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Biomechanics and Fashion: Contributions for the design of clothing for the elderly

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Abstract

The aging population is a growing reality in many societies and is leading to significant changes in public health policies and the strengthening of the economic sector of these countries. This scenario intensified discussions about ageing and its determinants within several areas and thus substantially reflected on the design and the projective aspects of certain objects. It is due to cognitive and physical constraints of this group, which imply the need for differentiated products that are designed properly in favor of psychological, emotional, cognitive and physical well-being of the elderly. Once the clothing remains integrated with the body, its design and constructive aspects become essential in promoting positive experience in product usage. Understanding the factors present in the acquisition and use of clothing by the elderly are relevant to the design actions of these products. Therefore, considerations about their anatomical, biomechanical and psychological characteristics must be worked in order to ensure the integrity of the movements, as well as comfort, safety and inclusion of these individuals.

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1. Introduction

The aging population is a growing reality in many societies and is leading to significant changes in public health policies and the strengthening of the economic sector of these countries. That reality could be seen initially in

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developed countries, however, over the past few years some developing countries began to present an ageing population more prevalent, thus intensifying the importance of discussing the issues related to this stage of life.

According to the World Health Organization [1] between 2000 and 2050, the world population over 60 years will increase from 605 million to 2 billion people, furthermore the elderly above 80 years will total 395 million. WHO also emphasizes that this growth rate is higher than any other age group, and is mainly the result of the raise of life expectancy, as well as of the falling of fertility rates. Eighty percent of this elderly population will be living in middle and low income countries [1].

The significant increase of this age range implies new questions about an increasing demand for individuals with specific physical and psychological needs, especially with regard to autonomy, mobility, access to information, security, and preventive health.

This scenario intensified discussions about ageing and its determinants within several areas and thus substantially reflected on the design and the projective aspects of certain objects. It is due to cognitive and physical constraints of this group, which imply the need for differentiated products that are designed properly in favor of psychological, emotional, cognitive and physical well-being of the elderly.

With respect to fashion design, this panorama has also contributed to discussions about the design of products oriented to the elderly, especially with regard to the conception of clothing, since it keeps itself in direct and constant contact with the user. Even timidly, some studies have already demonstrated specific characteristics of these individuals regarding usability and wearability issues, especially when their limitations and physical dissatisfaction are identified [2]. However, some researchers discuss that clothing with ergonomic qualities for the elderly population are scarce, possibly due to the little concern of companies and market with this age [3].

The complexity of clothing universe is justified through the interaction between body and product as well as by ability of the garment to protect and guarantee comfort to the user [4]. In this sense, the project of clothing must consider the anatomical (anthropometric and anthropomorphic), biomechanical and functional (skills and physical limitations) aspects as well as daily activities developed by the user which the product is oriented

These factors, when properly worked and handled, can interfere significantly on the evaluative aspects of the user, especially with regard to usability, wearability, comfort and safety.

In this perspective, considering the particularities of the elderly users, the problem about clothing includes physical and functional aspects inherent and characteristic of the aging process, which are determinant to the assertiveness of the fashion product in question.

However, the challenges about clothing for elderly go beyond the physical and physiological characteristic aspects of product and user and reach the universe of social and cultural relations that are established through nonverbal elements that are able to represent and materialize the subjectivity of the individual. These elements may reflect social discrepancies related to the aesthetic dilemma of what is or is not proper to the use of individuals with more advanced ages, especially in Western countries, which regard aging as a period of stagnation and exclusion.

In addition, it can be said that, at the present time, the attendance to specific segments of consumer emerges as a competitive strategy for the textile and apparel sector. Thus, with regard to the elderly user, the ergonomic design can provide appropriate tools that, when linked to the stages of clothing design, can provide more assertively safer, comfortable, effective and acceptable products [5].

In this perspective, this study is a preliminary analysis about physiological, anthropometric and biomechanical aspects inherent to aging process that may influence the usability and wearability of clothing for the elderly user. For this purpose, the research aimed to understand, in an interdisciplinary way, the problems involving the relationship of the elderly user with product within the fashion and biomechanics perspective.

1.1. About ageing

Ageing is a natural process characterized by significant physiological, psychological and social changes in the individual. From a physiological point of view, aging is characterized by declining ability of each system to maintain the balance, which directly affects the performance of human activities. In addition, factors such as increased body adiposity, inadequate skeletal muscle and loss of strength and power also contribute to the decline of physiological functions [6].

The loss of muscle strength results in physical limitations that are aggravated even more with the inactivity of the body characteristic among these individuals [7,8]. Ballak et al [9] highlight that this progressive decline in muscle function and muscle mass is presumed to be a significant contributor to the increased incidence of falls, transition to a dependent life-style and reduced quality of life in old age.

The occurrence of this natural process is called sarcopenia. According to Doherty [10], the term sarcopenia is commonly used to describe the loss of skeletal muscle mass and strength that occurs as a result of biological aging. The author also emphasizes that by the seventh and eighth decade of life, maximal voluntary contractile strength is decreased, on average, by 20-40% for both men and women in proximal and distal muscles. In another perspective, Malafarina et al [11] consider that the progressive loss of muscle mass already occurs from approximately 40 years of age.

Muscle reduction is accompanied by an increase in adipose tissue that begins to function as a sort of replacement for the muscle, leading to predictions regarding disabilities and mortality [12]. As analyzed by Visser et al [13], muscle fat infiltration may be an important risk factor for functional decline. Combined with very high rates of adipose tissue, the syndrome is named Sarcopenic Obesity, and is characterized by more pronounced symptoms such as muscle fatigue, fragility, and physical disability [12].

In parallel to the syndrome, cognitive and sensorimotor losses begin to install, contributing even more with the loss of autonomy of the elderly. The reduced thermoregulation is another factor that is also perceived. This loss is associated to a decrease in vasomotor responses of the individual and reduces the contribution of the skin to conserving or losing heat [14]. Consequently, the elderly are more likely to suffer from the adverse effects of hot or cold temperatures [14].

According to Homeier [15] aging also affects joint tissue and function. The author highlights that within the joints, cartilage becomes more brittle, and there is increased stiffness of tendons and ligaments. And complete by saying that the joints may become stiffer, less flexible, and more easily prone to injury [15].

As seen, these disorders interfere significantly in the elderly mobility, and imply biomechanical limitations that should be carefully considered and evaluated, mainly with regard to product design.

Within the biomechanics, the approach on the movements can be both through observation and description of the movements as by measuring a particular movement. Science provides necessary and meaningful data to the understanding of the body as well as of specific areas of body, which provides knowledge about the magnitudes and the reaching of certain members, as well as limitations of movement, especially when it is caused by physical constraints as well as the ones that happen to the elderly. For Schultz [16], one of the most important goals for biomechanics research in this context is to find what the critical elements of mobility impairment are.

These understandings, when added to other knowledge, such as anthropometry and ergonomics, provide important data and insights to assertiveness of the product designed for these specific users.

With regard to ergonomics, the science provides subsidy for the analysis of specific profiles of elderly users and their interaction with a particular product, task or environment. Based on the body, ergonomics works with a variety of aspects likely to be evaluated which identify the specificities of the performance of the elderly in their daily actions and tasks, demonstrating their bodily limitations.

This knowledge is of great importance, since in the design field, more specifically in fashion design, biomechanics and ergonomics can contribute to the professional guidance with respect to the adequacy of products to the physical characteristics and functional needs of the user during the use of certain piece of clothing. Considering the continuous contact between clothing and user, these data provide specific information on the development of appropriate modeling to the elderly needs, in order to contribute to the well-being and comfort of elderly users.

1.2. Modeling for seniors: usability and wearability considerations

According to Grave [04], dressing is a preventive act, therefore, all constructive and configurative aspects present in the clothing product should work in order to respect to anatomical, physiological and psychological function of the individuals. The author also demonstrates that activities such as the act of dressing require great movement and flexibility of the body, which has a significant influence in the development and quality of modeling. Thus, is

essential the evaluation in a segmented way of all part of the body that integrate clothing. For this purpose, Grave [04] divided the body into three levels (Figure 1 (a)):

- Sagittal: vertical cut that divides the body into left and right side - In this plan the modeling works directly over the body and makes clothing fits properly on the body;
- Coronal: vertical plane that divides the body into front and back side - This plan identifies the topographic differences on each side, showing curves and bumps of the body;
- Transverse: Horizontal cut that divides the body into top and bottom, defining the region of the thorax and abdomen.

The purpose of segmentation is to identify and classify patterns of movement and articulation of the body in daily activities, such as flexion, extension, lateral bending and rotation [04,17] (Figure 1(b)).

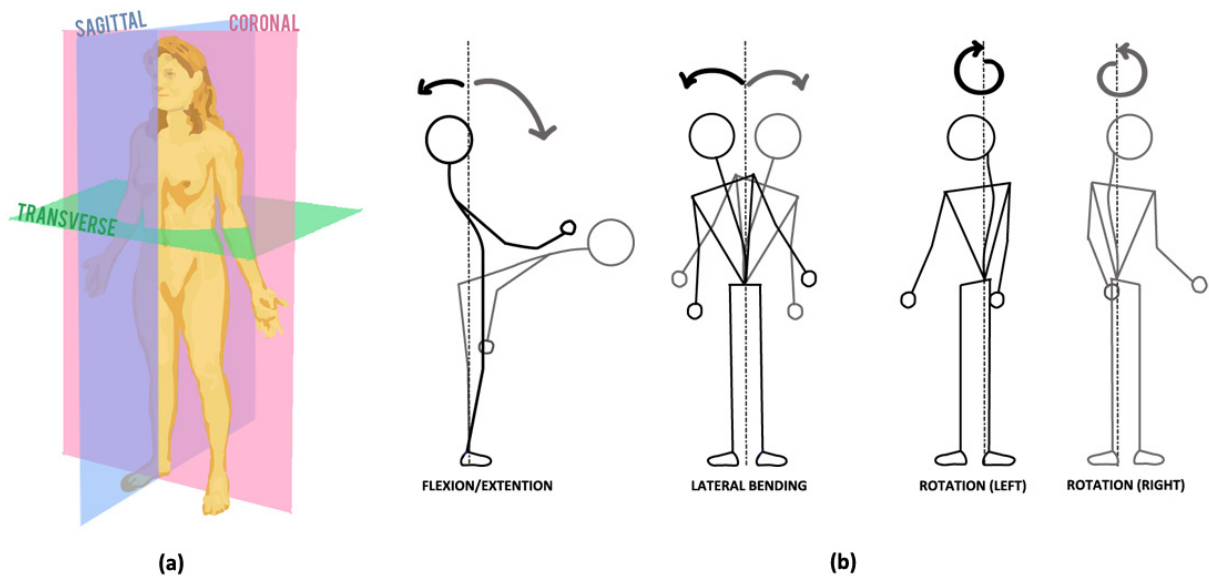


Fig. 1. Body levels according to Grave [4] and Movements

Trunk flexion occurs through the movements of the adjacent vertebrae, muscle and vertebral discs. The vertebrae slides slightly forward during movement, causing a disk compression, reducing the thickness in the front side and increasing its thickness at the back [18]. The dorsal region is propitious for previous flexion, being limited, especially in its upper part by the presence of ribs that limit the amplitude of movements [19]. In individuals with advanced age these movements become restricted, due to the reduction of muscular and articular flexibility, which can hinder the act of dressing of elderly. The act of dressing pants, skirts and/or other bottom clothing pieces, for instance, requires flexibility of torso and legs as well as the balance of entire body, so, when considered the body limitations of the elderly, these actions can be quite difficult, and even offer some risk to the user due the possibility of fall.

The movements of the neck are also part of the spine motion, and therefore should also be considered in the analysis of the process of dressing. Grave [04] indicates that the movement in this area must be always considered in the modeling procedures once the changes in head position can be impaired due to collar and sleeves of the clothing. Since the neck has seven vertebrae in activity, which allow the movement of the head and neck in extension, flexion, rotation and lateral bending/inclination, the collar needs to respect the circumference measures of both the head and the neck [04]. It is important to emphasize that in the context of elderly users the concerning with the comfort, wearability and fit of the collar must be even higher due to anatomical changes of the head and neck.

Arms and shoulder are also important parts of the body that are essential to quality and comfort of the user. The shoulder is responsible for flexion, extension, abduction, adduction, internal and external rotation of the arm. According Grave[04], considering the top piece of clothing, the draw/shape of the armhole must consider the movements of the arm and shoulder, making the work of bones, muscle and ligaments of this body part easier act with freedom.

As a result of aging, there is a decrease between the distance of the shoulders as well a change in curvature between the neck and shoulder which undergoes a slight tilt forward [19]. These factors influence both the shape of the armhole and its positioning. In addition, the increase of flaccidity in this region can contribute to the increase in the circumference of the arm. Considering this issue, the clothing, when incorrectly dimensioned, may cause stress and discomfort to the user. The movements of the arm and shoulder are also important to the dressing act, especially when considering the wearability of coats, blouses, t-shirts, and other.

In this sense, the complexity of movements in the upper part of the body requires a properly modeling project in order to make easier the movements of joints and muscles in the region. Considering the disability and restriction of the elderly walking, the arms and trunk contribute to the mobility and the balancing of the entire body, especially when considered the use of walkers, canes, handrails, and other. The wrist and hand perform multiple movements that allow more precise activities, and in the case of clothing, are important to close, open and handle with all kind of garment pieces. Considering the loss and the restriction of some of these movements and joints, performing these tasks may present some difficulties for the elderly user. Thus, some garment characteristics are of great relevance once it is important to guarantee welfare and comfort for the elderly during the activities of dressing. Buttons, zippers, buckles, elastic bands, etc., are important artifices to be considered, since they require of the wrist and hand more specific movements.

The hip joint, in turn, is important for the support of the spine and to the movements of flexion, extension, abduction, adduction, internal and external rotation of the lower limbs (thigh) [17]. Since this region corresponds to the midpoint between upper and lower limbs, its flexibility is essential to perform a variety of movements, and therefore, when responsive to the restrictive conditions of the ageing may hinder the performance of the column, knee and foot. This area is also responsible for the femoral flexion and extension movements that are essential to gait, squats, bends the knee, and others [17].

Regarding to the clothing, the movement of hips, added to the knee joint, are important for the actions of dressing, especially with regard to bottom piece of clothing. When the mobility and the balance is impaired due to physiological constrains of aging, some daily tasks inherent to dressing become practically impossible to be performed by the elderly. With this in mind, the modeling should consider tools that may contribute to the wearability of the pieces, such as the use of elastic, fabric with spandex, larger modeling, among others.

The study of motor restrictions and disabilities as well as of the morphological and physical aspects of the elderly provides important guidelines for the development of appropriate and quality modeling. All these characteristics should be explored with the objective of the understanding of the needs of these individuals. After all, as pointed by Boueri[20], it is relevant that the designer has the knowledge about the structure and the ability of articulation and mobility of the body to which a product is intended for, intending, thus, a correct interpretation of the limits and the dimensions of the body.

The modeling ergonomically designed, when properly adapted to the user, offers comfort, quality and functionality through the complicity between user-product. Allied to this, the development of textile raw materials and differentiated industrial technologies corroborate with the final quality of the items. Therefore, the joint work between ergonomic modeling, body, aesthetic and raw material, constitutes specific and qualified bases for the work of the designer.

1.3. Aging and elderly subjectivity

Ageing issues act negatively on the perception of the elderly and their personal evaluation about this stage of life. The levels of satisfaction are shaken due to the body functional disability and the increasing dependence in their daily activities [21] which is aggravated by the gradual decrease in muscle strength and endurance, balance,

flexibility and coordination [22]. Added to this, the cognitive impairment also acts negatively on the functional independence and mobility levels, making the elderly routine even more difficult [22].

The whole panorama of physiological and cognitive changes should be evaluated in order to consider the genetic predispositions of subjects and the influence of external factors such as lifestyle, personal habits, practice of physical activity, dietary, addictions, among others [23]. According Sant'Anna[24] ageing corresponds to a multidimensional concept that goes beyond the chronological assumptions and involves biological, psychological and sociological aspects.

Mainly within Western societies, the pathological condition of the aging becomes worse with the preconceptions that evaluate this stage of life as a period of stagnation and unproductive of the individual. Consequently, the psychological and emotional aspects are affected and may contribute to the seriousness of the physiological pathologies.

The influence of the media and the mentality of "stay young" stimulate the rigidity of the thinking about ageing. In the culture of appearance, most part of elderly people ends up being subdued by the unproductive and the social exclusion. This scenario affects mainly to women, who historically are more related to the culture of appearances and to the influence of social assessment of individuals. .

However, over the past few years, the increasing proportion of elderly in the total population, as well as the advances in medicine resulted in changes regarding ageing. These changes increasingly influence the way to experience ageing, which is no longer determined chronologically, but also by the social and psychological condition of the individuals.

Consequently, this process reflected on the subjectivity of the individual about their role within society, promoting new forms of social evaluation. Since the body is configured as one of the most significant channels for "subjective materialization", this becomes responsible for establishing a connection to the world through identity constructions of the subject [25]. In this sense, the changes of body due to ageing, linked to the context and socio-cultural paradigms, reflect on self-esteem of the elderly. In view of this, the clothing product becomes a favorable tool to personal image manipulation as well as to the reconstruction and materialization of the mental state of the individual. For this purpose, the clothing must be closely related to the needs and expectation of the elderly, respecting the particularities of this user in order to provide safety, welfare, comfort and notoriety.

1.4. Biomechanics of Dressing: a review on the current knowledge

How do people dress up themselves? Although each person has his/her own technique to put on clothes, pants and shoes, there are similar strategies among most people make use in order to get dressed. From a biomechanical point of view, what are the movements and muscular actions involved in the wearing process? For many users that have problems with postural balance, reduced strength and range of motion of the upper and lower limbs and motor control and coordination, dressing up may represent a challenging and dangerous task. Therefore, this knowledge is relevant and may contribute for the design of clothing that best meets users' needs and expectations, thus ensuring optimal usability.

Studies have shown that the aging process leads to a reduction of the muscular strength, postural balance, flexibility and coordination [09,22]. Although it is reasonable to assume that these changes somehow affect the dressing process, the extent to which the subject's ability to dress up with safety, efficiency and satisfaction is affected is still not known.

Biomechanics, as a field of research, has a number of methods that can be use in order to study the dressing process. Among the methods, it can be highlighted motion analysis and electromyography. The first allows the kinematic analysis of the movement of the trunk and limbs, addressing variables such as angular velocity, motion amplitude and the relative position of the body parts in a given moment of the wearing process. In turn, electromyographic data reveals muscular activity patterns and levels. Taken together, these two methods provide a wide view of the subject's actions while performing a task, in a biomechanical perspective.

Therefore, biomechanical measurements can be a powerful tool to investigate how aged subjects perform wearing tasks, contributing to identify inappropriate movements and unstable actions by objective measurements of joint angles, movements and the level of activation of different muscles. These data can be used to investigate how different designs of clothing components can influence the wearing process, providing objective additional

information on the efficiency of the task. Ultimately, it may contribute to designers in the design of clothing that allow the elderly subjects to wear it with safety, efficiency and satisfaction.

2. Final Considerations

Once the clothing remains integrated with the body, its design and constructive aspects become essential in promoting positive experience in product usage. Understanding the factors present in the acquisition and use of clothing by the elderly are relevant to the design actions of these products. Therefore, considerations about their anatomical, biomechanical and psychological characteristics must be worked in order to ensure the integrity of the movements, as well as comfort, safety and inclusion of these individuals.

These variables, when properly handled, add value to the product through the complicity and integrity in the interrelation of body x movement x clothing. Furthermore, given the close relationship between clothing and body, the fashion product generates value of judgment due to the perception of the aspects of usability, pleasantness, comfort, enjoyment and satisfaction of individual and subjective needs.

The elderly, given the physical constraints resulting from the stage of life, presents difficulties in the act of dressing and in the use of certain clothing products. In this sense, the integration among biomechanics, anthropometry and ergonomics are essential for the correct sizing of the clothing, since it protects its commitment with its users in order to satisfy their needs and expectations [2].

The study undertaken in this study exposed conflict points due to the use of clothing. The restriction of movements interferes mainly in the capacity of dressing, which may intensify the elderly negative perception about the aging. In addition, these physical disabilities as well as other bodily changes may highlight some aspects that are important to be considered regarding the quality of clothing as well as the wellbeing of the elderly. This scenario implies different perception about usability and wearability of fashion product, especially garment.

Given the ageing of population, these understandings is necessary in order to improve de products intended to this segment. Besides that, these considerations may contribute to the advancement of the textile e apparel industry, once the needs and expectation of a large portion of population can be satisfied.

The next few years will witness a growing awareness of the needs of elderly people. There is also strong evidence that elderly people are potentially the fastestgrowing consumer market in the developed world. Designers and manufacturers should make it their priority to undertake evaluative research with representative groups of end users, at all stages of the design process and, in particular, prior to the launching of products.[26].

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