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ERGONOMIC ANALYSIS OF THE OPTICAL RESIDENCE OF THE CHILD

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ABSTRACT

The period of childhood is where the human body changes the most, and part of that time is experienced within your home. This fact, which raises the need for this space to be ergonomically correct and adapted to receive it, to provide full growth and body development. However, it is observed that many houses lack a good ergonomic structure and present several situations that can be harmful for this process. Thus, the present work seeks to score, analyze, and discuss what are the problems and risks that exist in homes and propose possible solutions and improvements in order to raise the housing quality of these spaces.

KEYWORDS: Child Ergonomic. Child Anthropometry. Residential Ergonomic.

1. INTRODUCTION

Reflecting on the division of time throughout a child's infancy, it is noted that a significant portion of it is experienced between school and home. Although ergonomics is widely debated today, when the subject of study is the child audience, the research is limited to school spaces, lacking investigations related to the ergonomics of the child's living space.

When analyzed from an ergonomic standpoint, the child's living space presents a series of unsatisfactory situations that can be detrimental to the child's full development over time, even leading to physical pathologies. Thus, this current work aims to provide input for the improvement of housing conditions for children, identifying and analyzing the main ergonomic deficiencies to which children are exposed in the residential environment, as well as proposing possible solutions to prevent future complications.

To achieve the outlined objective, a literature review was used as the methodology for the conception of this study. Based on the work developed by Panero & Zelnik (2002) regarding ergonomics and human anthropometry, one of the main theoretical references in the field. It establishes anthropometric standards for children, as well as dimensions ergonomically suitable for housing and activities performed within. To establish a model of residence to be studied, as it is impossible to physically analyze all existing residences, Brazilian Standards (Normas Brasileiras – NBRs) were used, developed by the Brazilian Association of Technical

Standards (Associação Brasileira de Normas Técnicas – ABNT), regarding the standardization and regulation of furniture and residential spaces, with the aim of defining a model common to existing dwellings.

2. ANTHROPOMETRY AND ERGONOMICS IN INTERIOR DESIGN

There are various definitions of anthropometry; according to Panero & Zelnik (2002), it is the science that studies the measurements of the human body in the quest to differentiate individuals. For Álvarez (2009), anthropometry, or the description of the human body through measurements, is an application of physio-scientific methods for the conception of design standards. In essence, the studies aim to collect data such as height, weight, circumferences, among other measures, to assess the size, shape, and composition of the human body. However, Panero & Zelnik (2002) emphasize that this science cannot be considered exact, given the diverse nature of human body dimensions, with many variables influencing these numbers, such as ethnicity, gender, age, socioeconomic status, diet, among others.

As for ergonomics, it studies the relationships between humans and their surroundings, seeking greater efficiency and safety in the way they interact. According to the International Ergonomics Association (IEA) (2000):

> "Ergonomics (or Human Factors) is the scientific discipline that deals with understanding the interactions between humans and other elements of a system, and the profession that applies theories, principles, data, and methods to projects aimed at optimizing human well-being and the overall performance of systems." - (IEA, 2000, p. 1).

The IEA (2000) also mentions that ergonomics can be divided into three competencies for study: Physical Ergonomics, related to anatomical and anthropometric characteristics of the individual; Cognitive Ergonomics, which extends to human mental processes; and Organizational Ergonomics, referring to the optimization of systems and processes in the corporate environment. In the field of Interior Design, ergonomic concepts must be applied to ensure the safety, comfort, and efficiency of the experience for those inhabiting the designed environment (Panero & Zelnik, 2002). Anthropometric studies act as pillars in this analysis, particularly in the physical competency.

While there are many scientific studies in the field of ergonomics and its applications to daily activities, the majority are based on the characteristics of adult individuals, especially those above the age of twenty, as addressed by Panero & Zelnik (2002). They argue that this is the period when individuals reach the peak of their growth, unlike children, who are in a continuous growth phase, and the elderly, who tend to gradually decrease in stature after maturity.

However, in design, we work with a diverse range of body dimensions. To express this vast amount of anthropometric data, percentiles are used, defined by Panero & Zelnik (2002) as the percentage of individuals within a studied group who have a certain body dimension equal to or smaller than a certain size. The Anthropometric Source Book, published by the National Aeronautics and Space Administration (NASA) in 1978, exemplifies the concept of percentiles as follows: a "k" percentile measurement - between 1 and 99 - is a value higher than each of the k% smaller values and lower than the 100% - k. The authors add that the 50th percentile is where median values are found, dividing the studied group into two, with 50% having larger measurements and 50% having smaller dimensions than the specified value.

However, Panero & Zelnik (2002) caution that, although the 50th percentile mathematically reflects the average value of the studied dimension for that group, it is a serious mistake to use it as the ideal dimension in a project. Since a specific measurement meets the needs of only 50% of the applicable group, excluding the other half.

Álvarez (2009) reinforces the idea that the "average man" does not exist, adding that in ergonomics, the statistical man is considered, taking into account the extreme values of a given measured dimension. Its application should cover 90% of the studied population, situated between the 5th and 95th percentiles, ensuring that the design choice caters to the majority of the population. The author further notes that, for circulation and opening space situations, measurements of the 95th percentile are considered because, in a sufficiently dimensioned space for an individual of greater height or body width to navigate, there will be no obstacles for a person located in a lower percentile.

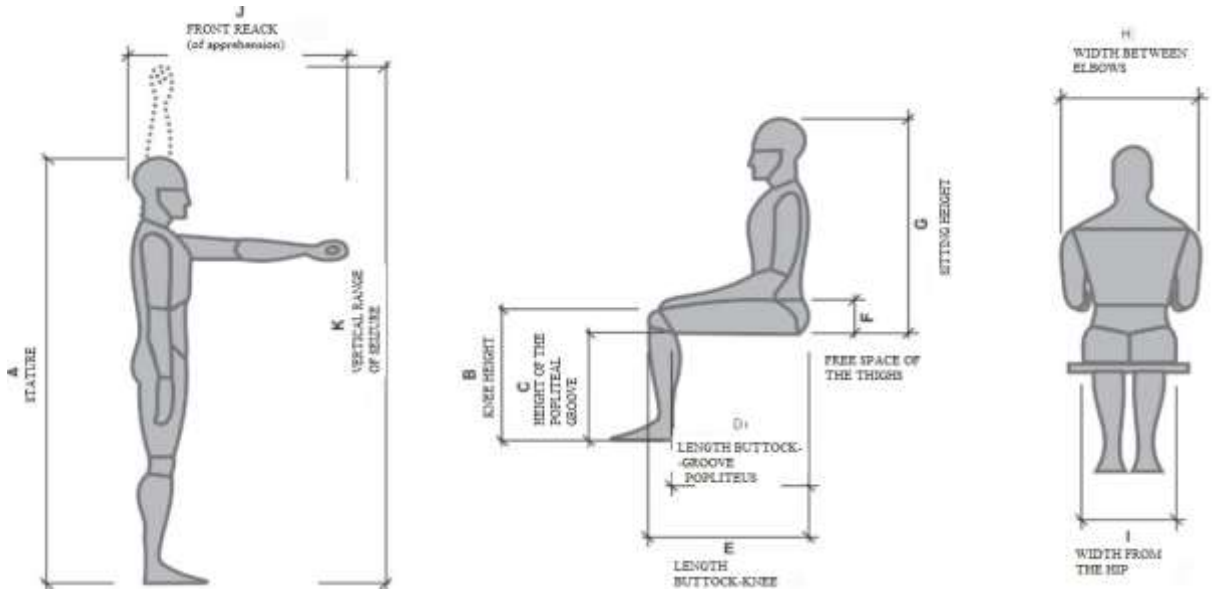
Regarding reach situations, the 5th percentile is considered, as the effort required is less for a taller person to bend down to pick up an object compared to a shorter individual trying to reach it above their range. These ideas will guide the following ergonomic analysis.

3. CHILDREN'S GROWTH AND HEIGHT

The child population is constantly growing. De Aquino (2011) defines growth as a continuous process of tissue multiplication and hypertrophy that occurs throughout an individual's life. According to her, this phenomenon is one of the main indicators of quality in a child's development, where environmental, pathological, social, and genetic factors strongly influence this process. The author discusses that, during the first 5 years of life, the growth rate is extremely high. In the first two years, it can reach approximately 36 cm and 8.5 kg. This period is most conducive to the emergence of growth disorders, which, when they occur, can reduce or even stop the growth rate, emphasizing the need for monitoring and maintaining the individual's living conditions and quality of life.

This rate tends to stabilize during the school years, between 5 and 11 years old, where the growth rate becomes almost constant, ranging between 5 and 6 cm per year. It increases again during the pubertal growth spurt, around 11 years in boys and 13 years in girls. This constant bodily modification, coupled with the various influencing factors, becomes an obstacle to establishing anthropometric standards. However, Panero & Zelnik (2002), based on other studies, present some of the main anthropometric dimensions of humans, as shown in Figure 1. The authors also provide some body measurements for adults, aged 18 to 79, and children, for an 11-year-old, allowing for a comparison of these measures, as outlined in Table 1.

Figure 1 - Main Anthropometric Measurements



Source: Adapted from Panero & Zelnik (2002).

Table 1 - Comparison of body dimensions between an adult and a child

	Percentage	Measurements expressed in centimeters.										
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**
MALE ADULT	**95**	188,6	60,3	47,8	55,1	65,4	17,5	99,0	50,5	40,4	88,9	224,8
	5	172,8	52,1	40,4	52,7	62,0	10,9	91,5	34,8	31,0	75,4	195,1
FEMALE ADULT	**95**	168,2	54,3	44,2	46,4	56,4	17,5	88,5	40,9	43,4	80,5	213,4
	5	152,3	46,7	37,8	43,7	53,3	10,4	81,2	31,2	31,2	67,6	185,2
11-YEAR-OLD BOY	**95**	157,0	50,9	41,3	48,3	53,7	14,7	80,6	37,3	30,6	*	*
	5	134,6	41,7	33,7	36,9	42,2	9,3	70,1	25,6	22,1	*	*
11-YEAR-OLD GIRL	**95**	159,7	51,2	41,7	50,5	55,9	14,9	83,4	37,4	33,8	*	*
	5	135,4	42,1	33,3	38,1	43,7	9,4	69,7	24,5	22,3	*	*

* Measurements not obtained.

Source: Adapted from Panero & Zelnik (2002).

Thus, it is possible to conjecture that, for almost all cases, the body measurements of a child will be similar to or smaller than the measurements of an adult at the 5th percentile. This prognosis is of utmost importance when analyzing the ergonomics of a residence, the objective of this study.

4. HOUSING STRUCTURE AND DIMENSIONING

Over the years, housing standards have been changing, and the basic housing needs of people from centuries ago are no longer the same as those of modern times. Due to significant technological and socio-economic advancements, the perception of housing has transformed, as Neufert (1976) explains. According to him, the houses or fortresses surrounded by immense stone walls and steel gates present in the 15th century have evolved over time, giving way to large openings and inviting entrances found in the 20th century. Neufert (1976, p.34) further states that "for modern man, the house is not a fortress to protect against enemies, thieves, and demons, but rather a pleasant, useful, and intimate setting for his life."

Thus, it becomes challenging to establish a standard typology of housing since it originates from a complex converging process of social, economic, and technical factors, as explained by Garcez (2014). However, it is possible to define common environments for all housing typologies and the activities that take place in them. Panero & Zelnik (2002) classify them as dining areas, living areas, resting areas, kitchen, and bathroom. However, for this analysis, we will also include areas dedicated to circulation. Thus, by addressing these spaces, we will encompass almost all existing housing typologies.

4.1. DINING AREA

In dining areas, the most common action is sitting at the table for a meal. According to Panero & Zelnik (2002), the chair's height should allow for full foot support on the floor; otherwise, the area behind the knees and the thighs will be compressed, causing discomfort for the user and, in the long term, circulation problems. However, a seat that is too low can cause body imbalance and remove support from the lumbar region. Still, the author states that it is more comfortable for a taller individual to sit in a lower chair, while a shorter person may find it uncomfortable to sit in a seat that is too high. Therefore, for the action of sitting, we must take into account the height of the popliteal fossa and the buttocks-popliteal fossa length of the child, which, at the 5th percentile, is 33.3 cm and 36.9 cm, respectively.

Another relevant point for the authors is the height between the top of the chair and the bottom edge of the table, where there should be enough space for thighs and necessary movements without limiting them. For this, we use the dimensions of thigh clearance at the 95th percentile, which is 14.9 cm, as it covers individuals with larger widths and also includes those at lower percentiles.

Finally, Panero & Zelnik (2002) emphasize the height of the table concerning the chair. In scenarios where the table is too high, it can overload the shoulders and become uncomfortable for meals, while if it is too low, it can cause a strain on the lower back. For this, the authors suggest the table height, relative to the floor, to be between 73.7 cm and 76.2 cm.

The NBR 9050 (2015), titled "Accessibility in buildings, furniture, spaces, and urban equipment," suggests a minimum chair height for an obese person of 41 cm and a maximum of 45 cm, with a depth between 47 cm and 51 cm. Regarding table heights, the standard recommends it to be between 75 cm and 85 cm, with a minimum free height from the floor to the bottom of the tabletop of 73 cm.

4.2. LIVING AREA

For living and leisure areas, numerous activities can be performed, with the most common associated with the action of sitting, for short and long intervals (on sofas, chairs, armchairs, or other seats). To ensure that the use of this furniture meets a diverse range of people, the same principles used for dining chairs will be applied, considering the height of the popliteal fossa and the buttocks-popliteal fossa length at the 5th percentile, which are 33.3 cm and 36.9 cm, respectively (Panero & Zelnik, 2002).

However, the ABNT 15164 (2004), a standard that regulates and standardizes the production of armchairs and sofas in Brazil, recommends that furniture should have at least 42 cm in height from the floor to the top of the seat and 47 cm of usable depth up to the backrest, although pieces with larger dimensions are also found in the market.

4.3. BEDROOMS

The bedroom is the space designated for rest. According to Panero & Zelnik (2002), the most important piece of furniture in this environment is the bed, where the action of sleeping takes

place, and it should completely accommodate the individual's body. The most relevant body measurements for this action are the height and body width of the child at the 95th percentile (159.7 cm and 37.4 cm, respectively). The author also emphasizes that, for the analysis, the presented measurements consider the body in an entirely upright position, although during sleep, we perform various movement variations.

There is no standard limiting the width and length of the bed; however, Grimley & Love (2016) mention that there is a wide variety of mattress sizes available on the market, ranging from cribs of 60 cm x 130 cm to "super king-size" beds of 193 cm x 203 cm, covering practically all possible body dimensions of a person.

4.4. KITCHENS

The kitchen is the space for meal preparation, as well as the storage of groceries and utensils. It is not common, nor recommended, for children to stay in this area. According to the Non-Governmental Organization (NGO) Criança Segura Brasil (2018), the kitchen is the room that poses the most dangers to children, as it contains objects that can cause serious accidents, such as cutting tools (knives, glass), chemical products (cleaning products), and items that can catch fire and cause burns (lighters, matches, and alcohol-based products).

In this area, prominent furniture includes cabinets, stove, sink, and refrigerator, with reaching actions being the most practiced. Regarding ergonomics, Panero & Zelnik (2002) highlight the height of the worktop and cabinets because when they are too low, they can cause discomfort, overload, and back pain. In scenarios where they are too high, it hinders reaching objects or performing activities, leading to accidents, object falls, and an increased risk of injuries when using chairs and stairs.

Therefore, the most important measure to consider is the vertical reach, at the 5th percentile, which, for an adult, is 185.2 cm. In the research, references for this dimension for children were not found. However, by comparing the height of a woman at the 5th percentile and an 11-year-old child at the 95th percentile, 152.3 cm and 159.7 cm, respectively, it can be speculated that, in most cases, the lower the percentile in which the child is situated, the smaller their total reach, and the greater the difficulties in reaching higher objects.

According to NBR 14033 (2005), the suggested height for the worktop, in relation to the floor, is between 80 and 95 cm. The total height of the furniture is not limited, at the discretion of the industry or designer.

4.5. BATHROOMS

The bathroom is the space for personal hygiene and physiological needs, with the basic furnishings in this space being the toilet bowl, sink, and shower. Panero & Zelnik (2002) recommend that the depth of the sink for children be between 40 cm and 45 cm, with a height ranging from 66 cm to 81.3 cm. However, these measurements become uncomfortable for an adult, even at the lowest percentile, which is between 48.3 cm and 61 cm in depth and 81.3 cm to 91.4 cm in height. Therefore, the author states that the final decision on the depth and height of the sink should be made by the designer, based on the users of the space.

Regarding the toilet bowl, the principles are the same as those used for other seats: the height of the popliteal fossa and the buttocks-popliteal fossa length at the 5th percentile (33.3 cm and 36.9 cm, respectively). As for the shower, Panero & Zelnik (2002) suggest that a free space of 137.2 cm × 91.4 cm is sufficient for an individual's free movement during a shower, considering the dimensions of an adult at the 95th percentile.

NBR 9050 (2015) states that, for the bathroom to be accessible to everyone, the height of the toilet bowl, with the seat, must be less than 46 cm in relation to the finished floor. Regarding the sink, the recommended height is between 78 cm and 80 cm, and the depth to the faucet

should be a maximum of 50 cm. Regarding the shower, the standard suggests a minimum measurement of the shower area of 90 cm × 95 cm.

4.6. CIRCULATION SPACES

In addition to the correct sizing of furniture, it is important to analyze other crucial aspects within a residence. One of the most mentioned in ergonomic references is the circulation space. According to Boueri (2008), the minimum space for the circulation of an adult between obstacles in a private space is 60 cm, although the adequate width for free movement or carrying objects is 80 cm. Panero & Zelnik (2002) suggest a dimension of 76.2 cm as comfortable, considering the body width of an adult at the 95th percentile, which is 57.9 cm. The authors emphasize that, for determining circulation spaces for people, we should use the larger percentile as a reference.

5. FINAL CONSIDERATIONS

Analyzing the environments, concerning dining areas, the national standard stands out, which contradicts the experts' recommendations, although it allows a dining table to be up to 10 cm higher than suggested in ergonomic references. However, regarding chairs, the dimensions of the furniture suggested by the standards are at the limit or unsuitable for the child audience, even at the highest percentile. The identified dimensions are approximately 4 cm above the 95th percentile of a child, suggesting that the younger and smaller the child, the more uncomfortable and harmful the furniture becomes. The same issues are found in living areas, where the measurements suggested by the standard are 9 cm higher than ideal for a child, and this difference can be even greater in certain cases.

As for the bedroom, few negative situations could be pointed out due to the diverse range of options available in the market, requiring only the appropriate choice of furniture by the designer and/or owner. Unlike the kitchen, which, although the least used by children, poses the most risks to the physical integrity of the child audience. Even though there are no significant long-term ergonomic impacts, the space provides a wide range of situations that can lead to household accidents. The lack of standardization of cabinet heights leaves the decision to the professional and industries. However, this process is often based on needs, commercial and business strategies, where decision-makers may not always be considering the specific needs of those who use them.

Regarding the bathroom, although there is a highly comprehensive and inclusive standard, from a child's perspective, it is not ergonomically suitable. Both for the toilet bowl and the sink, the standard suggests measurements greater than those of a child at the 5th percentile, with a difference of 12 cm and 25 cm, respectively, between the standard and the anthropometric measurements of the child. Regarding the shower enclosure, although the standard suggests a measurement below the recommended references, it is considered a space suitable for the child's body dimensions, presenting no major difficulties in movement. Finally, concerning circulation, it is conjectured that, if the project follows the recommended accessibility parameters for adults, it will provide comfortable circulation for the child audience.

In a broad context, it is concluded that, although Brazil is ahead of many countries in the world regarding concern for ergonomics, there is still a significant gap in existing standards, and in some scenarios, the absence of guidelines and regulations, especially regarding child ergonomics. It is observed that a considerable portion of the suggested dimensions focuses on adult anthropometry, disregarding the presence and needs of children in the residential

environment.

However, the need for the application of ergonomic fundamentals is not exclusive to adults, as the conception of an interior design project does not always encompass a single subject but extends to a diverse group of users, including the elderly, children, adult males and females, individuals with special needs, or those with reduced mobility. Therefore, a thorough analysis and reflection on anthropometric profiles and ergonomic needs of all users is necessary to meet their demands and add quality and functionality to the project.

In conclusion, the residence presents numerous ergonomic problems and poses various risks to children. Although it is impractical to plan it exclusively for the child audience, neglecting the needs of other users, simple measures and adaptations can help in adjusting the residence. Whether it's a footrest when sitting, a seat that adjusts the child's height in relation to the table, or keeping objects familiar to them in the lower compartments of cabinets and wardrobes. Such measures will bring practicality and efficiency to the execution of these activities, as well as prevent accidents and injuries, promoting the full and healthy growth and development of the individual, minimizing the chances of complications in adulthood.

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