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AN INVESTIGATION ON THE VIRTUAL PROTOTYPING VALIDITY – SIMULATION OF GARMENT DRAPE

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Abstract. *Achievement of desired garment form is essential in the development of clothing design, which depends on properties of its raw material - mainly fabric. Virtual prototyping can serve as a tool for assessing the form and fit of garments before real production and deciding whether to make changes in ease values, pattern cut or fabric parameters. The aim of the study is investigation of reliability of virtual prototyping results using Modaris 3D (Lectra) due to influences of changeable fabric parameters on garment drape effects, as well as verifiability with three-dimensional (3D) scanning (Vitus Smart XXL®) of real products. For the research half-circle cut skirt designed in appropriate size for standard figure dummy. Skirt virtually simulated on mannequin which previously scanned and imported into the system. Properties of three different types of fabrics examined in a material testing laboratory according to requirements of relevant standards. Skirt virtually tried-on defining fabric properties by gained testing results and afterwards made from real fabrics, put on the dummy and scanned. Drape effects of the various virtual prototypes and real product scans compared, both in the CAD system and the scanning system (Anthroscan) using cross-sections and their measurements (depths and diameters of folds, circumferences). Fabric parameters has an influence on the reliability of virtual prototyping results in terms of accuracy of parameters determined and put into the system. Cross-sections with measurements reveal differences between virtually sewn and real skirt drape configurations.*
Keywords: *drape, fabric properties, three-dimensional (3D) scanning, transversal cross sections, virtual try-on.*

Introduction

Computer aided design software not only provide the possibilities to speed up the process of putting new model into production and improve the quality of products, but also to reduce the costs of development, material costs and labour intensity (Lányi, 2012). 3D technologies can also improve the communication between designers, patternmakers, sewing technologists, sales management and retailors. If 3D prototyping succeeds, it can help avoid producing several number of samples, thus reducing both the consumption of materials and the

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time taken to improve models and sew them. The development of the sample, also called prototype, model or "guide-sample", which evidently describes the object of order and which materialization can be used for tangible notion how the products in serial production should look like (TTV, 1989), is a critical stage in the success of the product throughout the production chain.

Currently number of clothing CAD software packages are providing 3D prototyping or simulation modules, such as Modaris 3D (Lectra), Runway 3D (Optitex), Vidya (Human Solutions), V-stitcher (Browzwear), AccuMark 3D (Gerber Technology), Assol 3D parametric (Assol), clo3D, Marvelousdesigner etc. (Lányi, 2012; Fairhurst, 2008; D'Apuzzo, 2008) The prototyping can be performed on built-in standard figure mannequins, on personalized virtual parametric 3D dummies, and many of these systems have developed software enabling visualisation of garments on 3D avatars (Nayak & Padhye, 2015).

34 years after the inception of 3D technology for use in the fashion retail environment, the adoption of this technology has been largely in areas such as virtual try-on for online garment sales, including that of cloth definition and characterisation; making garment size selection faster and simpler; and towards the development of realistic anthropometric mannequins for quality control and garment production, even extended to personalised mannequins (Nayak & Padhye, 2015). By the use of 3D scanning human body or other objects surface point clouds or data sets with coordinates of surface points are obtainable for processing and export in required format for further input in virtual systems and use in prototyping process. Import of actual 3 body scan image data has become possible so that fit of a specific design can be virtually assessed on the actual fit body. 3D scanning has advantages of speed, accuracy and consistency of measurement data (Fairhurst, 2008).

Already at the beginning of the garment design process designers should consider all requirements for achieving the desired results and factors that can affect it. One of the targets is to achieve the desired silhouette of the garment. Various sources say - silhouette is - a graphic depiction (or characterization in words) of the shadow's contour from the clothing form (TTV, 1989); characteristic set of clothing (parts) cut lines; the outline, apparent planar shape or contour set visible on the background (LLVV, 1972–1996). The chosen construction method, applied ease and decorative allowances and different modelling solutions are the key factors to achieve the desired silhouettes. Not less essential factor is the selection of appropriate fabric which varies by the fiber composition, geometric characteristics and mechanical properties. But characteristics like thickness, weight, elasticity and drapeability of fabric can be decisive when "falling" voluminous garments are designed. Drapeability is defined as textile or garment ability to make folds (to drape) under influence of own weight (TTV, 1989).

Along with possibilities to change visual characteristics of fabric (colour, pattern and texture) 3D virtual prototyping systems provide the input of fabric material properties (geometric characteristics, mechanical properties) for predicting the draping effects of different fabrics (Lányi, 2012; Nayak & Padhye, 2017)

The issue is about reliability of these 3D prototyping technologies and the tools which can be used to check the validity of the gained results.

Review of studies. In other studies, different approaches used for identification of virtual prototyping reliability and validity, for example measurements and analysis of drape distances; analysis of correlation between drape coefficient of materials and the exterior shapes and visual images; comparison of actual and virtual hem lines etc. (Lee J., 2014)

For example, in a study, where simulations made on customised default 3D model and 20 real samples produced, is claimed that photographs for the front, side and back views are taken instead of use of 3D scanning because of noises and missing parts of scan. It could be related to the research year, because currently such problems can be avoided. Afterwards measurements extracted from images of the real samples and 3D simulations. The difference between 3D simulation and real samples shows that simulated results are often smaller than the real samples at the hip width Since images have different resolutions, the absolute pixel measurements are converted into ratio by formula. Should be mentioned, that the author is not mentioning the effects of lens distortion on the photograph proportions (Wu Y.Y., 2011).

The aim of the research is investigation of reliability of virtual prototyping results using Modaris 3D (Lectra) due to influences of changeable fabric parameters on garment drape effects, and verifiability with three-dimensional (3D) scanning (Vitus Smart XXL®) of real products.

The methodology of study process shown in Fig.1.

For the research purposes half-circle cut skirt designed and both real garments and virtual have been sewn using 3 different thickness 100 % cotton fabrics. Skirts virtually tried-on and real garments scanned after putting on the dummy for comparison and farther investigation of the virtual prototyping validity.

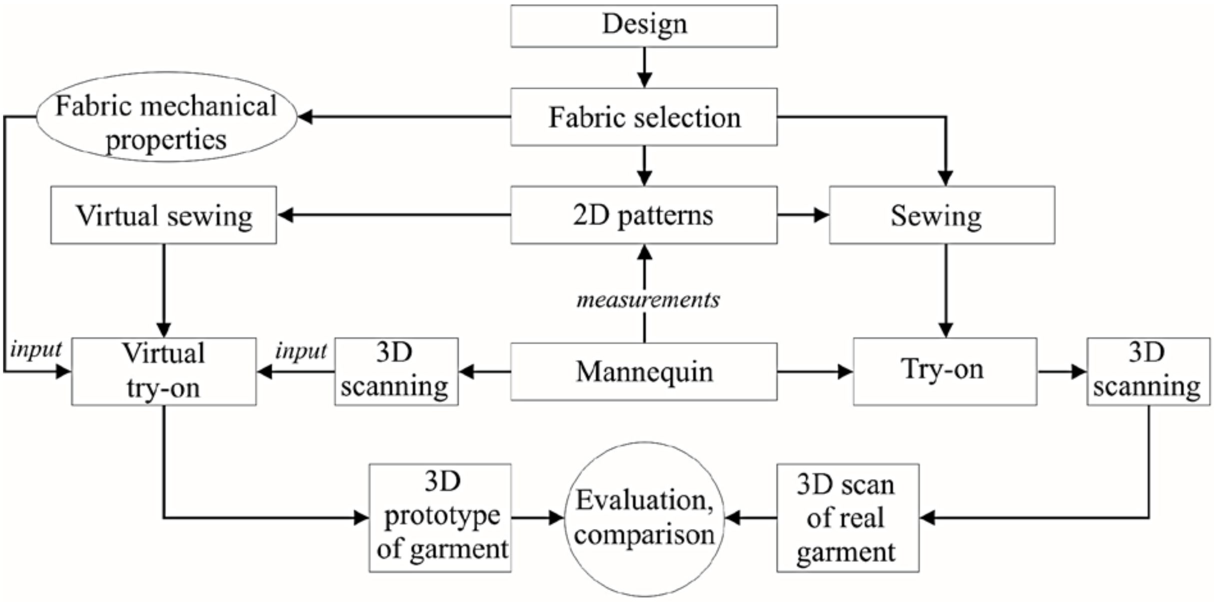


Figure 1. **Methodology of study**

Materials and Methods

Virtual prototyping system. In this research virtual prototyping performed by Modaris (system Lectra), including processes such as construction of patterns, work on set of cutting patterns, virtual sewing and virtual prototyping or try-on.

3D scanning. Scans of the mannequin and real made skirts were obtained using VITUS Smart XXL® (Human Solutions GmbH and VITRONIC GmbH) with Anthroscan software. One scanning lasts ~12 seconds, gaining the object reproductions with resolution 27 points/cm^2 and possibilities to get measurements with accuracy ± 1 mm.

Dummy for prototyping. Standard figure dummy was selected, scanned, measured and used for real skirt try-ons. The standard figure dummy is mannequin which size corresponds to certain standard figure (of human body), usually its torso dummy. It is used as reference measure tool for visual examination of garments anthropometric fit, in the process of model sample construction (prototype) or testing the fit of already produced clothing (TTV, 1989). It was selected for the reason of “fixed object” advantages, effects on soft tissues and posture changes as a result of breathing or just inability to repeat primary pose could cause changes in measurements and reproduction proportions if real human body was scanned dressed in 3 different skirts. In the case of the dummy proportions are fixed and in addition the base of the dummy’s stand is constantly placed in the same position on the scanning platform (see first picture in Figure 2). After the scanning and measurement obtaining the reproduction of dummy was processed with surface reconstruction tools to remove noises and prepare for export to compatible format for the try-on system (see steps in Fig.2).

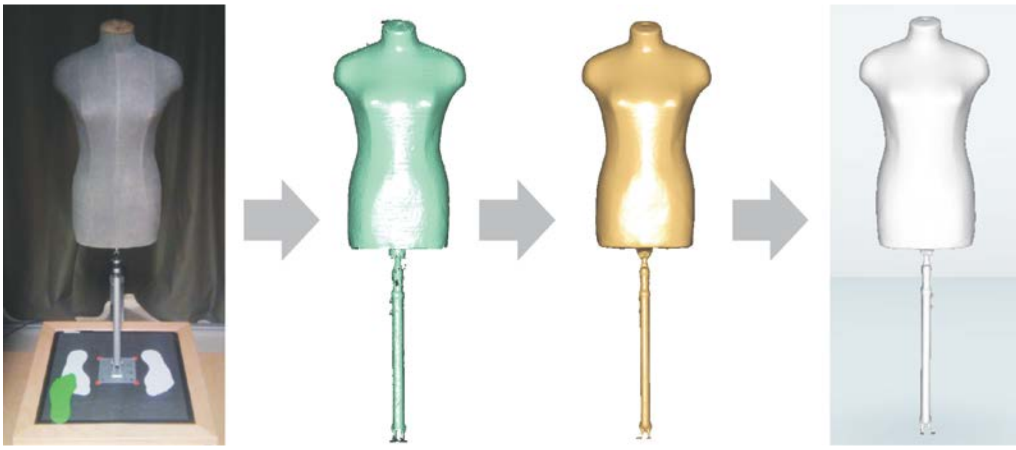


Figure 2. **Preparement of the dummy for try-on system**

Fabric parameters. Three different thickness 100 % cotton fabrics selected by the weight – light, medium and heavy. At this research according to parameters possible to indicate in the try-on system the material thickness and density was acquired. Samples kept under normal climatic conditions before the measurement process according to standard ISO 139:2005/A1:2011 „Textiles - Standard atmospheres for conditioning and testing - Amendment 1" (ISO 139:2005).

Thickness is set by compressing the fabric for 30±5 seconds between 2 plates with a pressure of 1kPa at least at 5 different areas of the fabric. It is described by average thickness in mm with a precision up to 0,001 mm. But the density is a mass of 1 m^2 of the fabric. For the laboratory samples it is ascertained according to standard LVS EN 12127:2001 "Textiles - Fabrics - Determination of mass per unit area using small samples" (LVS EN 12127:2001). Five 100cm^2 samples are cut out and weighed with precision up to 1 mg. The density is calculated by formula:

$$M_{m^2} = \frac{\mathrm{m \times 10000}}{\mathrm{A}}\ ,\ \mathrm{g/m^2},$$

where m – average mass of sample in grams; A – sample area, cm^2. Fabric parameters summarized in the Table 1.

Table 1 **Fabric parameters**

Characteristic		**Fabric** 1.	2.	3.
Selection criteria	Weight	light	medium	heavy
	Composition	100 % cotton (CO)		
	Category	Woven		
Laboratory testing according LVS EN 12127:2001	Thickness [mm]	0,240	0,371	0,842
	Density [g/m2]	67	183	319

Fabric properties which can be indicated in the virtual try-on system are composition by fiber type, geometric characteristics and mechanical properties. If it is relatively easy to determine composition and main geometric characteristics (density and thickness) than special systems and methods are needed to indicate detailed mechanic properties. In the system used in the study mechanic properties can be defined by testing results obtained by KES-F (Kawabata Evaluation System of fabric).

Since the beginning of scientific research into textiles, one aim has been to devise measurements that could be used to predict the behaviour of textile fabrics (Fairhurst, 2008). The Kawabata Evaluation System (KES-F) is used to make objective measurements of hand-touch properties. KES provides a capability, not only to predict human response, but also to provide an understanding of how the variables of fiber, yarn, fabric construction and finish contribute to the perception of softness. The KES instruments measure mechanical properties that correspond to the fundamental deformation of fabrics in hand manipulation. Five different tests can be performed using KES-F: Tensile and shearing, Bending, Compression, Surface friction and variation (Moiz, A. et.al.). Another similar fabric evaluation system that is considered more affordable and simple in use is FAST (Fast system (fabric assurance by simple testing)), which indicators can be used for some virtual try-on systems (Power E .J. et. al., 2011).

Both KES-F and FAST systems are not freely available – there is a need of a special laboratory with equipment or collaboration with laboratories to obtain cloth data, thereby their use, especially from a business perspective can be expensive. At the research the textile material types and properties in the virtual prototyping system were selected from Modaris Material Browser library – which are closest by the laboratory testing results. Within this research the aim is to evaluate the gained prototyping results in the case if the only available input characteristics of the textile materials are thickness and density.

Skirt design. At the next step of the study half-circle cut skirt designed for the experiments, it consists of two details (front and back patterns), the length is

60 cm and seam allowances are 1 cm wide. Parameters (Kapče, 2016) are used for skirt construction and pattern set in system Lectra (see Fig.3).

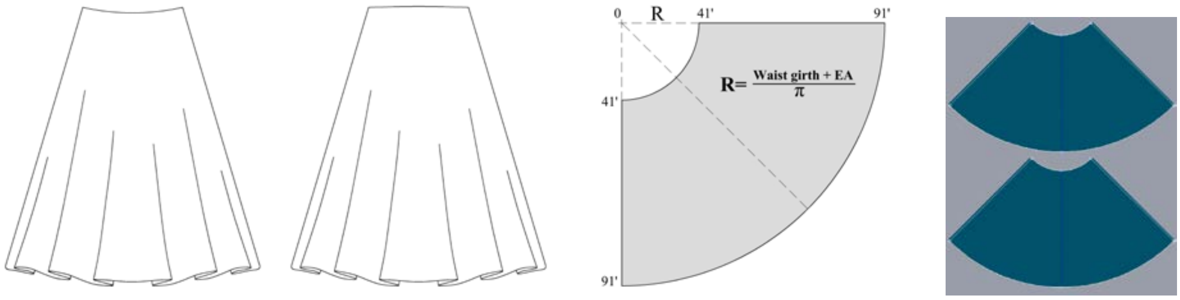


Figure 3. **Skirt drawing, construction and patterns**

Three real samples produced using 3 different fabrics, and virtual sewing is performed. The dummy is prepared for virtual try-on, fabric properties are defined and the process of virtual try-on is realized.

Transversal planes. For the evaluation and comparison of the gained results transversal planes used. Both the 3D scanning system and 3D prototyping system provides tools for acquisition of transversal planes (see Fig.4) and for their analysis by distance and perimeter or circumference measurements.

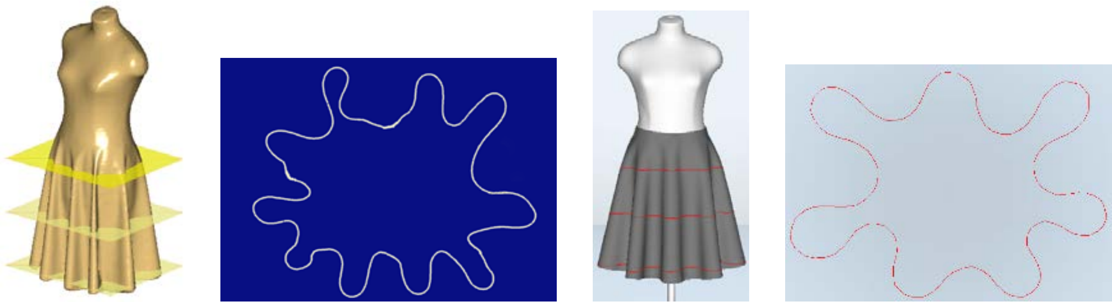


Figure 4. **Tranversal planes in Anthroscan and Modaris 3D**

Results and discussion

For visual evaluation of gained skirt silhouettes photographs, scans and virtual prototypes shown in front, side and back views (Fig.5). It is evident that first skirt - made of the thinnest fabric (width of the real draped skirt at hem 66 cm) - photography and the 3D scan picture differ significantly from the 3D prototype picture. Although there are significant differences in parameters, in the case of the other two fabrics - made of semi thick and the thickest fabric (width of the real draped skirt at hem 71 and 73 cm - accordingly) - the 3D results are almost identical.

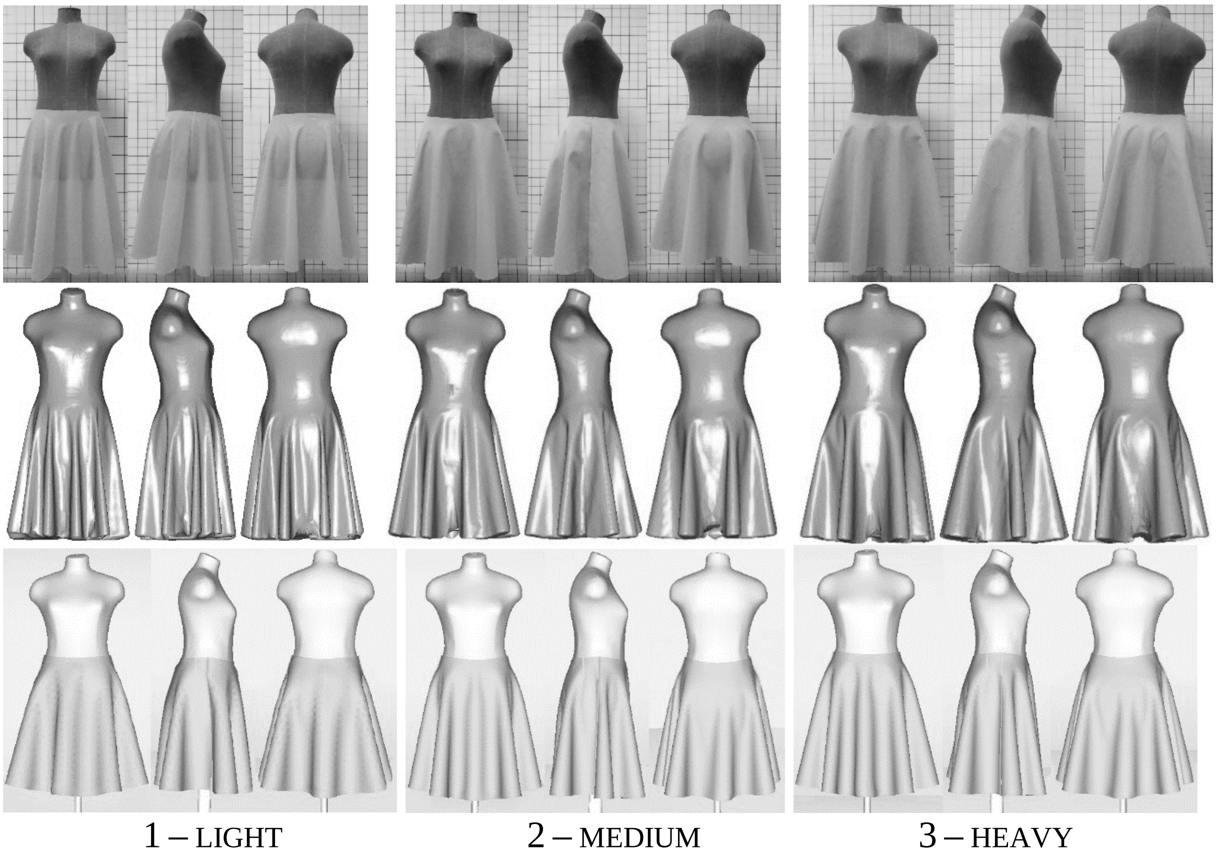


Figure 5. **Real, scanned and virtual skirt**

Transversal planes in system AnhroScan and Lectra gained in three levels (distance 22 cm) - hem level, middle level and upper level (see Fig.6). Gained sections superimposed (see Table 2: continuous line – 3D transversal plane, dashed line – 3D virtual try-on prototype), compared and measurements of width (dorso-ventral and lateral diameters) and perimeters of sections obtained.

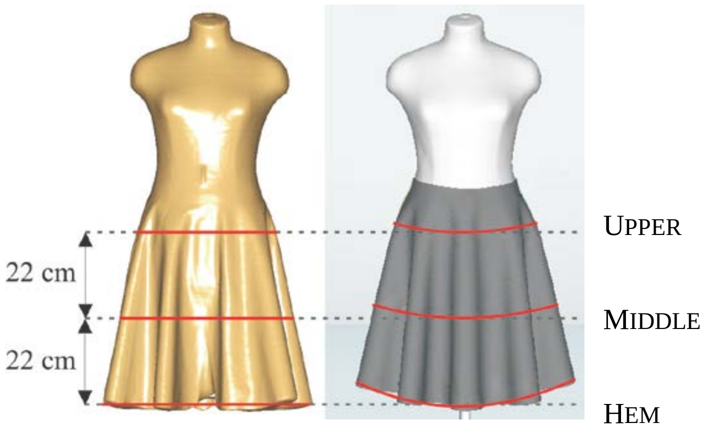


Figure 6. **Levels of transversal planes**

Table 2 **Superimposed sections of transversal planes**

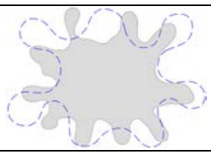
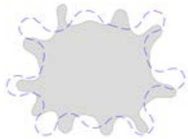
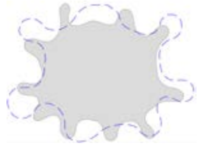
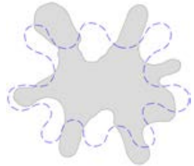
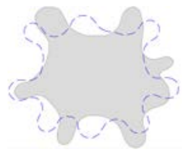
Fabric No.	**Hem**	**Middle**	**Upper**
1. Light			
2. Medium			
3. Heavy			

Table 3 contains data of diameters measured. All levels measured lateral (horizontal) diameter are larger for 3D virtual try-on samples than scanned real ones. All differences are positive and varies from 1 up to 8 cm. Differences measured at dorso-ventral (vertical) direction are smaller and 3D virtual try-on samples are smaller than real 3D scanned prototypes in most cases (differences varies from -13 up to +1 cm). Visual analysis of sections shows that real prototypes are uneven while virtually simulated drape are more even, symmetrical and curves are smoother – most visible appearance of this is at the hem level.

Perimeters measured vary a lot – especially at an upper level – which could be affected by weight of the fabric – might be it is not simulated properly. Differences at the hem level could be because of real scanned drape – inside of the draping folds laser beam cannot reach, so some differences can be caused by surface approximation.

The proportions of transversal plane diameters compared with correlation model shows great value – model validity tends to be 1. Nevertheless regression slopes differs (see Fig. 7) – the slope indicates the steepness of a line; it define the linear relationship between both diameters measured, and can be used to estimate an average rate of change. The greater the magnitude of the slope, the steeper the line and the greater the rate of change – which shows that in real 3D scans the ratios of horizontal and vertical diameters are more balanced comparing with 3D try-on prototypes.

Table 3 **Transversal plane measurements**

		Diameter [cm]						Perimeter [cm]		
		Horizontal			Vertical					
		Real 3D	**Virtual try-on**	Δ	**Real 3D**	**Virtual try-on**	Δ	**Real 3D**	**Virtual try-on**	Δ
Hem	1.	54	62	***+8***	44	44	***0***	258	260	***+2***
	2.	57	58	***+1***	51	42	***-3***	268	261	***-7***
	3.	56	61	***+5***	55	42	***-13***	274	261	***-13***
Middle	1.	46	51	***+5***	38	38	***0***	188	191	***+3***
	2.	48	51	***+3***	41	36	***-5***	194	196	***+2***
	3.	48	52	***+4***	43	37	***-6***	190	194	***+4***
Upper	1.	37	40	***+3***	30	31	***+1***	117	126	***+9***
	2.	39	43	***+4***	31	31	***0***	121	138	***+17***
	3.	38	42	***+4***	32	33	***+1***	119	132	***+13***

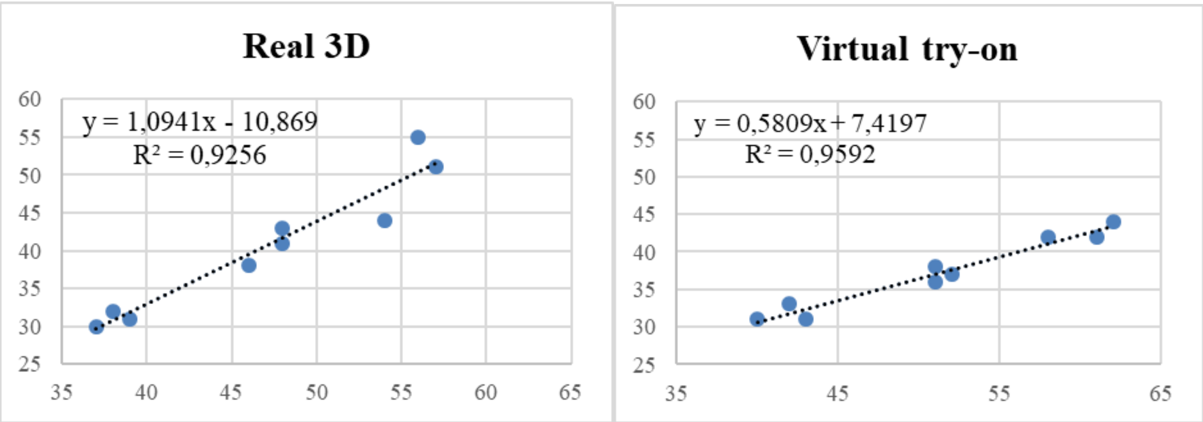


Figure 7. **Analysis of diameter proportion**

Conclusion, future research opportunities

Thanks to computer technologies and scanning equipment there is a more and more rapid development in anthropometry and cloth designing. Equipment for gaining 3D data of a human body has been invented very recently. It is possible to gain a great number and volume with different anthropometrical measurements and supplement data with 3D measuring appliances. Both the 3D scanning system and 3D prototyping system used in the research provides tools for acquisition of transversal planes and for their analysis by distance and perimeter or circumference measurements. It can be considered as a successful approach in the process of silhouette or clothing draping form analyse.

This research draws necessity for new garment designing and producing methods, which could provide the creation of the most appropriate garment for each customer, using calculation methods and therefore reducing costs, time spent on industrial production and waste generation. The method provided for testing virtual prototyping validity allows to outline lacks and benefits of virtual try-on systems. Also this research should be widened with more samples tested – as the topicality of research lies in rapidly growing on-line garment stores whereas the customers satisfaction with garments purchased should be increased.

Also research should be performed for investigation of different material testing methods – as more traditionally ISO standardized testing of textile physical properties is used. The work with KES-F and FAST data should be analysed and compatibility of results with traditional testing methods should be determined.

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