	Length	3,6	3,7	3,6
	Width	20,1	21,4	19,8
Hip	Length	0,7	0,7	0,6
	Width	4,0	4,3	4,2
Waist	Length	0,4	0,5	0,4
	Width	3,4	3,4	2,5
Sholders	Length	0	0	0
	Width	11,6	10	10,7
Soft avatar (soft)				
2x2 rib Human		Friction: (%)		
		Plastic	Cloth	
Chest	Length	2,5	2,7	2,4
	Width	20,7	20,2	20,7
Hip	Length	0,7	0,6	0,7
	Width	3,3	3,3	3,2
Waist	Length	0,5	0,6	0,5
	Width	3,3	3,1	3,1
Solid avatar				
Interlock Human		Friction: (%)		
		Plastic	Cloth	
Chest	Length	3,1	4,0	3,9
	Width	17,4	20,5	20,7
Hip	Length	0,5	0,4	0,6
	Width	2,6	3,8	4,4
Waist	Length	0,3	0,5	0,2
	Width	2,7	2,9	2,5
Sholders	Length	0	1,3	0
	Width	10,4	13	12,1
Sholders	Length	3,1	4,0	3,9
	Width	17,4	20,5	20,7

Soft avatar (soft)				
Interlock Human		Friction: (%)		
		Plastic	Cloth	
Chest	Length	3,0	2,6	2,7
	Width	18,2	17,7	18,1
Hip	Length	0,6	0,5	0,6
	Width	2,0	2,6	2,1
Waist	Length	0,5	0,3	0,3
	Width	1,3	1,5	0,2
Sholders	Length	0	1,3	0
	Width	11,8	13	10,2

Visual analysis of tension maps confirms these results. The most intense stress zones appear in the area of the chest, waist and hips, while other parts of the garment are loaded much less. Changing the characteristics of the surface of the avatar (human, plastic and cloth) leads to only minor changes in the stress intensity but does not change the distribution of critical zones.

With interlock knit, a somewhat more stable behavior of the material is observed compared to rib knit. In the chest zone, the stress values in the lengthwise direction are 3.1–4.0 for solid avatars, while in the widthwise direction they reach 17.4–20.7. These values are slightly lower compared to rib knit, which indicates greater dimensional stability of the interlock structure.

In the hip and waist area, the stress values are lower than in rib knit. Stretch in the width direction ranges between 2.5 and 4.4, while in the length direction it remains in the range 0.2–0.6. As with rib knit, in the shoulder area the stretch in the lengthwise direction is negligible.

With the soft avatar, stresses are further reduced in most zones, which confirms that the deformable surface of the avatar enables a more even distribution of contact between the material and the body.

Tension maps show that the highest stress zones in interlock knit are concentrated in the same parts of the body (chest, waist, hips and sleeves), but the transitions between stress zones are milder than in rib knit, which corresponds to the greater stability of this type of knitted structure.

A comparative analysis shows that the rib knit shows a more pronounced deformation in the width direction compared to the interlock knit. This is due to the specific structure of the rib knit, which allows for greater elasticity and adaptation to the contours of the body.

Interlock knitwear, on the other hand, shows more stable behavior and a slightly lower tendency to form pronounced local deformations. This is why the material drop in the interlock knit is somewhat more uniform in the simulation.

The results also show that the change in friction of the avatar surface has a relatively small effect on the material stress distribution, while the avatar type (solid or soft) has a slightly more pronounced effect on the local stress distribution and the visual drop of the material.

Overall, the results indicate that the mechanical properties of the material have a dominant influence on the behavior of the garment during the simulation, while the avatar characteristics and surface interactions have a secondary influence in knitted materials.

A visual analysis of the simulation from a top view perspective (Figure 3) allows an assessment of how the garment is distributed around the digital avatar's body. The results show that with rib knit on the solid avatar, the garment keeps a relatively stable shape, while with the soft avatar, a slightly softer fall of the material and a slight increase in volume around the body is observed.

With interlock knit, a more stable behavior of the material and a more uniform fall can be observed compared to rib knit. The differences between solid and soft avatars are mostly reflected in the way the volume is formed and the naturalness of the draping, while the soft avatar allows for a slightly more natural fall of the material.

The obtained results confirm that the deformability of the avatar can affect the visual appearance of the draping of the knitwear model.

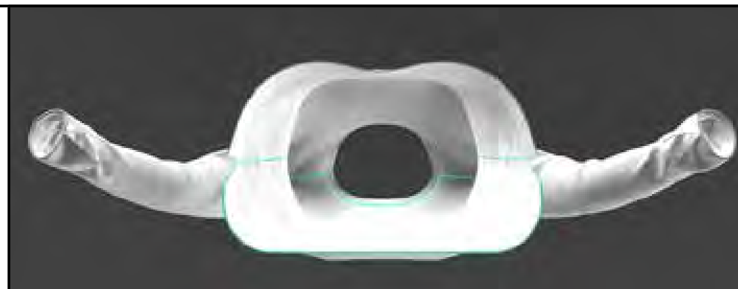
Solid avatar, friction: human	
Soft Avatar - human	
Solid avatar – human (interlock)	
Soft avatar – human (interlock)	

Figure 3: Visual analysis of the simulation from a top view perspective

4. CONCLUSION

The results of the conducted research showed that the characteristics of the digital avatar can influence the behavior of the garment during the 3D simulation, but to a different extent depending on the observed parameter. The analysis of tension maps showed that the highest stress values were recorded in the chest area, while the values were significantly lower in the waist and hip areas. It was also confirmed that the deformation of knitted structures is significantly more pronounced in the width direction than in the length direction, which corresponds to the typical mechanical behavior of rib and interlock knits.

A comparison of rib knit and interlock knit shows that rib knit achieves greater deformation and more pronounced adaptation to the contours of the body, while interlock knit shows more stable behavior and a more uniform fall of the material. A comparison of solid and soft avatars indicates that the deformable surface of the soft avatar allows for somewhat more natural fitting and a more even distribution of contact between clothing and body. On the other hand, changing the characteristics of the surface of the avatar (human, plastic and cloth), i.e. the friction between the material and the avatar, has a relatively small effect on the stress distribution and global fitting the garment.

The obtained results indicate that the mechanical properties of the material have a dominant influence on the behavior of the garment in the simulation, while the characteristics of the digital avatar have a secondary influence. Understanding the influence of avatar and material parameters on simulation results contributes to a better understanding of the reliability of 3D simulations in apparel product development. In this way, it contributes to increasing confidence in the application of digital tools and digital prototypes in the modern process of clothing design and development.

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