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Kinesiological analysis of the dressing process in musculoskeletal patients

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Abstract

The dressing process is among the five basic activities of daily life that define the degree of autonomy and independence of an individual. Self-sufficiency is historically recent as a status symbol, since only at the end of the nineteenth century royalty and wealthy people are no longer assisted during the dressing process. In the 1970s, the focus in fashion is indisputably youth, leaving aside everyone with symptoms incompatible with this youthful and healthy stereotype. Thus, the dressing process becomes essential for the maintenance of autonomy and social sustainability of individuals with some functional limitation. In this paper, we present a kinesiological analysis of the movements performed during the dressing process and identify the main difficulties experienced by twenty-six musculoskeletal patients. The movements required to put on different garments and parts of garments – i.e., dresses, tops, coats, collars, sleeves – as well as to fasten them and the variation of the implicated movements with reference to their position were directly observed and recorded. Among the main results obtained, we verified that, for the sampled target population, it is more difficult to perform movements with bigger ROM and gross motor skills than those requiring fine motor skills; also that the change of position of fastenings can make the dressing process easier, since they help combining two stages of the process – i.e., adjustment and fastening. Among the possible conclusions, we infer that maintaining autonomy is essential for the social sustainability of individuals with musculoskeletal pathologies. In association, the inclusion of users in the development of design products using a UCD process is imperative to enhance the products suitability for the end-user and it is also a means of social inclusion.

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1. Autonomy in dressing process

The dressing process is a daily activity being used to evaluate the functional capacity of an individual and thus to measure the degree of autonomy and independence [1,2].

The usual dressing process presents seven moments or steps: i) The ‘selection of clothes’ that a user wants to wear; ii) ‘Getting the clothes’ from the closet or drawer; iii) ‘Preparation’ of the clothes so they are put on the body; iv) ‘Donning’ or dress oneself with the selected garments; v) After getting into the clothes properly it is necessary to ‘fasten’ them – i.e. buttons, zippers, hooks, ties, elastic bands; vi) ‘Adjusting the donned clothes’ by properly positioning them along the body segments; and finally, vii) ‘Doffing’ or undressing the clothes – e.g., before the user goes to bed. We realized that people must have sufficient levels of flexibility, joint mobility and coordination of the body segments in question to perform the rather common activities involved in the dressing process in its entirety [3,4].

Although nowadays the dressing process defines the degree of autonomy and independence of an individual, it was not always so. In fact self-sufficiency is historically recent as a status symbol, especially because the concept of autonomy did not exist until 1758.

In ‘The Hidden Diary of Marie Antoinette’, Erickson presents several reports about the aid maid dressing the queen consort: In July 28, 1769 is the first time that Marie Antoinette writes in her diary something about Sophie – her aid maid since she is a child with seven years old – dressing her: “This morning Sophie got me up early and dressed me with extra care. I asked her why but she wouldn’t tell me. I knew it had to be something important when I saw her bring out my pale blue silk ball gown with silver lamé trim and the pink satin rosettes on the bodice [...] I could tell, as Sophie dressed me, the she was satisfied with the effect” [5].

Later, in December 28, 1770, the queen seems unsatisfied about her clothes and one of her aid maids: “I have decided not to wear corset stays any longer. They pinch, and make me short of breath. Madame de Noailles insists that I wear them. I tell her no, definitely and firmly, and my bedchamber women obey me. They are fond of me and dislike Madame de Noailles. When they dress me, they leave off the stays” [5].

In her last day of life we also can see that it was important for Marie Antoinette to be dressed properly. A note written on the evening of October 16, 1793, by Rosalie Larmorlière, the queen’s maid in the Conciergerie Prision, and added to this journal, reports: “My mistress the Widow Capet, formerly Queen Marie Antoinette, was taken from her cell this morning by the members of the Revolutionary Tribunal who had condemned her and by the executioner Henri Sanson. I had helped her dressed and put up her hair under her linen bonnet. She had saved the bonnet for this day, keeping it white and clean. But they did not let her wear it and they cut off her hair and bound her hands” [5].

The behavior of royalty is followed by the upper classes of society regarding being assisted during the dressing process. In the book ‘Catherine the great: Portrait of a woman’, in the section about ‘Serfdom’, Massie reports: “By the mid-eighteenth century, most Russian serfs had become possessions, chattel; in fact slaves [...] Sales of talented serfs often took place in cities where their skills were extolled by advertisements in the Moscow New or the St. Petersburg Gazette: [...] For sale: a girl of sixteen trained in lace-making, able to sew linen, iron, and starch and dress her mistress, in addition to having a pretty face and being well formed” [6].

In the book ‘From Queen to Empress: Victorian Dress 1837-1877,’ Goldthorpe reports, “one correspondent to the Englishwoman’s Domestic Magazine in 1867 spoke out in defense of tight lacing, which was being increasingly criticized by the medical profession: I was placed, at the age of fifteen, at a fashionable school in London, and there is was the custom for the waist of the pupils to be reduced one inch per month. When I left school at seventeen my waist measured only thirteen inches, it having been formerly twenty-three inches. Every morning, one of the maids used to come to assist us to dress” [7].

Likewise, as with most new styles, the crinoline, initially worn only by the fashionable high society, was soon adopted by aspiring women of other social classes [7].

The concept of autonomy appears only in 1758, when Immanuel Kant writes ‘Die Metaphysik der Sitten’ – ‘Groundwork for Metaphysics of Morals’ – associating the autonomy to moral and ethics and, later to freedom of choice. To Kant [8,9], when we can take conclusions by knowledge, it is autonomy of reason and it is determined by our moral. As stated by GDLAM [10], autonomy refers to i) action or physical independence, ii) will or self-determination and iii) thoughts, i.e., “the ability to control, act or make personal decisions about how to live every
day, according to one’s own rules or preferences” [11]. On the other hand independence is the ability of performing a task without any kind of help.

The autonomy is the capacity to deal with a series of dependencies [12]. This way autonomy and independence are related not only to physical aspects but also to psychological ones [11,13,14,15,16]. Both depend on the body as the vehicle that allows people to express themselves either through movement or as a support [1,2].

In contrast to other mammals humans are born fragile and weak, as they need their mother or a substitute for survival for a long time. Likewise the dependence in the dressing process is present in a person’s early years: babies need the assistance of the parents or someone else to be dressed and undressed. Children around two years of age are already capable of taking clothes off the body and around the age of five or six they are able to don and doff clothes without any help. Therefore autonomy is a learning process and every human must pursue his/her personal way of functioning autonomously [12].

Several authors point out that fastening clothing is the last ability to be developed although these skills can be affected in secondary aging – in other words: derived from pathological lesions that reduce the functional capacity and limitation of ROM. In this way, diseases of the musculoskeletal system are the main causes for the weakening of the dressing process, particularly in the donning and doffing steps [17,18,19]. The musculoskeletal pathologies are related to the ageing of bones, muscles and joints, resulting in movement limitation – reduction in angle, extension, flexibility and strength – and consequently in an increase of fatigue [20].

Bueno et al. [10] underline the importance of performing daily tasks with less effort as a way of extending functional autonomy. The authors also refer those tasks as being synonymous of self-sufficiency and dignity. Thus, the dressing process becomes essential for the maintenance of autonomy and social sustainability of individuals with some functional limitation. Being so this research has the goal of considering sustainable the means of keeping the autonomy for people with functional limitations due to musculoskeletal pathologies in what concerns their ability to get dressed and undressed.

The principal importance of maintaining autonomy and independence in the dressing process is closely related to the maintenance of individual dignity as well as quality of life. It is the perception of an individual about his/her life in the context of culture and the value system applied to society that guides his/hers goals, expectations, standards and concerns [13].

When an individual has a handicap that prevents him/her of executing a daily task a decrease in his/her social condition and involvement is declared. Therefore the personal sustainability, i.e., the maintenance of autonomy and independence, also decreases since it presupposes to achieve a balanced happiness and prosperity in all areas of human interaction in a social context that values the youthful and healthy stereotype [21]. From the 1970s, the focus in fashion is indisputably youth, leaving aside everyone with symptoms incompatible with it.

The main goal of this paper is to present a kinesiological analysis of the movements performed during the dressing process and to identify the main difficulties experienced by twenty-six musculoskeletal patients.

This analysis was done specifically to the movements required to put two different garments on – a top with a front opening and a pullover top –, as well to analyze the variation of the observed and recorded movements performed by those patients, as it is our conviction that clothing for people with some type of functional limitation need to be created.

Generally products and services offered to this target population are not designed to answer their needs and aspirations. Functional limitations and body changes added to psychological factors – e.g., losing friends and loved ones – determine somehow a reality that limits the quality of life of older people, leading to a ‘marginal’ life and social isolation, thus diminishing their autonomy [22].

2. Methodology and results

This study is part of a PhD research on inclusive clothing design for women with musculoskeletal limitations, in order to achieve the guidelines to be used in the development of clothing that can safeguard the individual autonomy.

To this effect we observed a group of users, checking the inadequacy of clothing for their movement limitations and difficulties. Thus, this research used the user-centered design process – UCD.
It is important to remind that UCD is the term that describes the design processes in which the end-users influence how a design takes shape. This is a very common methodology in Ergonomics project development. Therefore, in UCD, users are given extensive attention at each stage of the design process in order to make inclusive products and/or services. The principle behind UCD is that the designed products and/or services need to facilitate the people needs, limitations, capabilities, desires and motivations, as they are the persons who will use the product or system being built. In this way, UCD can be characterized as a multi phase process to solve problems that involves the designer and real end-users [23, 24].

Along with the described principles, we selected a group of twenty-six women for the first empirical phase to observe them through the dressing process. These are semi-dependent or independent women with a musculoskeletal pathology, i.e., arthritis, arthrosis, osteoporosis, tendinitis, bursitis or frozen shoulder.

We chose to include a sample group from Portugal and another from Brazil. The Portuguese sample group is composed by residents of ‘Casa do Artista’ in Lisbon – a retirement home for actors —, the Brazilian sample group is composed by nonresident patients of a physiotherapy clinic in ‘Rio Grande do Sul’. All of these women are undergoing treatment for some kind of musculoskeletal pathology at different stages. The choice of including two sample groups added to this research not only a geographic quality, but also quality in quantity and perspective. This last variable is mainly due to the fact that the Brazilian women, who live in their own homes thus having a better quality of life than the residents of ‘Casa do Artista’, have shown greater interest to take part in this research.

Using a direct observation methodology, in this first phase we observed the performances of the twenty-six women during the dressing process – specifically the acts of ‘getting the clothes’, ‘preparation’, ‘donning’, ‘fasten’ when required, ‘adjust’ and ‘doffing’. In this phase, the users were asked to select from their own wardrobes two types of tops to wear, i.e., a top with front opening and a pullover top, in order that the executed movements and level of difficulty were evaluated. The assessment was made using the research methodology developed by Foddy [25] and the answers were translated into a numerical scale from 1 to 5, where 1 stands for ‘high difficulty’ while performing the task and 5 for ‘no difficulty’.

The identified movements for evaluation concerned the mobility of the upper limbs and torso and are described and quantified in table 1.

<table>
<thead>
<tr>
<th>Pullover tops</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternate arm extension and flexion</td>
<td>2</td>
<td>8</td>
<td>9</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Neck flexion</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Arm bending with flexion of the forearm</td>
<td>3</td>
<td>6</td>
<td>11</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Shoulder rotation and elevation</td>
<td>5</td>
<td>12</td>
<td>7</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Pincer grip</td>
<td>0</td>
<td>6</td>
<td>7</td>
<td>12</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tops with front opening</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arm bending extending from the forearm</td>
<td>2</td>
<td>4</td>
<td>10</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Arm bending with forearm flexion</td>
<td>1</td>
<td>8</td>
<td>9</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Arm extension with forearm flexion (behind the back)</td>
<td>5</td>
<td>12</td>
<td>5</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Forearm extension</td>
<td>0</td>
<td>2</td>
<td>7</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>Shoulder rotation and elevation</td>
<td>5</td>
<td>12</td>
<td>7</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Forearm flexion</td>
<td>0</td>
<td>6</td>
<td>12</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Wrist rotation</td>
<td>0</td>
<td>4</td>
<td>8</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Pincer grip</td>
<td>0</td>
<td>6</td>
<td>7</td>
<td>12</td>
<td>1</td>
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</tbody>
</table>

Regarding the garments used in the study, the category of pullover tops included T-shirts, tank tops, blouses and sweaters. A pullover is by definition a garment pulled over the head, with a defined armhole and with or without set-in long and narrow sleeves. The stages required to don pullovers involve the arms, head and torso: the user has to put the head into the neckline from the inside, the arms into the armholes also from the inside and pull the front and
back down. In most cases the user is required to adjust it along the torso, neck, forearms and arms as it can get slightly displaced while it is being donned [3]. In this way, we identified the movements of alternate arm extension and flexion; neck flexion; arm bending with flexion of the forearm; shoulder rotation and elevation; pincer grip as a principal to don this kind of top.

The tops with front opening included shirts, jackets, coats, robes and button down blouses. The main characteristic of this type of garments is a full-length opening at the center front, a feature that differentiates the process of donning it from the process of putting on the garment described above, as the users have to put first one arm into one sleeve, then the other arm into the other sleeve, and only after she buttons down the font placket while adjusting the top along the torso. The main difficulty to don this type of garment is to grab the second sleeve from the back [3]. The main movements for donning this tops with front opening are: arm bending extending from the forearm; arm bending with forearm flexion; arm extension with forearm flexion behind the back; forearm extension; shoulder rotation and elevation; shoulder rotation and elevation; forearm flexion; wrist rotation; pincer grip.

In both types of tops the biggest difficulty is to don the weak side of the body. In pullover tops, the shoulder rotation and elevation is the main difficult movement; in tops with front opening, the arm extension with forearm flexion behind the back is the cause. By definition, flexion is a bending movement around a joint in a limb that decreases the angle between the bones of the limb at the joint, and extension is an unbending movement around a joint in a limb that increases the angle between the bones of the limb at the joint [26,27].

Related to the specific movements five of the women are incapable to don the top with front opening without help, especially the ‘arm extension with forearm flexion behind the back’ movement. Twelve of them do this movement with great difficulty.

The movement of ‘shoulder rotation and elevation’ is also one of the most difficult to do as well as arm extension with forearm flexion behind the back: five women are incapable to execute them and twelve of them do this movement with great difficulty.

‘Arm bending with flexion of the forearm’ is a movement that three users are not able to do, but for eleven users this movement is a level 3 in difficulty. The ‘forearm flexion’ and the ‘arm bending extending from the forearm’ movements also had most users place them in level 3 of difficulty.

The ‘arm bending with forearm flexion’ and ‘alternate arm extension and flexion’ present almost the same difficulty level, with high levels in 3, 2 and 4, respectively. Thus, the ‘neck flexion’, the ‘wrist rotation’ and ‘pincer grip’, were respectively the easier movements for both sample groups during the dressing process. ‘Forearm extension’ is also considered easier in comparison with the movements listed in the previous and penultimate paragraphs.

Subsequent to this phase, we selected eighteen women – Portuguese and Brazilian – within the group of twenty-six women to observe the dressing process of a top with long sleeves having five different fastening positions in order to test their difficulty.

In the same way we used direct observation paying special attention to the ‘fastening step’ within the dressing process, in order to evaluate the movements and the levels of difficulty for each one of the fastening positions. In this step we also used a numerical scale from 1 to 5, where 1 stands for ‘high difficulty’ while performing the task and 5 for ‘no difficulty’.

The levels of difficulty to realize each movement to fasten the garment – i.e., zip up and zip down – are quantified in table 2.

<table>
<thead>
<tr>
<th>Table 2. The five fastening positions.</th>
</tr>
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<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>Front center</td>
</tr>
<tr>
<td>Side</td>
</tr>
<tr>
<td>Shoulder</td>
</tr>
<tr>
<td>Front side</td>
</tr>
<tr>
<td>Neckline</td>
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</tbody>
</table>
The fastenings used in the test top are zippers placed at the: i) Center front – as seen in garments like hoodies, windbreakers, sports jackets, coats, etc., dividing the front in left and right from the neckline to the hem of the body; ii) Side and sleeve seams from the hem of the body to the wrist; iii) Front side positioned halfway between center front and side seams, also from the hem of the body to the wrists; iv) Shoulder seams, from the neckline to the wrists; v) Neckline, between center front and shoulder seams, 20 cm long towards the armpits.

Each woman chose to fasten the top according their weak side: if the weak side was the left the user zipped up and down the zippers placed on the left side of the top, using the right hand. Each zipper has four markings to define the limits of movements. In figure 1 the marking each user reached are identified with numbers; the pull tab represents where the zipper has to be zipped down.

In this analysis we noticed the following order for the fastening positions from more difficult to the easier: 1) the neckline zipper, 2) the side seam zipper, 3) the front side zipper, 4) the shoulder seam zipper and 5) the center front zipper.

![Fig. 1. Top with the five fastening positions.](image)

The neckline zipper is the hardest fastening to zip down, especially because the movement of forearms flexion requires more strength from both arms during handling. The difficulty level of this zipper is between 2 and 3, like the side zipper.

This last one requires a larger range of motion, or ROM. Six women only reached the first position – close the hem of the body –, and three the second position – by the armpit. The users that reached past the second position had no difficulty to zip down the top.

For the front side zipper the difficulty level is between 3 and 4, wherein eleven women are able to do it.

The center front zipper and the shoulder zipper obtained level 4 respectively. Regarding the first one, all users are able to zip up and zip down. Regarding the second, one woman can zip it up until the second position and another until the third one.

3. Discussion and conclusions

When evaluating the results of the observation, we infer that maintaining autonomy is essential for the personal and social sustainability of individuals with musculoskeletal pathologies. First because of the inadequacy of clothing due to the difficulties and limitations of women: some of these women do not dress themselves without assistance from others due to a decrease of movement, flexibility and strength.

Therefore it is necessary to identify the proper characteristics of garments in relation to the users’ abilities so as to maintain their autonomy in the dressing process for a longer period. This autonomy results in a high sense of
belonging, not just because people can dress clothes by themselves but also due to the satisfaction that comes with it, while providing the individuals a sense of personal wellness and the perceived quality of life.

However, self-sufficiency, youth and healthy stereotypes are valued nowadays, demanding that it is also of the utmost importance that clothes remain appropriate for the prevailing social aesthetic standards, so that the individual's relationship with the world – our social group – is not harmed. We thus recognize the relationship between design and sustainability – in particular social sustainability – also as fundamental to social (re)integration and maintenance of life in society [21].

We emphasize that maintaining the social sustainability of the individual, aimed at improving or maintaining the quality of life, is directly associated with autonomy. Likewise, the inclusion of kinesiological analyses in the design of clothes increases the efficiency of the dressing process, thus ensuring greater autonomy to the users.

In association, the inclusion of users in the development of design products using UCD processes increases the chances of success regarding inclusive and sustainable clothing development for the end-user and it is also a means of social inclusion. The inclusion of users before and during the design process by means of the UCD process not only provides a valuable interaction between the designer and the targeted user throughout the whole process and provides a greater identification of the final product to the end-user, as well as it increases the chance of success of the product considering the real needs of the targeted user.

In the first step of this study we noticed a high difficulty to don and doff the tops with front opening in comparison with the pullover tops, especially for women with a weak side, because it requires arm extension with forearm flexion behind the back and such movement presents difficulty in the dressing process. Besides, it requires the involvement of another person or equipment to facilitate putting on the second sleeve in most cases.

The less difficulty to put a pullover top on is especially observable when it is large and formless. It should be told that the pullover tops worn by the twenty-six were all knitted tops; the tops with front opening were made in different kinds of fabric or knits. In this phase, we noticed that a woman with musculoskeletal pathology is not able to put on a fabric pullover top unless its size and shape are totally changed.

We also verified that, for the first group of women, it is more difficult to perform movements with bigger ROM and gross motor skills than those requiring fine motor skills, due to the types of musculoskeletal pathologies they suffer from. We conclude, thus, that the easier tops to don are the ones that require a smaller amount of movements as well as a smaller range of motion, and emphasize the role played by the armholes in the dressing process.

The observation of users wearing their own clothes and the difficulties presented led us to introduce the second step of this study where we tested a top with five fastening positions. With this garment it was possible to test the fastening positions and perceive the ROM limitations as well the possibility to insert fastenings in different clothes’ positions.

Related to the side seam and the front side zippers, we identified a point of difficulty by the armpit region, due to movement limitation in this region. Similarly, the neckline zipper is considered a point of difficulty due to the necessity of having strength in both arms during handling, and on the other hand because the users did not identify to this zipper position as making the dressing process easier.

The main conclusion derived by the researchers and users’ evaluation, is that the change of position of fastenings can make the dressing process easier, since they help combine two stages of the dressing process: adjustment and fastening, thus providing greater autonomy to the users. The main reason is due to reducing the movement of the weak side. Also we highlight the importance of allowing the user to understand the fastenings positions, especially the shoulder seam and the side front zippers that were very well accepted by users. These women demonstrated interest in testing the five fastening positions and considered some of these zipper positions as a real alternative to provide them autonomy in dressing process.

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