DOI: 10.2478/9788367405805-037

FUNCTIONAL CLOTHING DESIGN FOR THE ELDERLY

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Functional clothing represents the evolutionary segment in the technical textiles market. The domain of functional clothing is large and varied, each functionality having its own set of specifications, material needs, and corresponding technologies and methods. Garments for persons with special needs are part of the functional clothing category and are meant to improve the quality of life of those whose body shape, mobility or dexterity differs from the norms. This paper presents the advantages of virtual fashion design, that for persons with special needs (the elderly) lead to more comfortable, fit, and easy to wear garments, from the perspective of clothing design. The steps involved in developing the virtual prototypes were: i) 2D design of the basic patterns in accordance with the anthropometric data from the size table using the Pattern Design Software (PDS); ii) Simulation of functional clothing on a virtual mannequin using the Optitex 3D Suite software. The 2D patterns made with the PDS software were placed on the parameterized model and the types of seams were defined for the virtual assembly by simulating their sewing. The landmarks were deformed according to the shape of the human body; iii) Evaluation of garment fit on the body: after the completion of the 3D simulation process of the product, the appearance of the product and the way it fits on the body were analyzed.

Keywords: functional clothing, elderly, virtual prototyping

INTRODUCTION

The domain of functional clothing is large and varied, each functionality having its own set of specifications, material needs, and corresponding technologies and methods. It is well known that all types of clothing perform multiple functions from aesthetic to basic protection. Functional clothing is defined by that garment specifically designed or engineered to meet the settled performance for the user, under extreme conditions (Gupta, 2011a & 2011b).

The process of design and engineering of functional clothing is based on the outcomes of an objective assessment of multiple user requirements thus tending to become a very complex and iterative project. Clothing with functional abilities cannot simply be mass produced like everyday apparel. The adaptability of all the stages of the manufacturing process is tested to produce functional clothing that ensures workability, desired functional performance and comfort. Special synergies between apparel and technologies are required for embedding the functionality within the garment and development of textile and apparel with built-in technologies that can enhance the end product with extended functions and better comfort (Neves *et al*., 2015a; Joshi, 2024).

The aging process causes a deficiency of cardiovascular functions, muscle resistance, joint flexibility, sensory and brain functions (Neves *et al*., 2015b).

Regarding the inevitable and irreversible changes in the elderly body, the following occurrences and risks can be highlighted: 6% of average height loss; decrease in muscle mass, which leads to other disorders, such as decrease in bone density, and joint flexibility, growth of adipose tissue, changes in the abdomen, bending and deposition of fat in certain areas of the body. Age-related medical conditions, such as arthritis or osteoporosis, can lead to a change in body shape and functional limitations, such as dexterity and mobility (Chung *et al.*, 2024).

https://doi.org/10.2478/9788367405805-037

Today, advanced computer simulation techniques and garments virtual prototyping are indispensable for the development of garments and their fitting on the 3D body models within a virtual environment, as well as real-time virtual clothes try-on (Jevsnik *et al.*, 2012 & 2017). Considering the direct contact between skin and clothing, information about anthropometry, biomechanics and ergonomics is of extreme relevance for the development of suitable models for different user segments, with various needs.

Modelling is a process that starts from the observation of the body and its mapping, and it ends with the dressing test of a body, in real conditions. Therefore, to the development of an adequate modelling is necessary to know anatomy as well as the functioning of the body (Neves *et al.*, 2015a). Garments for persons with special needs are part of the functional clothing category and are meant to improve the quality of life those whose body shape, mobility or dexterity differs from the norms.

The Tex4Age project aims to develop functional textile products (articles of clothing and textile materials for environment of the elderly) intended to improve the quality of the elderly life by approaching innovative technologies that integrate the Safe-by-Design concept. This paper presents the virtual prototyping of functional clothing for elderly that is more comfortable, fit, and easy to wear from the perspective of clothing design.

EXPERIMENTAL

Clothing products for people with special needs (the elderly) are generally limited in regards to the fit on the body and ease of dressing/undressing, which is problematic. These people want to be treated like any other group, they have a strong desire to have elegant and functional clothing, at the same time.

Designing clothing for people with special needs (the elderly) is an extremely complex activity. The complexity and the dual, apparently contradictory, nature of the requirements are imposed by: functionality in relation to the type of activity, comfort, aesthetics, reliability and maintenance needs of the wearers; the impact on human health and well-being define the design of clothing/textile products for the environment of people with special needs as a multi-criteria design problem.

The needs analysis revealed that, for the users of clothing items/textile products, designed for the environment of people with special needs, the products must fulfill the following key needs, in order of priorities: User comfort; Protection; Functionality; Durability under conditions of frequent wear; Aesthetics; Applicability for several categories of people with special needs; Acceptability by users; Reasonable cost. Starting from the identified key needs, the performance parameters that clothing items/textile products must fulfill for the environment of people with special needs (the elderly) were established (Zhang *et al.*, 2015).

When manufacturing clothing, for these people, the anthropometric standards elaborated for the population with proportional body dimensions cannot be used, nor the classic design rules. In order to design and manufacturing functional clothing for the elderly, the anthropometric database of the Romanian population between the ages of 6 and 60+ was refined, according to certain criteria, data obtained in the anthropometric surveys carried out by The National Research & Development Institute for Textiles and Leather (INCDTP), during the period 2008-2014, in the historical regions of Romania, in Bucharest, at the "Prof. Dr. N. Paulescu" National Institute of Diabetes, Nutrition and Metabolic Diseases and in public order structures, through a three-dimensional scanning process. The scan was performed with the Anthroscan 3D Mobile Scanning System from Human Solutions-GmbH, provided by INCDTP, which contains a family of ScanWorX-Anthroscan software modules for 3D body visualization and automatic processing and evaluation of anthropometric data (Bruniaux *et al.*, 2016; Nakić and Bogović, 2019).

The Specific Anthropometric Database

The primary 3D anthropometric database of INCDTP contains 6150 scanned bodies, of which: 2850 children, girls and boys, 1800 adult subjects, women and men, 1500 obese and elderly subjects and 150 subjects from public order structures. Primary anthropometric database was filtered, according to certain criteria (e.g. sex, age, and Body Mass Index, etc.) to constitute the databases specific to people with special needs (the elderly), namely Anthropometric database for women aged 60+, and for men aged 60+.

Each anthropometric dimension of the specific databases was subjected to a one-dimensional statistical processing by calculating the statistical parameters for the main dimensions of the body (bust and hip circumference, for women and chest and waist circumference, for men). Dimensional typology selection (establishing body shape variants to be included in the anthropometric dimensions table) took into account the frequency of the investigated sample, different combination of possible value of main dimensions. Thus, frequency values bigger than 5% were selected. Determination of body types, for these group of people with special needs, was realized by analyzing the frequency of the difference between Ps (hip circumference) and Pb (bust circumference), on women and Pt (waist circumference) and Pb (chest circumference), on men. The types of the bodies with the highest frequency were selected, and for these the sizes of the garments and the body dimensions that will be used in the design of the patterns were established.

Virtual Garment Design for the Elderly

The development of functional clothing for people with special needs is complex, costly, and time consuming. The use of computational modelling and simulation can reduce development time and production costs of functional clothing for elderly (Avadanei *et al.*, 2022). Therefore, in a first step, we made the virtual prototypes of functional clothing for elderly using the OptiTex software suite.

The stages completed were the following: i) 2D design of the basic patterns in accordance with the anthropometric data from the size table using the Pattern Design Software (PDS); ii) Simulation of functional clothing on a virtual mannequin using the Optitex 3D Suite software. The 2D patterns made with the PDS software were placed on the parameterized model to the dimensions in the anthropometric data table and the types of seams were defined for the virtual assembly by simulating their sewing. The landmarks were deformed according to the shape of the human body; iii) Evaluation of the fit of the product on the body: after the completion of the 3D simulation process of the product, the appearance of the product and the way it fits on the body were analyzed (Nakić *et al.*, 2019).

In order to create the virtual prototype, functional clothing products were selected from the most common range used by the elderly.

RESULTS AND DISCUSSIONS

Based on the mentioned algorithm, the virtual prototypes of functional clothing for the elderly were obtained. In the following tables are exemplified two of them.

Table 1. Dress for the elderly female

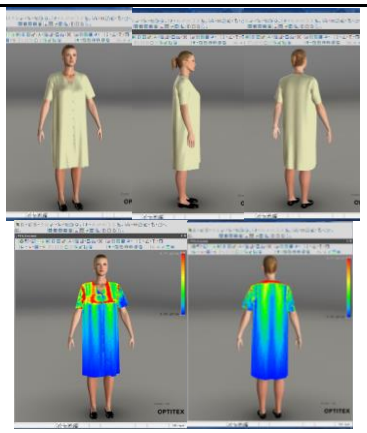
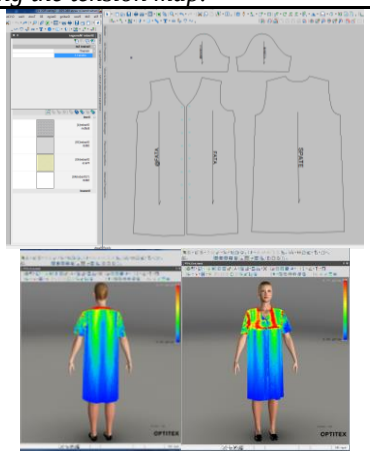
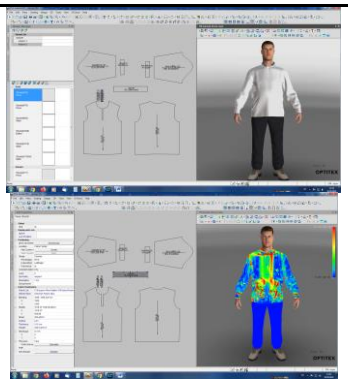
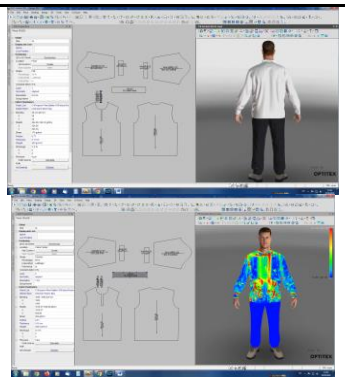
Conceptual model	*Parameterized mannequin and basic patterns: vB body type, size 48*	*Model patterns, virtual prototype on the body and checking the body-product fitting by viewing the tension map.*
		
The model is designed for people of different sizes and body type vB. The virtual prototype made with model patterns when analyzing the degree of body-product fit, on the mannequin parameterized according to body type and size, using the tension map, shows a high pressure in the shoulder area (normal for a product with shoulder support) and breasts. After correcting the model patterns in the breast area, when resuming the product simulation, a correct positioning of the product on the body and a reduction of the tension exerted in the breast area were highlighted.		

Table 2. Blouse for the elderly men

Conceptual model	*Parameterized mannequin and basic patterns: vD body type, size 56*	*Model patterns, virtual prototype on the body and checking the body-product fitting by viewing the tension map.*
		
The basic patterns were designed for Body type D, size 56. Visualization of the product made with the basic patterns, on the parameterized mannequin, indicates a proper placement and correct patterns. The analysis of the tension map of the product made with the model patterns, shows a good fit, without pressure on the body and sleeves well placed on the hands, without creases.		

CONCLUSIONS

The quality of life for the elderly can be substantially improved through a clothing design adapted to conformation, needs, special functional requirements, but also with functionality and aesthetics improved.

Design and engineering of functional clothing for the elderly is a complex and challenging process. Starting from the needs analysis, the key needs of functional clothing for

the elderly were identified, which were the basis for establishing the key performance parameters. The established performance parameters were translated into design requirements, based on which the raw materials, the realization technologies, the conception (design) of functional clothing were identified.

The solutions and advantages offered by the OptiTex software suite were used for the virtual prototyping of the functional clothing for the elderly prior to the physical realization and verification of its compliance through 3D simulation on an avatar.

The use of 3D virtual prototyping offers many advantages as: the possibility to check the aspect of the product and how it fits on the 3D model of the human body, without requiring physical development of a prototype; the reduction of the time to produce the first prototype; a significant reduction of the manufacturing costs; the reduction of waste; the possibility of diversifying the model – by combining or altering the textures of materials.

The results obtained in the design and creation of the virtual prototype, which included the function of modeling the product according to the technical characteristics of the materials, are used to define the technological parameters of making the functional clothing products for elderly.

Acknowledgements

This work was carried out through the Core Programme within the National Research Development and Innovation Plan 2022-2027, carried out with the support of MCID, project no. 6N/2023, PN 23 26 0103, project title "Advanced functional textile materials for protection and improving the quality of life – Tex4Age".

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