REFLECTIONS ON ERGONOMIC PATTERN DESIGN IN PLANNING AND DEVELOPMENT OF GARMENTS

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***Abstract**: Ergonomics applied to product design gives safety of use and comfort to the user, thus, products designed for humans should be based on their physical and mental characteristics. The methodological procedures used were based in literature review, with the ergonomic studies here addressed being related to anthropometry, to the ergonomic relationships with the body and to comfort, necessary for the development of pattern design in the clothing production process. The discussions of this paper result from the author's master and doctoral theses, aiming to stimulate the academic community to address the relationships between these aspects and the clothing product, especially in the pattern design process, approached in detail in both studies. It is observed that the use of this knowledge and its application, make it possible to understand pattern design as a favorable and decisive element of clothing as a flexible space, that fits to different bodies and silhouettes, sizes and ages, in order to allow the user satisfaction.*

***Keywords:** Ergonomic pattern design. Comfort. Clothing.*

1. Introduction

Ergonomic studies have been intensified during World War II to encourage the development of equipment and the workspace relationship with such equipment, whose main objective was to accelerate the user's responses, so that strike and defense procedures were not compromised by errors in planning and project development. Over time these studies were widened beyond the systemic human-environment-work.

Consequently, they have extended to general product design (Iida, 2005), however ergonomic studies with garments are still limited, although discussed in two main scenarios: when performed in the context of the manufacturing production is considered both the system man-work-environment and man-object-environment; and when approached in the context of the development of the garment products. There is thus the need for deepening of ergonomic studies in the area of clothing, in the aspects of the study of the dressed body movements and suitability to the various activities carried out, in order to study the human body, its movements and interaction with the environment (Iida, 2005).

Iida (2005) and Moraes and Mont'Alvão (2003) consider that ergonomics applied to product design gives use of safety and comfort to the user, thus products designed for humans should be designed based on their physical and mental characteristics. Brown (2010), Iida (2005) and Schmitt (2004) add sensory concepts such as design thinking, emotional and experiential, which deal with the user's emotions.

Physical, physiological and anthropometric aspects are fundamental in ergonomic studies. Considering that they are essential in the design and development of garments, this paper aims to stimulate the academic community to address the relationships between these aspects and the clothing product, especially on its pattern design process. Pattern design was fundamental in the development of the garments created in the

previous master and doctoral studies, addressing the characteristics of people with special needs and high performance athletes, respectively, both being focus in designing garments to be used in sports activities. In both studies were considered the anatomical, physiological and psychological aspects, in its morphological and ergonomic relationship regarding the position and movement of the human body. The literature review, supported by authors like Saltzman (2004), Araujo and Carvalho (2014), Araujo (2009), Araujo and Carvalho (2009), Bastos and Sabra (2014), Grave (2004, 2010) Sabra (2009) Filgueiras (2008), provided the support for the importance of pattern design in ergonomic studies during the garment production process.

2. Anthropometry

Anthropometry has an ancient origin, as Egyptians and Greeks have observed and studied the differences in the proportions of each body segment. Iida (2005, p 97) states that anthropometry refers to the physical measurements of the human body "in terms of size and proportions" and is the basis to obtain the measurements, in different individual factors variations, including gender, age, ethnicity and biotype, climate influence and extreme differences.

Iida (2005) describes the anthropometric dimensions in three positions: the dynamic, which is related to the movements of the body parts and prioritizes the movement without addition of large magnitude stress; the static, which refers to the body dimensions at rest; and the functional, covering all moving parts of the body and the measurements related to the execution of specific tasks.

Relevant subject in the study of anatomy, anthropometry, biomechanics and physiology, the human morphology also involves posture and body movements. Considered as a system of levers, in which bones and muscles interact allowing movements, the human body undergoes changes in its conformation (Bass, 2010; Iida, 2005), which makes it necessary to design garment able to adapt and suit these changes. The ease values, depths, darts, folds and curves are elements that allow the relationship body-clothing-comfort (Sabra, 2009).

Workstation projects (furniture, equipment and machinery) are based on anthropometric data used in the improvement of transport, spaces and environments for better accommodation of the individual, and in product design projects in general, allowing standardization. However, authors like Razza *et al.* (2013) and Iida (2005) point out that, not always, standardization is positively used when potential users improperly acquire these products.

Razza *et al.* (2013) reported that ethnic variations, intra-individual, age, gender or climate lead to anthropometric differences, which can also occur by economic and social factors. These variations lead to the formation of different biotypes of the human body. Sheldon, in 1940, defined three biotypes (Figure 1), used as a basis for many later studies.

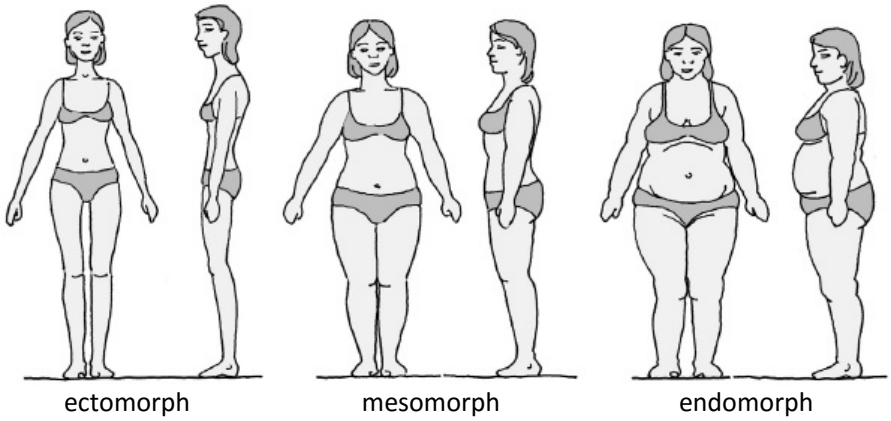

Figure 1: Biotypes of the human body according to Sheldon (1940)
Source: Iida, 2005, p 104.

From this study several biotypes were determined as triangular, inverted triangular, square, among others. Recently, the *CETIQT - Technology Center of the Chemical and Textile Industry* from *SENAI (Sao Paulo, Brazil)* conducted an anthropometric survey, *Size BR*, using images from a body scanner, with 10000 people aged between 18 and 65, from the five Brazilian regions, resulting on a map of the Brazilian biotypes, considering the regional and ethnic diversity (Bastos *et al*., 2013).

This research presented twelve biotypes[1] to be used in the manufacture of sewn products by the industrial value chain (Bastos and Sabra, 2014). These variations will provide important information for the pattern design process of the garments for the Brazilian population, as they consider the real body measurements and proportions of the body, which not always vary gradually and evenly when increasing the size of the mannequin.

3. Ergonomic relationships with the body

Ergonomic relations regarding clothing and the body involve the garment structure to the user's structure and his freedom of movements. They are directly linked to the characteristics of the textile materials and the pattern design of the garment (Filgueiras, 2008).

3.1 Ergonomic relationship body-anatomy- pattern design

Saltzman (2004) states that during the development of clothing design the body must be considered as the three-dimensional base and the support that sustains the textile material. The clothing product is projected on the basis of morphology, shape and movements of the body, this way:

> *"[...] The joints and their different angles of opening and direction require thinking garment morphology according to user activities. In this sense, joints outline formal limits that need to be considered to avoid tensions or impediments to the natural development of the body" (Saltzman, 2004, p. 30).*

The authors present clothing as a flexible space that conforms and follows the body at all times, whether in motion or at rest, and in this context, pattern design is an element that favors this flexible space.

For the development of pattern design it is crucial to know the measurements and the proportions of the human body, because "*knowing the principles of anatomy we can transfer our ideas knowing how to value the silhouette, being able to follow the contours or changing them* [...]", is also fundamental "consider that the development of pattern design has a direct relation with the volume and indentations the body's anatomy presents" (Araujo and Carvalho, 2014, p. 83). The anatomy is derived from the Greek *anatémnein* (dissect), is the science that studies the structure of organized beings, through a detailed examination of their body. The study of the anatomical shape of the human body is crucial in the area of clothing, and body measurements must be obtained precisely, because the support of the industrial fashion product is the human body, a three-dimensional and articulated structure.

To Grave (2004), a pattern design developed considering the anatomical shapes of the body is not straightforward, considering that the human body is made up of 208 bones and over 600 muscles that manifest their action by means of the central nervous system through stimulation and reactions. However, the anatomical study in order to adapt the garment design process to be used according to each market reality, must consider the heterogeneity between the male and female body and the existing anatomical differences in the bodies of people with special needs.

[1] Definition of the twelve biotypes: Bottom Hourglass, Hourglass, Top Hourglass, Triangle, Inverted Triangle, Spoon, Rectangle, Full 2, Large Build, Abdominals, Athletic and Normal 2 (Bastos and Sabra, 2014).

It is worth noting the gravitational centers as well as the antigravity supports that contribute to the body to keep its balance; the hip, responsible for mobility with a broad movement, responsible for leading the lower limbs while walking and accommodate them when sitting; the thorax, with the shoulders that play the role of balance and movement of the upper limbs; and the muscles, which distinguish the volumes of the body that determine the position and the posture, and also play an important role in the body movement.

Araujo and Carvalho (2014) consider that the necessary measurements for the creation of an anatomical pattern design are grouped according to the circumference/width and height of the pattern that is being developed and the depth of the indentations, locating its balance point, using the central, vertical and horizontal lines and the symmetrical, asymmetrical or curved lines.

The female, male and child pattern design is done based on such lines and positions. However, considering the differences in the anatomy of the bodies of the individuals with special needs, the pattern design process should consider the needed adjustments in these lines and the need to obtain the measurements individually, according to each physical impairment, and also the influence of the sitting position, which is commonly used during the time the garments is used.

3.2 Ergonomic relationship body-materials

According to the configuration of representation of the design in the procedures of the pattern design production, Araujo (2009) considers that clothing refers to a broad universe that relates to other segments and has a great interference in the economy and history. The concepts and definitions referred to clothing have multiple interpretations, ranging according to the context in which they are evaluated and used.

As mentioned by Gonçalves and Lopes (2007) the support of the industrial fashion product, in the area of clothing, is the human body, a three-dimensional and articulated structure. Since clothing establishes an intimate relationship and direct tactile contact with the body, visual and sometimes audible and olfactory, justifying the concern for the individual's well-being, considering its constant movements, able to react differently to environmental stimuli.

Garment production is complex and all aspects involved in the process should be checked, seeking aesthetical, functional and comfortable solutions, from the use of the ergonomic principles, in order to expand the benefits that increase the level of consumers' satisfaction. Thus, the emphasis on the research of the fashion trends, materials and production inputs, trimmings, properties and behavior of some fabrics, cannot be ignored during the planning and evaluation of the production process of ergonomic clothing.

When importance is given to the ergonomic issues in the selection of materials, such as fabrics, trimmings and accessories, it is important to consider factors such as the aesthetics, the fit, the absence of wrinkles in the garment when dressed (Araujo, 1996), and also the adequacy of the tissue to the user and the climate, the drape, the stiffness of the fabric, texture, softness, suppleness, flexibility, compression, toxicity and all kinds of finishings that can assure the body/skin health, safety, protection and effectiveness in relation to the welfare, as well as cost and market.

It is also important to understand that the ergonomic relationship body-materials must consider the responses of the body to the physical stimuli caused by the contact of the clothes in different types of bodies, in the various stages of life. For example, the needs of pregnant women, children, high-performance athletes, the elderly and disabled people, with respect to the properties of the textile materials, its flexibility, softness and rigidity, to be observed according to the specificities of each anatomy, physical condition and real needs of these users.

Broega and Silva (2009, p.59) reported marketing studies showing that consumers in general have increasingly demonstrated, in its garment buying decisions, interest in materials more pleasant to touch. This happens because "*if styles increasingly approach, consumers become aware that materials have different values and can make a difference through welfare and touch*". All the characteristics of the textile

materials that are in direct contact with the body, like fabrics, linings, sewing threads, embroideries, trimmings and accessories, must be considered so as not to hurt, cause skin irritations, cause pressure zones and also obstruct the actions of dressing and undressing.

These aspects need to be considered in order to avoid that the consumer, whether he has or he has not some kind of special need, feels discomfort when using any textile product, as clothing, beyond the aesthetic function, has the function of protecting our body like a second skin (Martins, 2008).

4. Sensorial, thermo physiological, psychological and ergonomic comfort

The feeling of comfort with garments is determined by its characteristics, such as the properties of heat and moisture transfer of textiles, and the physical properties as the textile structure, texture and fibers composition. Filgueiras and Araujo (2015) point out that these factors, in addition to comfort, can determine the effectiveness of the functionality that the product claims to offer.

Authors such as Li (1998), Filgueiras (2008) and Broega and Silva (2008) state that in the development of clothing, comfort should be considered as a function of the sensorial, thermo physiological, psychological and ergonomic aspects. The total comfort involves subjective and objective properties and is one of the essential attributes to attract the consumer's desire in garment products.

The feeling of comfort in the skin is a result of a combination of several factors such as the environment, the microclimate and the feeling of the fabric in the skin. It is a feeling perception, captured by the skin surface receptors and sent to the brain, which perceives and transforms the feeling as comfort or discomfort (Souza, 2008). Thus, the sensory-tactile or physical comfort is directly related to the body's responses to the physical stimuli caused by the contact of the clothes with the body. In this case, the properties of the textile materials are fundamental, such as the flexibility of the fabric, the softness and stiffness. These properties are very important regarding the selection of the materials. They should be soft and anti-allergic to skin contact, to avoid hurting and causing problems to the skin.

As for the clothing psychological and aesthetical comfort, Barnard (2003) refers that should be considered also other factors, such as the environmental, social, economic and personal style, among others. Filgueiras (2008) reports that, directly connected to the visual design, psychosocial comfort is defined by personal preferences, shapes, colors, ideologies, among other aspects, being the appearance the predominant factor, regarding the sensation the user needs to feel, according to his status, social, cultural and professional level.

Li (1998) shows that the ergonomic comfort is a physical and mental balance situation, related to the sensations resulting from the material contact with the skin and the adjustment of the garment to the body without limiting its movements. "*Deals with the structure of the garment with the structure of to the user and his freedom of movements, and is directly linked to the degree of elasticity of the textile material and the garment pattern design*" (Filgueiras, 2008).

For Filgueiras (2008, p. 63-64) the thermo physiological comfort is "*associated with the individual thermal equilibrium with the environment, i.e. when the body heat loss is equivalent to the amount of heat produced by the internal physiological processes*", thereby indicating that the thermo physiological state is closely related with the thermal sensation and the thermal comfort.

5. Pattern design in the clothing production process

The message that clothing transmits is directly related to issues such as age, gender and culture, as well as to the economic condition, social status, personal style and activity. It is essential to consider the aesthetic factors such as color, design, pattern design, sizing, cut and fit, which can be adapted to the various requirements and styles (Araujo and Carvalho, 2009).

In the current demanding and complex fashion market, a good differentiation strategy involves a constant search for product improvement, through design, the most suitable techniques to the reality of the company and, above all, through the choice of competitive advantages that allow the consumer to remember their product. The industry has been offering garments that suit the needs of consumers, according to the various activities imposed on contemporary life, but remains as a prime feature the aesthetic function "*added to comfort and functionality*" (Santos, 2009 p. 39). In addition, during the development process of pattern design, the main factors of comfort should be considered from the conceptual design, such as fit, adjustment, usability, movement, physical differences, among others (Araujo and Carvalho, 2014).

Pattern design constitutes one of most important factors with direct influence in the production process of clothing, since it involves, besides the pattern maker, the designer, who needs to work together with the various professionals involved in the process (printing, embroidery, laundry, cutting and sewing sectors), to validate the project and be understood, making it possible to be executed. The teamwork among these professionals avoids problems with low productivity and quality of the final product. Sabra and Rodrigues (2009) reported that productivity in production is related to the quality of the processes previously developed to the sewing room, beginning with the purchase of raw materials, creation of the sketches, pattern design, prototyping, cutting and labeling. Regarding an adequate quality control to ensure increased productivity and reduced production costs in the pattern design sector, the authors consider that should be tested the pattern design developed to produce the first prototype, checking the matching of he notches, seam allowances, stitch types, stitch density, machine type, needles used, sewing threads, fabric stretching, shrinkage and the garment fit. Problems with pattern design can interfere with the draping of the garment and prevent consumer satisfaction by using such product.

The experience of the authors as flat and three-dimensional pattern design professors in fashion design graduations for long periods, leads them to verify the difficulty that the fashion/design professionals have during the pattern design process. It is also observed that the pattern design academic subjects are not the most desired by students. So, only few of them are able to develop it safely, considering in their execution all the necessary knowledge to achieve the materialization of an idea until the execution of the product. According to Sabra (2009, p. 14), pattern design has meaning and significance worthy of "*study, reflection and questioning, coming from the practical and empirical knowledge, often undervalued for a planned and structured execution*". The authors believe that the "*good professional*" that operates in the textile and apparel industry, even with expertise in specific areas, should learn more about pattern design and all its meaning from its training.

For Santos (2009 p. 39) the process of developing a garment begins with the "*observation of the body, its mapping and ends with the approval of the body itself*". Understanding and giving meaning and significance to the body from the measurements, shapes and proportions, help us realize the value of ergonomic and anthropometric studies, as essential supports for the garment industry.

6. Final considerations

Pattern design is one of the fundamental procedures in the development of a clothing product, since it is through its implementation that the ideas of design take shape and are materialized, and, in many cases, can be the competitive differential of the company in the market. The pattern design process is paramount in the development of fashion products, considering it, allows the most adequate fit of the garment on the human body, independently of its specific characteristics.

The discussions raised here highlight aspects that should be considered, so that the end result enables the well being of the user, whether in safety, comfort or even functionality. This well being, reflecting the comfort, being thermo physiological, aesthetical, sensorial or ergonomic, is translated in the interest of acquiring the product.

This study is based in previous studies and reflections made from the researchers, in a master and doctoral theses, in which were developed garment products for people with special motor needs and high-performance athletes.

An ergonomic pattern design allows clothes to fit different bodies and silhouettes, different sizes and ages, and specific physical needs of the user, considering important aspects in the selection of materials such as fabrics, trimmings and accessories, the adequacy of the material to the user and climate, the fit, the stiffness of the fabric, texture, softness, suppleness, flexibility, compression, toxicity and all kinds of finishing to ensure the body/skin health, safety, protection and effectiveness of this in relation to the user's well being and satisfaction.

Thinking clothes as a flexible space, as does Saltzman (2004), is understanding it in all its project, from design to the development and construction, is understanding the pattern design process as a favorable and decisive element of this space, is reflecting the user with all his perception capabilities.

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