

ASSESSING GARMENTS FIT TO WOMAN'S BODY

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Abstract

Fit of a garment on a body model is an important factor for designing comfortable, functional and well fitted garments. The aim of the research was to research and estimate the fit of women's garments to the body. Within this study, we designed and developed a number of styles of skirts and jackets. The conventional and virtual prototype development process was carried out first. Next, we defined the method for assessing the fit of real and virtual women's garments to various body models. Finally, the assessment of how virtual and real garments fit to different body models was performed and a comparison between the conventional and virtual fit to the body was performed.

Introduction

Virtual prototyping is a technique in the process of garment development that involves application of computer aided design intended for garments development and virtual prototyping of them. It aimed to integrate all specific characteristics of the garment into the virtual prototype that fit the virtual human body model. Another characteristic of the virtual prototyping relates to its use in validation.

Results of many recent studies show that virtual garment prototyping is a promising technique, which will due to its potential considerably replace conventional methods of clothing prototypes' development. It is well-know that for virtual prototyping the virtual body model could be the parametric mannequin, measures of which could be adjusted according to measuring the real human body or body measures obtained on the basis of the human body scanning [3]. Additional research in this area obviously focuses on the development of efficient mechanical simulation models, which can accurately reproduce specific mechanical properties of textiles. The other aspect of this research focuses on modelling virtual humans to assure representation of the exact human body figure needed for virtual prototyping. Garment fit is regarded as the most important element to customers in clothing appearance. There are many definitions of the garment fit. One of them is "Clothing that fits well conforms to the human body and has adequate ease of movement, has no wrinkles and has been cut and manipulated in such a way that it appears to be part of the wearer" [1]. The fit of a garment depends on the selected construction system for pattern design [2, 3, 4]. Evaluation of the garment fit is usually performed using the fit evaluation scale. Since the virtual cloth simulation received much attention in the past decade, research in this area mainly focuses on comparison of the garment fit to the real, scanned and parametric mannequin of the used 3D CAD system, respectively [1, 3, 4, 5].


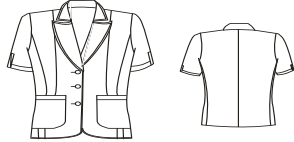

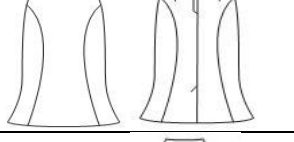


This study deals with the evaluation of women's garments fit to different body models. For this purpose a comparison between the conventional and virtual fit to the body was performed.

1 Materials and methods

The study focuses on the research of women's garments fit to the body. Real body model, parametric and scanned 3D body models were used for comparison of the real and virtual garments on the basis of the criteria for assessing the fit of clothing to different body models.

The styles of women's jackets and skirts as well as basic properties of fabrics are represented in Tab. 1. All fabrics are suitable for upper garments. In addition, front parts of the jackets, collars and lapels were fused. Fusing was performed for all models using the same type of fusible interlinings. Fusible interlining had the following characteristics: basic textile material of 100 % polyester, thermoplastic adhesive of 100 % polyamide, thermoplastic adhesive quantity of 23 meshes and surface mass of fusible interlining of 35 gm².

Tab. 1: Styles of the women's jackets and basic properties of the fabrics.

Name and drawings of the jacket styles		Fabric code	Fabric composition [%]	Yarn density		Surface mass [g/m ²]
				Warp [yarns/cm]	Weft [yarns/cm]	
N I K A		TK-1Z	85% linen 15% polyamide	42	23.5	109
		TK-1Č	85% linen 15% polyamide	42	23.5	113
L I D A		TK-2M	98% cotton 2% elastane	85	34.0	200
		TK-2Č	98% cotton 2% elastane	84	33.5	164
M I A		TK-4B	97% cotton 3% elastane	63	29.0	184
		TK-4M	97% cotton 3% elastane	58	28.5	182
N I K A		TK-1Č	85% linen 15% polyamide	42	23.5	113
		TK-2Č	98% cotton 2% elastane	84	33.5	164
S A N D Y		TK-1Z	85% linen 15% polyamide	42	23.5	109
		TK-3Z	100% linen	19.5	17.5	158
V E R E N A		TK-4B	97% cotton 3% elastane	63	29	184
		TK-3M	100% linen	20	18	170

Source: Own

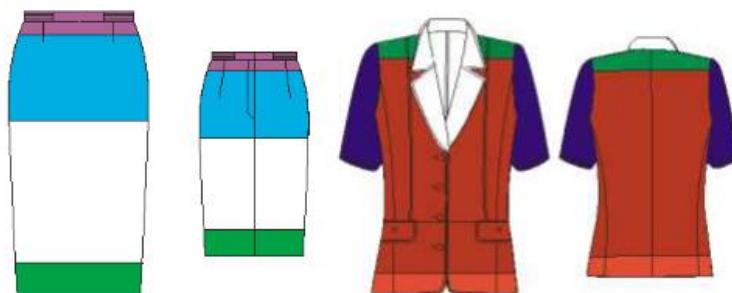
The research was conducted in two stages:

1. Selection of the women's jackets and skirts styles, and fabrics and fusible interlinings for their production. The process of computer pattern design was carried out using the OptiTex CAD system.

2. Evaluation of the jacket prototypes fit to the real, parametric and scanned body models depending on the mechanical properties of the used fabrics for this study

The evaluation procedure women garment fit is suitable for both real and virtual models and includes the following steps [5]:

- Selection of the jacket style.
- Selection of the evaluation area on the jacket (Fig. 1).
- Assessment of a jacket and skirt fit to the body model using the following criteria grades: 1 (good), 0 (satisfactory) and -1 (inappropriate), Tab. 2 and 3.



Source: [6]

Fig. 1: Three evaluation areas (coloured) of skirt and five evaluation areas of jacket (front and back views)

Tab. 2: The evaluation areas and criteria for the jacket

Area	Evaluation area	Area definition	Criteria description	Grade
F R O N T	Bust and hips	15 cm above the bust line and up to 5 cm above the jacket edge.	Jacket fit to the body shape: - Jacket fits the body shape - Slight wrinkling of fabrics due to the body shape - Strong longitudinal or transverse wrinkles	1 0 -1
	Shoulder	Shoulder area and 10 cm below the shoulder on the front part.	Jacket fit to the shoulders: - Just enough long shoulder - Slight wrinkling in the shoulder area - Too long shoulders; strong wrinkling in the shoulder area	1 0 -1
	Sleeve	The whole sleeve.	Sleeve fit to the body: - Great appearance of the sleeve - Slight wrinkling of the sleeve - Shift of the sleeve and wrinkling	1 0 -1
	Collar and lapels	The whole collar and lapels.	Collar and lapels fit to the body: - Smoothly lies on the front part - Slightly deviates from jacket - Turning up, tightening and wrinkling	1 0 -1
	Bottom edge	The whole bottom edge of jacket (5 cm).	Bottom edge fit to the body: - Clean straight line of the bottom edge - Slightly restless bottom edge - Bottom edge weaves	1 0 -1

Area	Evaluation area	Area definition	Criteria description	Grade
B A C K	Back and hips	5 cm below the shoulders and up to 5 cm above the bottom edge.	Jacket fit to the body shape: - Jacket fits the body shape - Slight wrinkling of fabrics due to the body shape - Strong longitudinal or transverse	1 0 -1
	Shoulder	Shoulders and 5 cm below the shoulder.	Jacket fit to the shoulders: - Just enough long shoulder - Slight wrinkling in the shoulder area - Too long shoulders; strong wrinkling in the shoulder area	1 0 -1
	Sleeve	The whole sleeve.	Sleeve fit to the body: - Great appearance of the sleeve - Slight wrinkling of the sleeve - Shift of the sleeve and wrinkling	1 0 -1
	Collar	The whole collar.	Collar fit to the body: - Smoothly lies on the back part - Slightly deviates from jacket - Turning up, tightening and wrinkling	1 0 -1
	Bottom edge	The whole bottom edge of jacket (5 cm).	Bottom edge fit to the body: - Clean straight line of the bottom edge - Slightly restless bottom edge - Bottom edge weaves	1 0 -1
S I D E	Sleeve	The whole sleeve.	Sleeve fit to the body: - Great appearance of the sleeve - Slight wrinkling of the sleeve - Shift of the sleeve and wrinkling	1 0 -1
	Collar	The whole collar.	Collar fit to the body: - Smoothly lies on the back part - Slightly deviates from jacket - Turning up, tightening and wrinkling	1 0 -1
	Hips	Area from waist to the bottom edge	Jacket fit to the body shape: - Jacket fits the body shape and side seam is in the middle - Slight wrinkling in hips area - Strong wrinkling in hips area, side seam is not in the middle	1 0 -1
	Bottom edge	The whole bottom edge of jacket (5 cm).	Bottom edge fit to the body: - Clean straight line of the bottom edge on front and back part - Slightly restless bottom edge - Different length of jacket on the front and back part	1 0 -1

Source: [6]

Tab. 3: *The evaluation areas and criteria for the skirt*

Area	Evaluation area	Area definition	Criteria description	Grade
F R O N T	Waist	Waist area and 5 cm below the waist	Form of skirt waist on the body: - The level of the waist on the line of the body - Slightly lowered belt is not in the line of the body waist - Belt deviates significantly from the waist line on the body	1 0 -1
	Hips and abdomen	Area 5 cm below the waist and 3 cm below the hips line.	Longitudinal or transverse folds in fabrics: - No folds; garment fits the body line - Garment slightly deviates from the line of the body - Many transverse or longitudinal folds	1 0 -1
	Length	Whole length and 7 cm above the line of skirt edge	Draping of fabrics and line of skirt length: - Smooth wrinkles, straight line of skirt length - Less pronounced wrinkling, adjusted length - Uneven wrinkling, restless line of skirt length	1 0 -1
B A C K	Waist	Waist area and 5 cm below the waist	Form of skirt waist on the body: - The level of the waist on the line of the body - Slightly lowered belt is not in the line of the body waist - Belt deviates significantly from the waist line on the body	1 0 -1
	Hips and abdomen	Area 5 cm below the waist and 3 cm below the hips line.	Longitudinal or transverse folds in fabrics: - No folds garment fits the body line - Garment slightly deviates from the line of the body - Many transverse or longitudinal folds	1 0 -1
	Length	Whole length and 7 cm above the line of skirt edge	Draping of fabrics and line of length skirt: - Smooth wrinkles, straight line of length skirt - Less pronounced wrinkling, adjusted length - Uneven wrinkling, restless line of skirt length	1 0 -1
S I D E	Waist	Waist area and 5 cm below the waist	Form of skirt waist on the body: - The level of the waist on the line of the body - Slightly lowered belt is not in the line of the body waist - Belt deviates significantly from the waist line on the body	1 0 -1
	Hips and abdomen	Area 5 cm below the waist and 3 cm below the hips line.	Longitudinal or transverse folds in fabrics: - No folds garment fits the body line - Garment slightly deviates from the line of the body - Many transverse or longitudinal folds	1 0 -1
	Length	Whole length and 7 cm above the line of skirt edge	Draping of fabrics and line of length skirt: - Smooth wrinkles, straight line of length skirt - Less pronounced wrinkling, adjusted length - Uneven wrinkling, restless line of skirt length	1 0 -1

Source: [6]





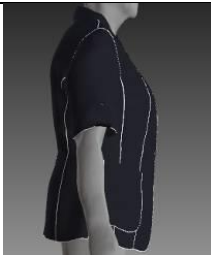




2 Results discussion

The main purpose of this study was to define and evaluate different women's garment styles fit to the real and virtual body models. The research results of clothing fit on the real body and on the virtual body models (3D scanned and parametric models), are given in the form of:

- Graphical representation of jackets' fit to all body models from front and back views, as well as side view and
- Assessment of the jackets' and skirts' fit to the real and virtual body models.










The real and virtual prototypes of the jacket Lida made up of a fabric coded TK-2M and skirt made up of fabric coded TK-1Z are presented in Tab. 4 and 5. Furthermore, the estimation of fit for all analyzed women's styles on real, parametric and scanned body is presented in Tab. 6 – 8.

Tab. 4: Fit results for the jacket's style Lida made up of fabric coded TK-2M

Real prototype of the jacket on the real body model	Virtual prototype on the scanned 3D body model	Virtual prototype on the parametric 3D body model	View
			FRONT
			SIDE
			BACK

Source: Own

Tab. 5: Fit results for the jacket's style Sandy made up of fabric coded TK-1Z

Real prototype of the jacket on the real body model	Virtual prototype on the scanned 3D body model	Virtual prototype on the parametric 3D body model	View
			FRONT
			SIDE
			BACK

Source: Own

Tab. 6: Assessment of fit for individual areas of jacket prototypes on the real body model

Evaluation area		Jacket NIKA-1Z			Jacket NIKA-1Č			Jacket LIDA-2M			Jacket LIDA-2Č			Jacket MIA-4B			Jacket MIA-4M		
		Grade			Grade			Grade			Grade			Grade			Grade		
		-1	0	1	-1	0	1	-1	0	1	-1	0	1	-1	0	1	-1	0	1
FRONT	Bust area	3	9	4	2	10	4	0	9	7	3	11	2	8	8	0	6	10	0
	Shoulder	5	7	4	0	12	4	0	7	9	0	6	10	2	11	3	5	9	2
	Sleeve	3	11	2	0	10	6	0	4	12	2	9	5	3	10	3	8	8	0
	Collar and lapel	1	2	13	0	4	12	0	2	14	0	3	13	2	7	7	4	6	6
	Bottom edge	5	7	4	8	6	2	0	8	8	2	10	4	0	9	7	4	10	2
BACK	Back area	5	10	1	5	7	4	5	10	1	6	8	2	7	8	1	6	8	2
	Shoulder	4	4	8	2	9	5	3	8	5	1	9	6	3	10	3	2	8	6
	Sleeve	4	10	2	6	8	2	5	9	2	3	9	4	7	8	1	7	8	1
	Collar	1	5	10	0	6	10	1	6	9	0	3	13	1	3	12	3	3	10
	Bottom edge	1	8	7	2	8	6	2	5	9	1	7	8	1	8	7	0	4	12
SIDE	Sleeve and shoulder	7	8	1	5	5	6	1	10	5	2	7	7	3	9	4	6	8	2
	Collar	2	4	10	1	4	11	1	1	14	1	6	9	2	8	6	0	8	8
	Hips	2	5	9	2	4	10	2	10	4	1	10	5	2	9	5	0	12	4
	Bottom edge	5	8	3	5	7	4	3	7	6	2	8	6	0	5	11	0	7	9

Source: Own

Tab. 7: Assessment of fit for individual areas of jacket prototypes on the scanned body

Evaluation area		Jacket NIKA-1Z			Jacket NIKA-1Č			Jacket LIDA-2M			Jacket LIDA-2Č			Jacket MIA-4B			Jacket MIA-4M		
		Grade			Grade			Grade			Grade			Grade			Grade		
		-1	0	1	-1	0	1	-1	0	1	-1	0	1	-1	0	1	-1	0	1
FRONT	Bust area	0	4	12	0	7	9	1	9	6	2	6	8	0	7	9	1	4	11
	Shoulder	1	8	7	1	4	11	1	4	11	3	3	10	1	3	12	2	3	11
	Sleeve	3	5	8	1	10	5	1	8	7	4	5	7	2	4	10	2	4	10
	Collar and lapel	1	2	13	2	2	12	1	2	13	0	2	14	1	5	10	1	4	11
	Bottom edge	3	9	4	3	2	11	5	8	3	6	10	0	0	7	9	0	5	11
BACK	Back area	9	6	1	3	12	1	6	8	2	4	10	2	3	10	3	3	10	3
	Shoulder	3	6	7	1	8	7	2	8	6	2	5	9	2	8	6	3	7	6
	Sleeve	6	9	1	3	8	5	5	7	4	4	7	5	2	10	4	1	8	7
	Collar	0	5	11	0	2	14	0	4	12	1	2	13	9	2	5	5	8	3
	Bottom edge	1	11	4	7	6	3	2	11	3	3	9	4	1	7	8	0	6	10
SIDE	Sleeve and shoulder	5	8	3	5	7	4	5	8	3	2	8	6	2	7	7	0	9	7
	Collar	3	4	9	0	7	9	3	2	11	1	5	10	7	5	4	6	5	5
	Hips	0	7	9	1	5	10	3	9	4	4	9	3	1	7	8	0	10	6
	Bottom edge	9	6	1	8	6	2	10	5	1	11	4	1	5	6	5	4	8	4

Source: Own

Tab. 8: Assessment of fit for individual areas of jacket prototypes to the parametric body

Evaluation area		Jacket NIKA-1Z			Jacket NIKA-1Č			Jacket LIDA-2M			Jacket LIDA-2Č			Jacket MIA-4B			Jacket MIA-4M		
		Grade			Grade			Grade			Grade			Grade			Grade		
		-1	0	1	-1	0	1	-1	0	1	-1	0	1	-1	0	1	-1	0	1
FRONT	Bust area	1	8	7	1	6	9	0	2	14	0	2	14	0	2	14	0	2	14
	Shoulder	1	6	9	1	1	14	1	2	13	0	4	12	0	1	15	1	1	14
	Sleeve	1	1	14	2	3	11	3	4	9	3	6	7	0	2	14	1	3	12
	Collar and lapel	6	2	8	7	4	5	0	2	14	0	1	15	1	2	13	0	2	14
	Bottom edge	3	8	5	4	7	5	4	7	5	2	9	5	0	2	14	0	3	13
BACK	Back area	0	7	9	0	5	11	0	5	11	1	5	10	1	8	7	0	9	7
	Shoulder	1	1	14	1	1	14	1	1	14	1	0	15	1	3	12	1	0	15
	Sleeve	1	6	9	1	6	9	3	2	11	3	3	10	1	5	10	0	4	12
	Collar	1	0	15	1	1	14	0	0	16	0	1	15	2	5	9	0	0	16
	Bottom edge	0	1	15	0	4	12	0	4	12	0	3	13	3	10	3	0	4	12
SIDE	Sleeve and shoulder	0	0	16	1	6	9	1	4	11	0	2	14	0	3	13	1	3	12
	Collar	6	3	7	6	3	7	0	6	10	0	2	14	1	2	13	2	4	10
	Hips	1	7	8	1	10	5	0	7	9	0	8	8	1	9	6	0	10	6
	Bottom edge	2	10	4	3	9	4	2	4	10	4	6	6	6	9	1	6	4	6

Source: Own

For assessing the women's jackets and skirts have used parametric and scanned digital body models, as well as a real female body. The parametric model was selected from the base of different virtual parametric models of the human body, offered by the program OptiTex. [7]. Parametric models have defined the basic and the supplementary body measurements according to the of the real body measurement for body size 42.

Virtual body scan was obtained with a 3D scanner Vitus Smart 3D at the Faculty of Textile Technology, University of Zagreb, Croatia. The scanned human body was suitable for further analysis after the reconstruction phase performed with the following computer programs: MeshLab, Blender and Atos. The final 3D body model was imported into the OptiTex PDS program for the simulation of virtual garments.

For virtual simulation of women garments the fabrics were defined with the following characteristics using the FAST measuring system in order to obtain the realistic virtual jacket prototypes measurements: tensile, bending, shear, surface thickness and fabric weight.

16 experts from the field of textile and clothing engineering were assessing and analyzing the fit of garments.

Real prototypes of jackets got grades for all assessment criteria: good, satisfactory and inadequate fit, Tab. 4. In most cases the respondents assessed the collar and lapels of all jackets with grade 'good'. The most frequent grade 'satisfactory fit' was given to jackets' fit to the body figure on the front and back side as well as for sleeves. Grade 'inadequate fit' was given to prototypes Mia-4B and Mia- 4M for the bust area on the front part and on the back part and for the sleeve because of high stiffness and wrinkling of fabrics. The differences of grades are resulting from the fact that real prototypes are not made for particular women but the real prototypes were made for jacket size number 42.

The results of the assessment of the fit of the jacket prototypes to the scanned 3D body model have shown very similar estimation for all analyzed jackets, Tab 5. Namely, the same fabric in two colours was used for one style. Therefore, it can be concluded that differences in the jackets' fit to the scanned body model depend on the construction of the jacket and characteristics of the body model.

The fit of all 3D jacket prototypes to the parametric body model was evaluated with grade 'good fit', Tab. 6. In most cases the respondents assessed the bottom edge in the front view with grade 'satisfactory fit'. The bottom edge of the jacket styles Nika and Lida was slightly more turbulent due to the sewn pockets. In general, it was found that the respondents evaluated with grade 'good fit' all jacket styles on the parametric body model. The reason for this is the fact that a parametric body model is symmetrical and perfect. Therefore, the fit of jackets and apparel appearance were good. However, the simulation is not completely comparable with a real body model.

Conclusion

The estimation of garment fit to the body is very difficult because we cannot eliminate the subjective attitude of individual evaluators. Virtual prototyping has got a good potential; this confirms the needs of garment producers who want to have their products very soon on the market. In addition, the production processes usually take place in different parts of the world today. For these reasons suitable assessment protocols for garment fit have to be developed in the future for an appropriate dialogue between producers and costumers.

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HODNOCENÍ DOBRĚ PADNOUCÍCH ODĚVŮ NA ŽENSKÉ TĚLO

Jak dobře padne oděv na modelu těla je důležitým faktorem pro vytváření pohodlných, funkčních a dobře padnoucích oděvů. Cílem výzkumu bylo prozkoumat a odhadnout, jak dobře padnou dámské oděvy na tělo. V rámci této studie jsme navrhli a vyvinuli celou řadu stylů sukní a sak. Nejprve byl proveden konvenční a virtuální proces vývoje prototypů. Následně jsme definovali metodu pro posuzování padnutí reálných a virtuálních ženských oděvů pro různé modely těla. Na závěr jsme vyhodnotili, jak virtuální a reálné oděvy padnou na různé modely těla a porovnali konvenční a virtuální padnutí na tělo.

BERECHNUNG DER ANPASSUNG VON KLEIDUNG AN FRAUENKÖRPER

Die Anpassung eines Kleidungsstücks an das Körpermodell ist ein wichtiger Faktor fürs Design bequemer, funktioneller und gut angemessener Kleidung. Das Ziel dieser Arbeit besteht in der Untersuchung und Einschätzung der Anpassung von Frauenkleidung an den Körper. Innerhalb dieser Studie haben wir eine Anzahl von Stilen von Hemden und Jacken entworfen und entwickelt. Zuerst wurde ein konventioneller und virtueller Prototypentwicklungsprozess durchgeführt. Als Nächstes haben wir eine Methode für die Berechnung der Anpassung realer und virtueller Frauenkleidung an verschiedene Körpermodelle definiert. Am Schluss wurde eine Berechnung durchgeführt, wie virtuelle und reale Kleidung zu verschiedenen Körpermodellen passen, sowie ein Vergleich zwischen der konventionellen und virtuellen Anpassung an den Körper.

OCENA ODZIEŻY DOBRZE DOPASOWANEJ DO KOBIECEGO CIAŁA

Dobre dopasowanie odzieży do ciała stanowi ważny czynnik w produkcji wygodnych, funkcjonalnych i dobrze leżących ubrań. Celem przeprowadzonych badań było stwierdzenie i ustalenie, na ile damskie ubrania dopasowane są do ciała. W ramach niniejszego opracowania zaproponowaliśmy i opracowaliśmy cały szereg fasonów spódnic i żakietów. W pierwszej kolejności był to konwencjonalny i wirtualny proces opracowania prototypów. Następnie zdefiniowaliśmy metodę oceny dopasowania realnych i wirtualnych ubrań damskich do różnych modeli ciała. Na zakończenie oceniliśmy, na ile ubrania wirtualne i realne dopasowane są do różnych modeli ciała oraz porównaliśmy konwencjonalne i wirtualne dopasowanie do ciała.