

# Digital methods in the development of adaptive clothing for people with disabilities

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## ABSTRACT – REZUMAT

### Digital methods in the development of adaptive clothing for people with disabilities

*Social integration of people with disabilities is a significant issue, therefore effective interventions to provide improvement of quality of life for people who have some kinds of disabilities are crucial. Specialists from various fields, including those in the field of clothing design, are working on creating products that meet people with disabilities' needs. These products must be ergonomic, comfortable and provide the necessary psychological comfort. The whole process of designing functional products is very complex, it requires continuous research, using knowledge from various fields for better development of products.*

*This paper addresses the topic of developing adaptive clothing for people with multiple sclerosis in the context of social inclusion and adaptation to new ways of life. All the proposals and ideas are analysed accordingly and different constructive and technological solutions are proposed to customize and adapt the basic clothing.*

**Keywords:** adaptive clothes, multiple sclerosis, 3D design, CLO 3D software, simulation

### Metode digitale în dezvoltarea articolelor de îmbrăcăminte adaptate pentru persoanele cu dizabilități

*Integrarea socială a persoanelor cu dizabilități este o problemă importantă, prin urmare intervențiile eficiente pentru a asigura îmbunătățirea calității vieții persoanelor, care au anumite tipuri de dizabilități, sunt cruciale. Specialiști din diverse domenii, inclusiv cei din domeniul designului vestimentar, lucrează la realizarea de produse care să răspundă nevoilor persoanelor cu dizabilități. Aceste produse trebuie să fie ergonomice, comode și să ofere confortul psihologic necesar. Întregul proces de proiectare a produselor funcționale este foarte complex, necesită cercetare continuă, folosind cunoștințe din diverse domenii, pentru o mai bună dezvoltare a produselor.*

*Această lucrare abordează tema dezvoltării articolelor de îmbrăcăminte adaptative pentru persoanele cu scleroză multiplă în contextul incluziunii sociale și al deprinderii cu un nou mod de viață. Toate propunerile și ideile sunt analizate în consecință și sunt recomandate diferite soluții constructive și tehnologice pentru personalizarea și adaptarea îmbrăcămintei de bază.*

**Cuvinte-cheie:** articole de îmbrăcăminte adaptative, scleroză multiplă, proiectare 3D, softul CLO 3D, simulare

## INTRODUCTION

Multiple sclerosis is an autoimmune disease that affects the central nervous system, causing demyelination, axonal degeneration, and gliosis. This impairment of the immune system leads to lesions that produce motor, sensory, cognitive, visual or even sphincter dysfunctions (most often urinary and intestinal). In the more or less long term, these disorders can progress to an irreversible handicap. Even if current treatments can reduce relapses and improve the quality of life of patients, they are most often insufficiently effective in preventing the progression of the disability in the medium-term [1, 2]. Between episodes, the symptoms may disappear completely; however, it often results in permanent neurological problems, especially in more advanced stages of the disease.

For most people with multiple sclerosis, the severity of the symptoms depends on the temperature. Therefore, choosing the right clothes is very important.

At the beginning of the disease, weakness is often the problem and the best clothing choices would be zippered clothing or Velcro. As the disease progresses, partial paralysis may occur, which requires the choice of traction items or side zipper pants. Of course, the level of the person's ability to dress himself and the choice of what would be most useful to him must be assessed. If a person has complete paralysis, the best items would be the products with the back open, as the person will be locked in a wheelchair or a bed. If the person uses a wheelchair the accessories that make life easier with assistive devices, such as wheelchair bags, cup holders and more are recommended.

Adaptive clothing should be designed to meet the needs of the people that wear this type of clothes [3–6].

It is recommended that the following factors be taken into account when designing or choosing clothes for people suffering from multiple sclerosis:

- To opt for light, breathable fabrics: they can have a cooling effect because they “breathe”. In other words, we need to make sure that the heat can escape and, if necessary, work with different layers of breathable fabric.
- Choose light colours because they reflect sunlight, while dark colours absorb heat.
- Put comfort first and choose clothes tailored to the needs.

For the analysis, 2 cases found in people suffering from this problem were selected. The first case is going to be about people who have difficulty walking and moving with the help of a cane. And the second case will be about people who cannot move alone and are in a wheelchair.

## THE ANALYSIS OF EXISTING PRODUCTS

### Market analysis for adaptive products

Making clothes for people with disability is a little more complicated because these people need clothes adapted to their measures and movements. To ease their life as much as possible, the clothes also have to provide thermal comfort, protect them regarding climatic variation, to be easy to dress [7–11].

Sometimes fashionable clothes available in stores do not meet the demands of people with Multiple Sclerosis because they don't offer thermal comfort and security and do not provide autonomy [12].

To have a better idea of the needs of the market and this niche, it is a good idea to perform the marketing analysis and what it proposes. For this analysis, we

stopped on the first 4 webpages that came up when searching for clothes for this specific group of people (figure 1).

According to figure 1 and the analysis carried out by browsing the existing online stores, it was noticed that most of the adaptive products for people with multiple sclerosis were simple, for older people and many of them were meant to be worn at home. Taking into consideration that MS often debuts at the age of 20–40, it can be concluded that most of the clothing articles available on the market were not fit for the MS people age group.

To correct and provide comfort while wearing clothes, it was proposed to develop products adapted to the needs of these people and with a pleasant aesthetic appearance and adapted to today's trends.

Although further research is needed in this area, the findings have a favourable impact on how this issue is explored [17].

### Ordinary clothing for people with disabilities

To understand where to start with adaptive clothing, an analysis of existing ordinary products was needed. For people with multiple sclerosis, even the slight tremble of the hands can cause a big discomfort in dressing. That's why to better understand what was needed to adapt and to change to ease the life of a person with MS it was decided to try on different types of clothing that people were normally wearing and to see the places that may cause discomfort (figures 2 and 3). This was done by simulating an avatar

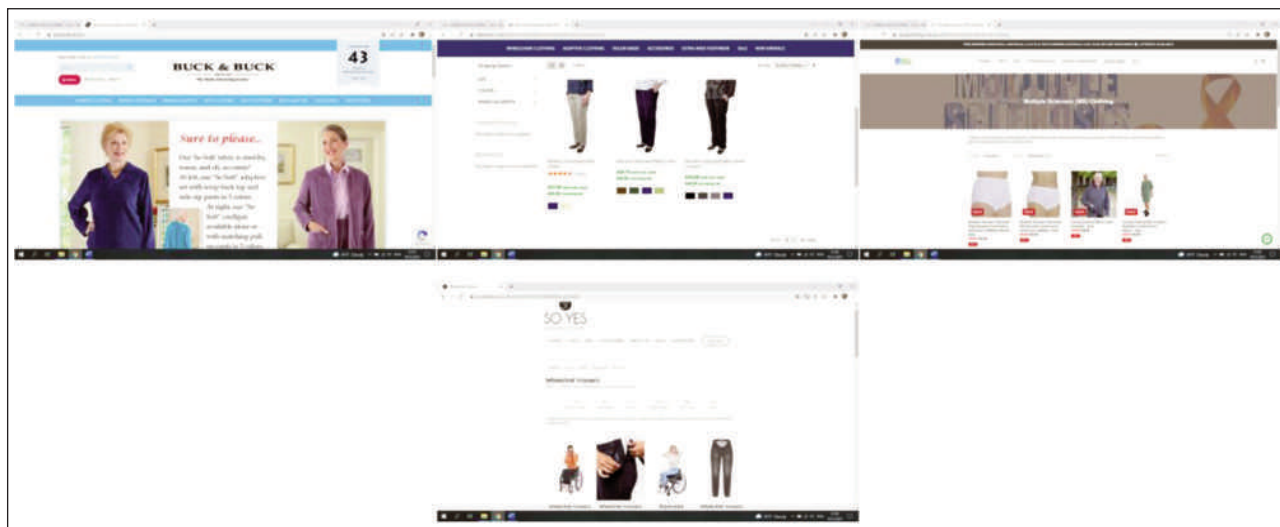


Fig. 1. Market analysis for adaptive products [13–16]

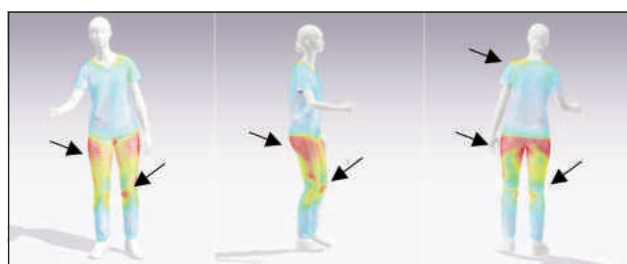


Fig. 2. Topographic diagram for the person moving with the help of the cane

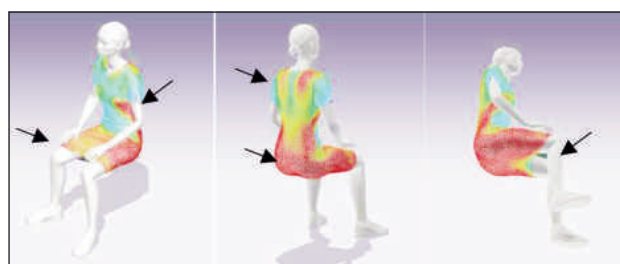


Fig. 3. Topographic diagram of a person in a wheelchair

in CLO3D software which is a 3D fashion design software program creating virtual, true-to-life garment visualization with cutting-edge simulation technologies for the fashion industry [18].

By using the virtual prototypes [19–21] the user can see and explore the final product on a virtual mannequin (avatar) before the manufacturing and if the chosen design solution is the right one.

By applying this software, as can be seen in figure 2, when the avatar was moving with the help of a cane, the most uncomfortable part of the pants was around the hip area, more specifically from the hip to the knees. We can also see that near the shoulder area, some tension might appear because of the movement of the body.

Following the analysis of the topographic scheme for figure 3 it can be noticed that the dress was very uncomfortable for a person in a wheelchair. The most affected zones were the leg, hip, upper back part and bust area. These areas were the ones that hindered the movement of the hands and also created great discomfort for the person who wore clothes not adapted to their needs.

### ELABORATION OF PRODUCTS ADAPTED FOR PEOPLE WITH DISABILITIES

Following the analysis from above, it was proposed to try to adapt different types of clothing and to see how the adaptive clothing fit and what kind of comfort they offered using the CLO3D software for simulation and fitting the virtual garments. The topographic diagrams were used as a way to analyse the obtained results of this research paper.

#### Elaboration of products adapted for people who travel with the help of a cane

In figure 4 the first presented set was adapted for people who moved with a cane. This was done by adapting the pants and the t-shirt. For the upper part, the t-shirt was adapted by making the silhouette larger, and more flexible. Additionally, the form of the neck part was changed to make it free and comfortable. The most important part was the back. It was made from two parts that overlapped and were fixed



Fig. 4. Model A: Development of products adapted for people who travel with the help of a cane

on the shoulder with clasps. This allowed the wearer to be more flexible and was very easy to put on.

The pants were adapted by adding the elastic band and by adding clasps and zippers on both sides of the pants. This was done to make the process of dressing easier and the clasps and zippers were easy to use even when the wearer had trembling hands.

The same proposal was applied to figure 5, where the t-shirt was unchanged but the emphasis was put on the textile. The material used was stretch cotton. For the shorts, the same technique was applied as in the first case. Part of the belt was made elastic to ensure comfort and on the sides of the pants, clasps were applied to ensure an easy putting on of the clothes. Further, the silhouettes were kept free to ensure the movement of the body.



Fig. 5. Model B: Development of products adapted for people who travel with the help of a cane

In the last case (figure 6), elastic was used on the back of the dress to ensure comfort, the sleeves were made with ruffles at the top to ensure the movement of the hands and the placket in front was with Velcro band to create easy putting on of the clothes. In the example the dress was done long because some of the people with MS can be insecure with their legs and the way they walked to ensure psychological comfort; it was decided to try this type of length on the dress.

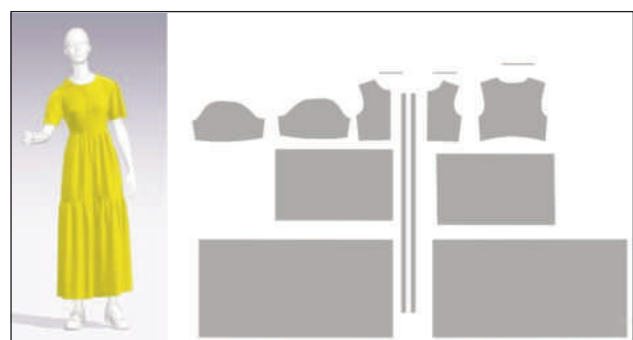


Fig. 6. Model C: Development of products adapted for people who travel with the help of a cane

The next step consisted of analysing the topographic schemes of the adapted clothes above to see how

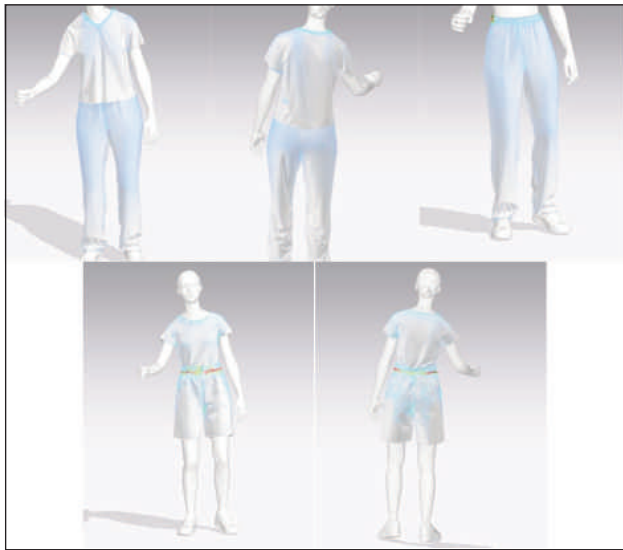


Fig. 7. Topographic scheme of adaptive products for people travelling with a cane



Fig. 8. Topographic scheme of adaptive products for people travelling with a cane

successful the adaptation process was (figures 7 and 8).

Figures 7 and 8 show us the topographic schemes of the adapted clothes and how successful were the ideas and the methods selected. The fit seemed good without any major discomfort that could irritate the wearer. The places that were mentioned above that created discomfort have been adjusted to fit normally.

Following the analysis of the constructive and topographic schemes of the adaptive products for the people who moved with the help of the cane it can be seen that the red areas have disappeared, they are freer, more flexible and more comfortable to wear. In figure 7 some yellow/orange areas around the waist can be seen which showed the tension of the elastic introduced at the base for a more comfortable fit. For the rest of the clothes, it can be noticed that the fit did not create any tension or discomfort in any parts of the clothes or body.

#### Development of products adapted for people using a wheelchair

Compared to the first case, where the cane was used to walk, in this one, the wheelchair was used as a

means of transport. This made the adjusting process more complex and complicated because the person was most of the time in a sitting position.

So, for the second example, a deeper study was done and different ideas and methodologies were applied to obtain adapted clothing for people in a wheelchair.

Different cuts to a mix of textiles and adjustments were applied to try to obtain a variety of ensembles. The following results are presented in figures 9–11.

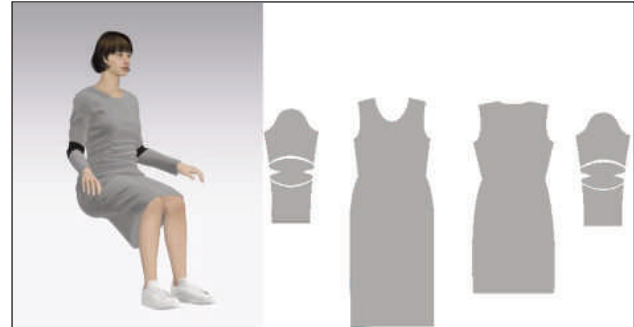


Fig. 9. Development of products adapted for people using a wheelchair

For the first model (figure 9), the adaptation was done by creating the pleats in the front with the help of an elastic. This was done both for comfort and an aesthetic look. For the sleeve, it was decided to adjust the length and add another soft textile so that in the elbow region there would not be any injuries or discomfort. The neck area was lowered in an oval shape to ensure easy putting on.

As for the textile it was decided to choose an elastic one made of cotton to guarantee the circulation of the air and the heat of the body.

As the last adjustment, a slit was added on both sides for comfort and not to cause any discomfort while sitting.

Continuing this idea, more complex models were adapted. For the next two figures from below the pants were selected as the main item to adjust and conform to the necessity of the people who were going to wear these clothes (figures 10 and 11).

This ensemble was full of different items and construction details. The first item was a type of sleeveless



Fig. 10. Development of products adapted for people using a wheelchair

bomber jacket. It was done by adding a zipper in the front and the straps were regulated with the help of a Velcro band. At the neck part, a collar was added. The back part was shorter than the front, so when seated, the back would not have any discomfort in the wheelchair.

The shirt had a raglan type of sleeve to ensure easier movement and to minimize the discomfort that might have appeared. The dressing was done from the front part with the help of the clasps. The hem of the shirt was shorter in the front and longer in the back. This was done so there won't be any discomfort and excess textiles in the front. The same idea was applied in the back. Because the person is in a sitting position the shirt will ride up and the lower back part will be exposed. To prevent this a longer back part was added.

And the last part of this ensemble was the pants. This pair presented a lot of cuts and extra textile material. This was done to ensure comfortable wear for the person.

The back of the pants has darts around the hip and back of the knee area. This was done because these parts gather a lot of material, especially around the knee. So, to ensure a comfortable bent of the knees, some darts were introduced in these specific areas. The front part of the pants was very sectioned. This was done to ensure comfort in the bent parts of the legs where a lot of textiles gathered. At the knee section, an extra soft and elastic textile was added because this part stretches out. For the bottom part of the legs, an extra textile was added to adjust to different sizes of the calf because the legs can swell, especially in the lower part. Moreover, this makes the dressing process a lot easier. The upper and lower bent is both with an elastic band.



Fig. 11. Development of products adapted for people using a wheelchair

The locking system was combined. The first part was made from clasps that stopped at the mid-upper leg part and the rest with a zipper. This was done on both sides of the pants.

The most important piece was the back. It was made from two parts that overlapped and fixed at the shoulder with clasps. This gave more flexibility and was very easy to put on, the sleeves being kept short.

The pants were adjusted by adding the elastic band, clasps and zipper on both sides of the pants. The zipper was placed in the front part of the pants to make wearing it easier. All the adjustments were selected to ease the use even when the wearer had trembling hands (figure 11).

Further the topographic schemes of the adapted clothes were analysed to see how successful the adaptation process was (figures 12 and 13).

The models below showed us the topographic schemes of the adapted clothes and how successful were the ideas and the methods selected. The fit seemed good without any major discomfort that could irritate the wearer. The places that were mentioned above that caused discomfort have been adjusted to fit normally.



Fig. 12. Topographic diagram of adaptive products for wheelchair users



Fig. 13. Topographic diagram of adaptive products for wheelchair users

Analysing figure 13, it can be seen that the products were adapted to the needs. For some parts of the items, a change of colour can be seen because in those regions an elastic was added to offer comfort and to adapt to the necessities.

This cannot be avoided, but every effort has been made to minimize any inconvenience this may cause. Otherwise, the garments were free and convenient.

### Details of adaptive products for cane and wheelchair users

To make the clothes more comfortable different and unusual types of closures were added. Because people with MS often have trembling hands and sometimes have no strength to dress, or can get tired very quickly a lot of adjustments were added. As we know



Fig. 14. Details of elaborated adaptive clothing

MS attacks people from the age group 20–40. A lot of research was done to find the right way to modify the outfits. At the same time the items needed to be fashionable and fit the taste of young people. To facilitate this process, it was proposed to use zippers, clasps, Velcro bands, and elastic in different parts of the clothes to insure ease in the process of dressing. The photos from figure 14 demonstrate the methods used for adapting the elaborated garments.

## CONCLUSION

This paper aims to study the existing adaptive clothing for people with multiple sclerosis and to try to develop products taking into account certain needs and requirements of these people.

As a first step, a mini study of the online market offering adaptive products was carried out and it was found that most of the products were for older people and the clothes were meant to be worn at home. For young people the range found is more limited. And considering that this disease begins in young people between the ages of 20–40, the given products do not fit into the segment given by consumers.

The next step was to study the topographic pattern of ordinary clothing used by most people and note some inconveniences and problems that may arise in the case of people with more special needs. In the next phase, an attempt was made to develop patterns and templates for tailored products so that they would be stylish and provide the necessary comfort to the wearer.

In addition, the topographic pattern of these garments was checked and it was observed that the products were more comfortable, in both cases. This area still needs further research, but the results obtained have a positive influence on exploring this theme.

Therefore, this study comes with the idea of elaborating and performing the adapted process in 3D, to see the applicability of these systems and help integrate 3D with adapting clothing. This represents a significant step towards a better understanding of the processes, errors and new possibilities that may arise. Further research can be oriented towards the customization of adaptive clothing products according to the specific destination and the categories of the wearer studied.

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