

DOI: 10.20983/culcyt.2021.1.2.3

# Comparison of Assistive Orthopedic Products using the Pugh Matrix. A Universal Design and Ergonomics Approach

## *Comparación de Productos Ortopédicos de Asistencia Utilizando la Matriz Pugh. Enfoque de Diseño universal y Ergonomía*

Alana Rosa López<sup>1</sup>, Juan Luis Hernández-Arellano<sup>1</sup>, Edson Francisco Estrada-Meneses<sup>1</sup>

<sup>1</sup> Universidad Autónoma de Ciudad Juárez

### ABSTRACT

The objective of this article is to analyze the relationship between universal design and ergonomics as key factors in the design and selection of assistive products developing a comparison using the Pugh matrix. A group of users was interviewed to determine the design requirements of aid products and then, the products available in the market were evaluated to determine which could be the best. The user's needs were identified through the evaluations among patients with rheumatoid arthritis focusing on universal and ergonomic design and sixty-nine assistive products were selected. The Pugh matrix was applied to compare and evaluate them based on design criteria. The results indicate that accessibility products must be more efficient in terms of reach, grip, apprehension, pincer grasp, materials, and the force required to use the product. However, the aesthetics of the design was a key factor for the user to select the product and feel more comfortable when using it.

**KEYWORDS:** Universal design; ergonomics; Pugh matrix; autonomy; rheumatoid arthritis.

### RESUMEN

El objetivo de este artículo es analizar la relación entre el diseño universal y la ergonomía como factores clave en el diseño y selección de productos de asistencia, mediante una comparación con la Matriz de Pugh. Se entrevistó a un grupo de usuarios para determinar los requisitos de diseño de los productos de ayuda y luego se evaluaron los productos disponibles en el mercado para determinar cuál podría ser el mejor. Las necesidades del usuario se identificaron a través de las evaluaciones entre pacientes con artritis reumatoide, centradas en el diseño universal y ergonómico, y se seleccionaron 69 productos de asistencia. Se aplicó la matriz de Pugh para compararlos y evaluarlos en base a criterios de diseño. Los resultados indican que los productos de accesibilidad deben ser más eficientes en términos de alcance, agarre, prensión, agarre en pinza, materiales y la fuerza requerida para usar el producto. Sin embargo, la estética del diseño fue un factor clave para que el usuario seleccionara el producto y se sintiera más cómodo al usarlo.

**PALABRAS CLAVE:** Diseño universal; Ergonomía; matriz Pugh; artritis reumatoide, autonomía.

**Corresponding author:** Alana Rosa López  
**Institution:** Universidad Autónoma de Ciudad Juárez / Instituto de Arquitectura Diseño y Arte  
**Address:** Av. Del Charro núm. 450, col. Partido Romero, Ciudad Juárez, Chihuahua, México, C. P. 32310  
**E-mail:** al183022@alumnos.uacj.mx

Manuscript received February 8, 2020; accepted: April 4, 2021. Date of publication: April 28, 2021.



## I. INTRODUCTION

When talking about design, it is known that a solution will be given to a problem or problems where a balance between the formal, functional, structural, and use properties are sought. The first phases of any design method are emphasized in research, analysis, and planning, all of them to represent the needs in requirements, which can be legal, ergonomic, functional, formal, engineering, user, etc., always looking forward to innovation or attractive improvement to the user making it helpful.

Universal Design (UD), as well as ergonomics, is used in various fields where a wider social integration and different design factors, such as culture, ergonomics, anthropometric measurements, social background, mental/physical abilities, age, gender, abilities, physical/sensory/cognitive limitations, among others, are seen. These factors must be taken into account as they can help us to create design requirements to respond to the user's needs [1]–[5]. At the same time, UD influences the social progress of attitudes and respect towards diversity with a daily practice of inclusion [4], [6], [7].

For this reason, UD is a broad topic that can be used in different situations and fields of studies, but one of the main objectives is to make a change in inclusiveness. For inclusion to persist, it is necessary to fight against the culture that slows it down and create a counterculture on customs and ideology so the society is more reflective of its surroundings and sees its diversity thus making more people involved in long-term changes in society.

In the same way, it is taken into account that creating a product for special cases does not change the environment for everyone, however, the same product can be useful and comfortable for a large part of the population [8]. However, throughout life people go through stages and change their physical characteristics, cognitive processes, culture and activities.

Especially before the age of 65, people can contract some physical, psychological and sensory disabilities and although this does not happen to anyone. During life, people have 40% of problems of interaction with the environment, which could have originated in the childhood or in the development of the person. Some of the problems are to experience an old injury that exerts pain in the body like a sprained ankle, or simply the change of abilities when people get old.

Arthritis is an autoimmune, chronic, systematic, and inflammatory disease that causes impairment in the functional capacity of people. Due to decreased strength, movement problems, joints alterations, people reach a point of dependence that affects psychologically and socially, causing deterioration in the quality of life. Globally, rheumatoid arthritis affects 0.2% to 2% of the global population, frequently affecting women versus men with a ratio of 3:1 [9]–[11]. Additionally, the environment and the products used by people diagnosed with arthritis are not appropriate to their reality. Therefore, when it is not understood how design should work in this context, people experience more problems in their daily activities, for example, eating, showering, and putting on clothes, among others [2], [6].

As previously stated, UD is a tool that goes hand in hand with ergonomics and both are used together to create better products to give independence and autonomy to every person in their daily activities. As in the case of rheumatoid arthritis, a chronic and degenerative disease that causes problems in the functional capacity in the joints thus generating limitations in the ranges of movements, people's lives change while living in dependency, creating biopsychosocial problems. That is why technical aid or assistance products are created to help them in their environment and provide independence when doing their activities, but is very important to analyze the user experience to understand the context before starting the design process [12]–[15].

This research aims to show the relevance of UD and ergonomics to identify design requirements favoring the social inclusion of people with hand disabilities due to rheumatoid arthritis, through an evaluation of orthopedic products using the Pugh matrix.

## BACKGROUND AND CONCEPTS

### DESIGN

The human being has sought to design for himself based on modifying his natural environment to improve their activities according to the context. For this reason, the needs must consider both technical and priority criteria to develop solutions to the problems. It has been noted that the environment changes over the years, and the adjustments that the human has made must be changed because new aspects of human limitations within the natural or modified habitat have to be considered.

In any design process, the following three parallel steps are established: analysis, synthesis, and execution. These steps serve as a unified methodological structure of industrial design, that is, each author has a different name for each step within the methodology, however, everyone considers the same basis and each phase has an evaluation to obtain feedback [16]. For example, in Flores [17], two methodological processes within industrial design are shown, which are the ergonomic process and the industrial design process.

The book *Metodología de diseño para todos: Herramientas para considerar las capacidades cognitivas* [4] talks about two design processes, one of which is the “design methodology for everyone” and the other is the “People-Centered Innovation Methodology” of the Center for Innovation in Industrial Design of Mondragon Unibertsitatea, or the same design thinking that [18] exposes and although the latter is not a linear method, it is like the UD that we understand that everything leads to the same results; the variables look different but are under the same design context.

Every product designed should follow a method and/or a methodology. Regardless of the method chosen, every method has in common the improvement, change, or innovation. A defined path must be followed and the information takes the requirements where the synthesis of the quantitative and qualitative was found in context. But what happens when the user does not fit the standards? The user tends to have difficulties to develop the activities they are used to doing and increases a mismatch between the design and him.

#### UNIVERSAL DESIGN

UD, also known as design for everyone or inclusive design, shows that when a normal design is created, the designer must keep in mind that diversity is normal, that is, normal is not normal [6]. This indicates that the needs of the population should be considered more globally. There are electronic devices where this application is seen, such as cell phones, where everyone can understand it without having to do a mental or physical overstrain.

Therefore, an important part of any methodology is to understand and provide solutions to cover the user's needs, placing special emphasis in the early stages to minimize design errors in the later stages. The investigation has to lead to the requirements stage, which

focuses on the reflection of the needs that have been found as an important part of the UD. Additionally, during the process followed in the UD is essential to consider the user experience to understand the context that the design should analyze. Also, during the innovation process, the user needs that whoever lives in the world of disability should be considered in the list of requirements and specifications [8].

Typically, during the design process, the design focuses on the standard user considering both measurements and capacities, but what happens when the user does not match the standard? This creates difficulties to develop the normal activities freely and increases a mismatch between the design and the user characteristics creating the question about something that was not created for them. The UD, also known as design for everyone or inclusive design, shows that when a product is created as normal, the designer must be considering that normal is not normal. On the other hand, the daily experiences of society generate patterns that include traditions, routines, the rhythm of life, and way of being [19].

UD is a tool for accessibility and there is social inclusion within environments for different activities, including products and services. To make all things usable for everyone, regardless of the differences among the users, there are various user characteristics to consider during the design process, for example, gender, anthropometric dimensions, age, culture, dexterity, strength, capacities, and cognitive processes, among others, to improve the quality of life, and people can move freely within a more inclusive environment. This is where UD comes into action [4], [6], [20].

For this reason, UD is a broad topic that can be used in different situations and competencies, but one of the main objectives is to make a change in inclusivity. To achieve inclusion, designers must fight against culture, manners, traditional products, and the opinion of society, among others. At the same time, UD influences the social progress of attitudes and respect for diversity with a daily practice of inclusion. Also, the designer must consider that creating a product for special cases does not modify the environment for everyone, however, that same product should be useful and comfortable for the population [8].

Even so, giving way to the enrichment in the design when different aspects of the user begin to be contemplated

so that a greater range of needs can be met in favor of a better quality of life and that people can move freely in an inclusive environment, it is still missing that the UD becomes a basis for any design, because everyone talks about anatomical inclusivity and think that everything ergonomic remains with the physical body, so there is still a deficiency in some designs and interfaces. This may be because the UD is something new to product design.

Ergonomics postulates that it will always be present so that the user can enjoy their surroundings while carrying out their activities. For this reason, ergonomics extends to different specialties and is relevant in its application in direct or indirect biopsychosocial aspects so their absence is noticed at the time when people adapt to the designs and not the other way around.

It also takes into account that there are different types of users and all of them must be taken into consideration, that is, not only is there a single user who is the one we see as the target market, but that the user is everyone who interacts because there are different ergonomic relationships with the product or what is implicated in the complexity of the system, service, product or process. So there are two types of users: the primary, which is known to be the one who directly uses the product and for which the change or design was made, and the secondary, which is the one who has a direct relationship with the product, but their interaction is not the primary activity. Also in UD, different areas concern the product life cycle [6], [17], [21].

#### DIFFERENT POINTS OF VIEW OF UD

There are different points of views of the UD depending on the design process and usage. Some of them found in the literature review are shown below.

For the client, it can be reflected in investment because he buys for himself or someone else like a loved one.

For the company, it has more market diversity and market loyalty.

Design for everyone has advantages for everyone involved, such as the user, client, designer, and the company [6].

For the designer, is being able to have the fastest design process providing a better design with the contribution

of user information, which is a very important part to be able to find the main characteristics for the design of a product or service:

1. It should be simple: Everything should be reduced, not saturated in form or operations for use.
2. Adjusting to the user: User capabilities, perception, cognitive processes, actions, culture, age, habits, dimensions, physical capacities, strength, etc., must be taken into account.
3. Perception: It must be easy to understand and use.
4. Experience: This must be related to what the user knows or that can be associated with his previous experience and expectations.
5. Clear: The systems with which the user is interacting must be understandable as well as the results that are gotten.
6. Feedback: There is constant feedback to improve the design and avoid future mistakes, and if it goes hand in hand with the sustainable economy, it is oriented to better future designs.
7. Unforeseen: A threat to the product must be taken into account, which could be improper use by the user.

Within life changes, intervention is necessary for people who appear as a specific case generated by some disability that causes functional dependency, to help their autonomy with the support technologies that will be used or used in their environment for adaptation [8].

Also within the UD, different problems with their different alterations are taken into account; in this case, mobility difficulties are considered within rheumatoid arthritis due to the deformities that affect mobility where it is located in: the pincer grip, which is done by opposing the thumb to the index finger, precision work is done.

In general, hand injuries leave people with grip problem. However, in rheumatoid arthritis they cannot hold objects strong enough or for too long.

Control of small movements by inflammation, pain, stiffness together with some joint deformations, and joint movements are limited.

In design, together with ergonomics, it is also experimented to know the user and his context, where the designer's perception is changed so that he can see and

experience the situation for himself; it is a reflection about the needs. It also creates awareness and the different and new solutions that the same people create in the situation and how they face their reality can also be taken into account [6], [17].

On the experimentation, we analyze the problem, the environment, and what it encompasses must be taken into account to further analyze something more detailed. Elements are taken from the environment and activities described with perceived limitations are formed. Anthropometric evaluation, human, ergonomic, environmental, socio-cultural, and objective factors, simulations, or evaluations can be done. Different techniques for the detection of important information can be used.

Thus, it is possible to help with all the areas of knowledge with the information that has been selected so that the solution has balance in its user-object-environment triad.

When synthesizing the results for the optimum to be used, such as in the anthropometric dimensions, strength, or all that human factor that leads to achieving a greater or lesser result, especially of its capabilities and limitations that are at the ends of the hood of Gauss. To choose the data that works best, for example, can find the 5th or 95th percentile that can respond to a larger range of anthropometric needs.

Just as when it is possible to use what is simplest for the person, special populations are taken into account, which are minorities, so if the majority can use the minority normally, finally with the results, the synthesis creates the requirements that are needed to design.

## II. METHODOLOGY

The methodology shows an important part of the study design, where the methods and tools were used to generate information from our study.

**Study design.** In a design of a cross-sectional study, information was obtained from a case study of 4 people with whom instruments (questionnaires) were used to measure the quality of life in rheumatoid arthritis disease. There were taken into account demographic aspects that include sex and the number of years since the onset of symptoms.

Aspects and concepts of the user profile and the Pugh matrix are listed and defined below.

### USER PROFILE: INCLUSION AND EXCLUSION CRITERIA

Below is the user profile determined by inclusion and exclusion criteria.

**Inclusion:** male or female people diagnosed with arthritis.

Regardless of age, the severity of the disease, having a deformity of the hands, and weakness are considered. It required that people have movement in the shoulders and elbows. Within the user profile, the economic-productive occupation did not matter.

**Exclusion:** not showing nodules/deformations, discomfort, or in an advanced stage of shoulder or elbow impairment.

**Materials:** quality of life questionnaires about the disease, disability questionnaire, and questionnaires about whether they have used “assistive devices” throughout the disease; which ones, if they continue to use them; the difference they feel with the devices, in which activities they have to use them, and descriptions about their experiences.

**Assessment and exploration of the group/case study:** measuring the ranges of movement due to deformations.

To assess the point of view of healthcare professional, we conducted a semi structured interview and a survey to two physical therapist, two occupational therapist and one orthopedist. The evaluation of the orthopedic products was conducted using the Pugh matrix.

**Methods:** the instrument of Quality of Life – Rheumatoid Arthritis Scale (QOL-RA Scale) [22] was used for the arthritis-specific questionnaires. It is divided into 8 items and consists of physical ability, social interaction in their different circles as friends and family, pain, help from their closest social groups, their health, is easy to answer, and has a Spanish version.

A disability questionnaire is also taken into account and the Health Assessment Questionnaire (HAQ) is available online. The items are based on daily life activ-



ities, what people assess how much help is needed, how much, or if there is no need for help; how the people value self-cleaning, dressing, walking, hygiene, eating, reaching for objects, their activities with the disease [23]. This quality of life, disease, and disability questionnaires, as well as the assessment and examination tables, are shown in the annexes.

There were interviews with the people one by one, coming with a previous appointment with each person, and they were explained what the evaluation consisted of. With the surveys, they were asked and their response was recorded on the computer. The interview was made within a pleasant conversation so that they entered into confidence and thus make them tell their entire context from their point of view.

The evaluation of the affectations was visually when they showed their hands to be able to identify what kind of deformations they present in relation to the evolution of the disease and the evaluator assessed how many years they had been suffering with this condition. Then, in the evaluation of the joint ranges with a goniometer and a finger goniometer, the measurement of each movement of the visualized joints was carried out with a comparison of the degrees that should be achieved without difficulty. When doing grip activities, different objects were used to simulate the movements. A dynamometer was used with an individual who had the most affected hands.

The interviews with the health experts were semi-structured, so there was no pre-established questionnaire.

On the other hand, the Pugh matrix is a decision-making tool, the comparison of products or design concepts in a multidimensional arrangement for make decisions according to how many criteria are rated as worst, the same, or better. Leaving subjectivity aside, allowed the comparison of design options, its application is normally during the creation of new concepts, comparing them with what already exists as a reference for evaluation. A table of the matrix is made, on one side criteria or requirements are set, and design alternatives are placed at the top; its scale is +1 (meet or improve the criterion), 0 (meet the criterion way as the reference), and -1 (not meet the criterion or get worst). Finally, these are added and the one with the highest score is the one that meets the criteria the most, being the best solution [24].

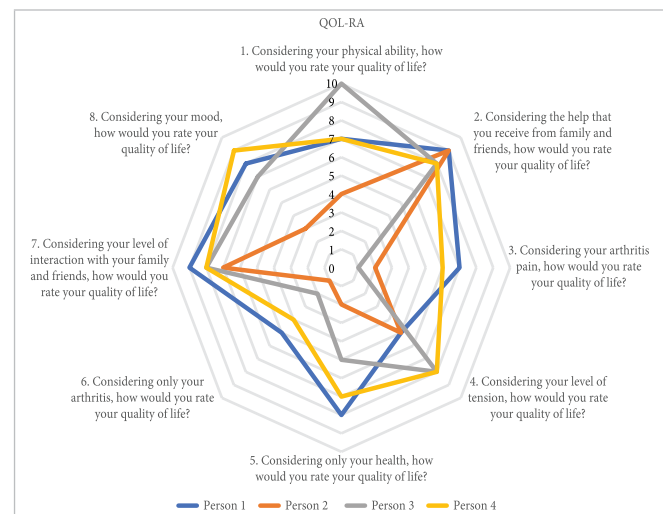
This time the Pugh matrix was used without a referential design, only the assistance products included in the table with the criteria on one side and only one score was given. Most of the assistive products being evaluated have been found in orthopedic and Internet catalogs.

The products were selected based on their usefulness and people can crucially use them with rheumatoid arthritis in different activities of daily life.

### III. RESULTS AND DISCUSSION

After reviewing the individual evaluations, graphs and tables of the results were obtained.

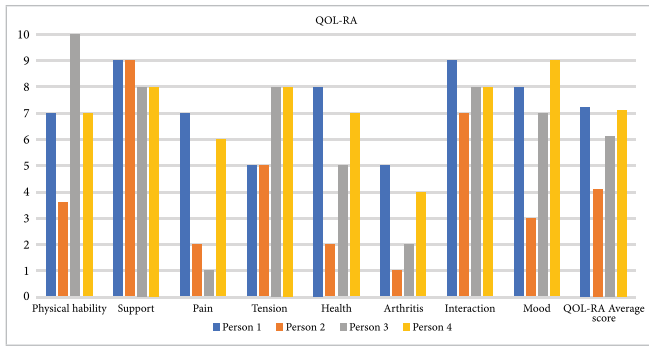
Graph 1 shows the QOL-RA questionnaire regarding the quality of life within the disease, with the 8 questions, their answers vary from 1 to 10 depending on how interviewees felt about their disease in different items.



Graph 1. QOL-RA by questions.

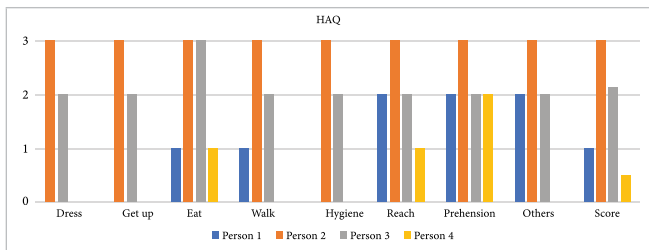
Graph 2 shows the results for each item and its QOL-RA average score.

In the QOL-RA results, interviewees consider that arthritis and arthritic pain decrease their quality of life within their disease, thus showing that it directly affects their nervous tension, and on the other hand, the help they have from their friends and family is a fundamental part for their quality of life. Although arthritis affects their physical abilities, people with AR are also psychologically compromised. Then lightening the physical aspect can help to improve mood.



Graph 2. QOL-RA by items.

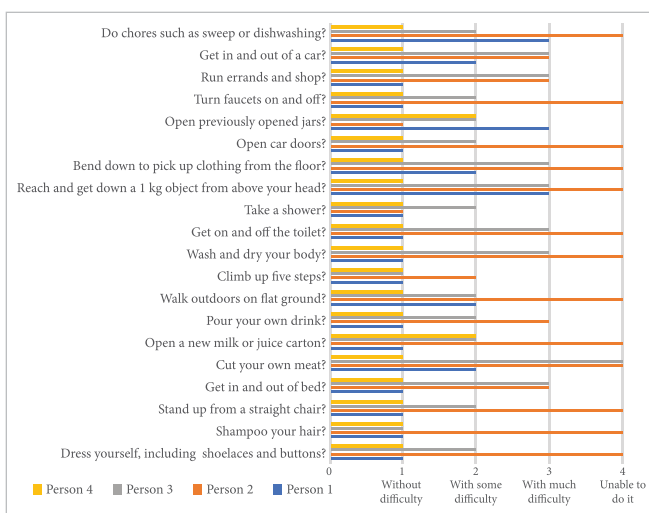
Graph 3 shows the data based on the answers to the questions on the HAQ dependency questionnaire.



Graph 3. HAQ by items.

Graph 4 shows the results that each person obtained in the HAQ questionnaire according to their items and score. Depending on the score, it is determined at what point of the disability is the subject.

- 0 a 1: mild difficulties to moderate disability.
- 1 a 2: moderate to severe disability.
- 2 a 3: severe to very serious disability.



Graph 4. HAQ by questions.

The HAQ questionnaire shows that they have more problems in grasping, reaching, and eating, following other activities that, as they put in the questionnaire, getting out or entering the car or doing the shopping or others activities not necessarily primary.

Table 1 shows the visible affectations on the hands of the patients. All the participants present ulnar deviation, two showing slight deviation and two with visible deviations, three showed a goose-neck and the rest were developing deviations, which can be taken as the most common. In two patients, interphalangeal subluxation, that is, Z deformation was manifested, and only one presented subluxation in the ring finger.

TABLE 1  
DISABILITY

PERSON	SCORE	OBSERVATIONS
1	1.00	Moderate disability.
2	3.00	Severe to very serious disability.
3	2.13	Severe to very serious disability.
4	0.50	Mild difficulties to moderate disability.

TABLE 2  
RHEUMATOID ARTHRITIS HAND AFFECTATIONS

AFFECTATIONS	PERSON			
	1	2	3	4
Slight ulnar deviation of the fingers at the metacarpophalangeal level.	●	○	●	●
Subluxation of the interphalangeal of the thumb and the interphalangeal distal index (Z deformation).	●	●	○	○
Visible ulnar deviation of the fingers at the metacarpophalangeal level. Fusiform swelling of the proximal interphalangeal burst fingers.	●	●	○	○
Subluxation of the proximal interphalangeal of the middle and ring fingers.	○	●	○	○
Boutonniere deformity – flexion in the proximal interphalangeal joint (PIP), hyperextension in the distal interphalangeal joint (DIP) results from the relaxation of the central displacement with the PIP clamping button between the lateral band.	○	○	○	○
Gooseneck is a deformity that is denoted by flexion in the metacarpophalangeal joints (MCP) and DIP with hyperextension in the PIP - it can be movable or fixed.	●	●	●	●

● = yes ○ = no

#### CHARACTERISTIC OF THE PARTICIPANTS INTERVIEWED

There were four interviewees with RA and each one had different characteristics.

1. Woman, 26 years with the disease who indicates that the severe deformations were in the first years, she did exercise like walking.
2. Woman, 32 years with the disease who indicates that severe deformations.
3. Woman, 30 years with the disease, has her whole life exercising.
4. Man, 8 years with the disease, has his whole life exercising.

### RANGES OF MOVEMENT AND GRIP

First, wrist movements are almost unaffected in supination and pronation. In the evaluations of the measures, notes were made about the activities that were carried out. All four subjects had grip difficulties.

In the results of the measures of range movement, they show that the right hand was more affected. In accordance with an interview with a doctor indicates that according to the use that is given to the hand, it is how it degrades, as well as the ulnar deviation of the metacarpal and proximal joints that the deviation is generated by the continuous movement of the hand. For this reason, that in this case, the right hand is the first to be affected.

As well as in the other interviews, the health experts, who were a chiropractic doctor, two physiotherapists and an occupational therapist, in which all agreed that the first thing that becomes affected are the hands, which causes a difficult to carry out activities that depend on clamping, very large or very fine joint movements, and the force decreases. Along with the help of the employees of an assistance store, it was found that aesthetics is very important to the user.

TABLE 3  
RIGHT HAND/ THEY CAN GRIP

TYPE GRIP	PERSON			
	1	2	3	4
Cylindrical	●	●	●	●
Tip fingers	●	●	○	●
Handle	●	●	●	●
Palm grip	●	●	●	●
Spherical	●	●	●	●
Key	●	●	●	●
Pincer grasp	●	●	●	●

● = yes ○ = no

TABLE 4  
RIGHT HAND / THEY HAD DIFFICULTIES

TYPE GRIP	PERSON			
	1	2	3	4
Cylindrical	●	●	●	○
Tip fingers	●	●	●	○
Handle	●	●	●	○
Palm grip	●	●	●	○
Spherical	●	●	●	○
Key	○	●	●	○
Pincer grasp	●	●	●	●

● = yes ○ = no

TABLE 5  
LEFT HAND / THEY CAN GRIP

TYPE GRIP	PERSON			
	1	2	3	4
Cylindrical	●	●	●	●
Tip fingers	●	●	●	●
Handle	●	●	●	●
Palm	●	●	●	●
Spherical	●	●	●	●
Key	●	●	●	●
Pincer grasp	●	●	●	●

● = yes ○ = no

TABLE 6  
LEFT HAND / THEY HAD DIFFICULTIES

TYPE GRIP	PERSON			
	1	2	3	4
Cylindrical	●	●	○	○
Tip fingers	●	●	○	○
Handle	●	●	○	○
Palm	●	●	○	○
Spherical	●	●	○	○
Key	○	●	○	○
Pincer grasp	●	●	●	●

● = yes ○ = no

### THE WEAKNESS OF THE PARTICIPANTS DURING THE TASKS DEVELOPED

Person one.

- With the cylindrical grip, she must reposition her body for the grip and help herself with the other hand.
- Fingertips: left grip with the first three fingers. Same situation with the right grip. Clearly showing that movement and force are exerted with the first three fingers.



- Spherical: she does it with the first three fingers, the last two have full flexion.
- Handle: correct pressure.
- Palmar: wrist hurts after writing, hurts to write, she likes thicker pencil gauge.
- Pincer grasp: use her body for balance.
- Who was tested with the dynamometer and gave 10 kilograms-force.

Person two.

- Cylindrical: puts force on the hand palm.
- Spherical: hardly uses his hand palm.
- His right hand has almost no movement, although he could do the activities, she has to position the objects with her left hand.
- Due to the progression of the disease, she must already reposition her hand to be able to do the activities as well as person 1.

Person three.

- The grip with the right thumb is not correct since it can barely support it, she expected surgery, but she

will continue without mobility of the thumb, in the left hand, she does not present mobility problems.

- The pincer grasp force does with the proximal phalanges of the right-hand thumb, the other phalanges of the other fingers are used, everything is correct with the left hand.

Person four.

- It does not have any problems and without so much evolution of the disease.

### ASSISTIVE DEVICES

Interviewees filled out a questionnaire about the assistive devices, in which they were asked if they have used any or some, their experience with them, and they were shown images of the most representative to reinforce the help so that they could recognize them. They were also asked which would be more useful or what would change those who already had, which they had not seen, etc. And based on the responses, Table 6 was made with the responses.

TABLE 7  
ASSISTIVE DEVICES

QUESTIONS	1	2	3	4
Have used	She uses a jar opener but feels that it's not useful at all. She uses the OXO peelers because their handles are wide and with a soft non-slip texture, in addition to the shape and thickness of the grip, it facilitates the movement from the inside out without twisting the wrist. She indicates that it uses rubber bands on objects to be able to open them using them as a non-slip surface and thus exerting more force when opening lids.	She uses a toilet seat elevator.	She has not used any kind of assistive products and is only aware of canes, wheelchairs, or walkers.	He has not used any kind of assistive products and is only aware of canes, wheelchairs, or walkers.
Activities are affected by something	The can opener is fine but you need support when holding the can with the other hand as you need more help when gripping. He mentioned that smooth doorknobs are a problem and more so if they are completely round. Difficulty buttoning the buttons.	She needs both hands to bring 250 ml to her mouth. It is difficult to pour the drink; this may be due to a decrease in strength or a smaller diameter of the lid. Difficulty buttoning and unbuttoning the shirt. She doesn't use his right hand much.	She has no mobility of the right thumb. Grip problems, for very large or very small diameters, for example, a jar or a bottle. Smooth surfaces are a problem, reaching things above the head (this can be a problem for the shoulders and the entire upper limb and force applied), cutting a steak can also be a problem.	Grip problems, for very large or very small diameters, for example, a jar or a bottle. Smooth surfaces are a problem, reaching things above the head (this can be a problem with the shoulders and the entire upper limb and force applied), cutting a steak can also be a problem.

TABLE 7 CONTINUED:  
ASSISTIVE DEVICES

QUESTIONS	1	2	3	4
Activities are affected by something	<p>Pincer grasp and the application of force are difficult in various activities.</p> <p>In the grip of diameters greater than 8 cm or very small for example a jar or a bottle.</p> <p>It is exhausting to hold a cup (250 ml) for a while.</p> <p>It hurts after writing for a certain amount of time.</p>	<p>Grip problems, for very large or very small diameters, for example, a jar or a bottle.</p> <p>Smooth surfaces are a problem, she reaches things above the head (this can be a problem for the shoulders and the entire upper limb), cutting a steak can also be a problem.</p>	<p>applied), cutting a steak can also be a problem.</p>	
Comments about showed assistive devices	<p>She thinks that long grippers (Easy Reacher) can be a little bit awkward to handle.</p> <p>Vertical knife handles can hurt your shoulders.</p>	<p>She did not know about so many products but she would like to know more about them and be able to purchase them</p>	<p>She did not know about so many products but she would like to know more about them and be able to purchase them.</p>	<p>He didn't know about the products and would not use them unless he really needs them.</p>
Interests	<p>An object that can have multiple uses could be helpful but as long as it does not obstruct the hands.</p> <p>She indicated that she wants to speed up activities.</p> <p>Exercise is also a point of her interest.</p> <p>She also indicated that clothing should be redesigned for people with rheumatoid arthritis.</p>	<p>Being able to open the jars, products for keys to help with her pincer grasp problem, a bath brush and something to hold a pot.</p>	<p>She is more interested in shoes and products that help grip.</p> <p>Exercise is also a point of her interest.</p>	<p>Little or no interest at all.</p>

### REQUIREMENTS IDENTIFIED

Once the evaluations were conducted and the results were obtained, the list of requirements for products to find out which of them would be the most efficient for people with rheumatoid arthritis were divided into four categories (force, movement, activity, and design) and are presented below. In the following list, the numbering may not be sequential because each digit represents the number of the requirement, which, in turn, falls into different categories (movement or activity).

#### FORCE

1. Do not use more than 10 kg of force.
2. Avoid continuous effort.
3. That avoids pain: that it can be automatic or without so much effort, lever, and not so much force.
4. That mainly helps in grasping, reaching and eating.
5. Helping with the grip of diameters greater than 8 cm or very small than 3 cm, for example, a jar or a bottle. In the palmar grip, there will depend on how thick

it is with the hand palm and the phalanges that must have a slightly more elliptical grip, during the grip.

6. Weigh a maximum of 250 g.
7. Help the first problems in the hand: in the grip, prehension and pinch.
8. Something to carry something heavy things.

#### MOVEMENT

7. Help first the problems in the hand: in the grip.
9. It can be used with hand palm and 3 fingers.
10. Not much flexion or extension of the wrist.
11. Use more of the rotary motion of the elbow or shoulder.
12. It can be easily taken with 2 hands, individually, be used with both hands regardless of whether it is right or left-handed

#### ACTIVITY

12. It can be easily taken with 2 hands, individually, be used with both hands regardless of whether it is

- right or left-handed
4. That mainly helps in grasping, reaching and eating
  13. Do not disturb the other flexed fingers use more rotary movement of the elbow or shoulder that it can be taken with 2 hands easily, individually, be used with both hands regardless of whether it is right or left-handed
  14. Helps with large or very fine joint movements
  15. Multipurpose.
  16. Let your hands-free to move

#### DESIGN

14. Helps with large or very fine joint movements
15. Multipurpose.
17. Proper grip at hand
18. Extension for grip
19. Attractive/innovative that does not reveal a disability.
20. Materials: a non-slip grip with materials such as silicone and texture that gives it more support.
21. It can use a base product like ABS to prevent it from moving. They can be materials such as ABS, ABS/TPR, implant grade platinum silicone, and/or stainless steel for more resistance.
22. If it is for grasp for heights above the head.
23. If it is to open jars, because of one of the main problems in their daily life.
24. Curved shape without affecting lacerations – ergonomic.
25. Make it easy to understand: here are the shapes, colors, what the user can easily recognize to understand their use, as well as code usage.
26. Easy to clean: preferably without difficulty to clean holes.
27. Dimensional diversity from the 5th to the 95th percentile: for example; for the length of the handle, it can be 95 of hand width which is 90 mm.

The requirements obtained are general and the list is the minimum that the products must be meet to be more efficient. Then, sixty-nine different products were evaluated with the identified requirements to know which could be the best assistive product for people who have affectation in the hands due to rheumatoid arthritis. When having the evaluation of the products, only those with scores between 19 and 22 points were included in Table 8. The one-touch automatic jar opener and the tap turner were the products with the highest score.

TABLE 8  
HIGH SCORE PRODUCTS

No.	PRODUCT	SCORE
1	One-touch automatic jar opener	22
2	Tap turner	22
3	Automatic bottle opener one touch	21
4	One-hand squeeze opener	21
5	Capkey screw cap opener	20
6	OXO good grips peelers	20
7	Universal spinner	20
8	Universal one-touch opener	20
9	One-touch automatic can opener	19
10	Bottle, jar and can opener	19
11	Bottle, jar and can opener	19
12	Multifunctional kitchen table	19
13	Knob handle extension lever	19
14	Norco Deluxe wrist support with universal cuff	19
15	Better grip on hot cookware	19

Aspects evaluated in the assistance products were two: the activities that can be performed with the products, and the ability of design to perform the activities, focusing on the difficulties that people with affectations in the hands due to rheumatoid arthritis.

#### IV. CONCLUSIONS

Nowadays the UD, as well as the ergonomics, can already be seen as an indispensable duo to apply UD in any field. For this, the users' experience must be taken into account, and the designer can acquire a broad knowledge about the problem being faced, as long as it is aimed at the capabilities of minorities, which can work for the majority of the population. When a specific problem is going to be attacked, many points must be considered that globalize the environment of that same problem, the design can be a social change if there is more integration of the same minorities for daily activities to have an effective result. The designer always needs a good investigation about the case; for this reason, more designs are needed where the entire population fits to bring more benefits to the entire society by being able to increase the quality of life for people.

Derived from the interviews, 27 design requirements for assistive devices were identified and divided into four areas: force, movement, activity and design. It can be concluded that assistive products should be more efficient in the areas of grasping, clamping, pincer grasp, large or

fine joint movements, materials, usage codes, aiding in recreation, eating, assisting with the strength people can have when using a product and as users specified. There is a field of opportunity in clothing design since users complain that dressing is a problem because clothes and shoes are not designed for elderly people. It was also perceived that a key point for a product is the aesthetics of design so that users feel comfortable wearing them.

The products that have higher scores have in common that they have innovation in their design, they can be used in different activities, there are also automatic products and those that are for the same activity have different measures so that they can be used in different objects. Among the requirements that are produced, they can get more specific for a particular activity or a multipurpose product.

Although such a strong relationship was not found between years and deformations due to the disease, it was found that if the person has more physical activity throughout his life (not only at the time of the disease), along with control of the medications on time, joint problems may be delayed. One detail observed was that rheumatoid arthritis attacks the dominant hand more frequently.

When developing a new product or improving one for a growing market, product evaluations are needed. One of the most important issues/items to consider is the user experience in handling the products that are already on the market, because a person who lives in a different reality is not in direct contact with a problem, some facts can be ignored and the results could be affected. There are some artifacts that are considered to work properly or are easy to understand, but it has to be proven if they have a good performance, or how they can be improved, and take all the opportunities that can be changed to reach a technological development.

## REFERENCES

- [1] G. Rodríguez-Morales, *Manual de diseño industrial: Curso básico*, 3rd ed. México: UAM-A/Ediciones G., S. A. de C. V., 1983.
- [2] INTI, *Proceso de diseño: Fases para el desarrollo de productos*. Buenos Aires, Argentina: Instituto Nacional de Tecnología Industrial, 2009. [Online]. Available: <https://karabato.files.wordpress.com/2009/12/proceso.pdf>
- [3] J. Lillo and H. Moreira, "Envejecimiento y diseño universal," *Anu. Psicol.*, vol. 35, no. 4, pp. 493–506, 2004. [Online]. Available: <https://www.raco.cat/index.php/AnuarioPsicologia/article/view/61801/88585>
- [4] F. ONCE/Vía Libre, *Metodología de Diseño para todos: Herramientas para considerar las capacidades cognitivas*. Madrid: Fundación ONCE/ Vía Libre, 2018. [Online]. Available: <https://www.plenainclusion.org/sites/default/files/metodologia-diseno-para-todos.pdf>
- [5] C. Alba-Pastor, *Aportaciones del Diseño Universal para el Aprendizaje y de los materiales digitales en el logro de una enseñanza accesible*. Madrid, España: Universidad Complutense de Madrid, 2012. [Online]. Available: <https://www.infoap.edu.pe/wp-content/uploads/2020/12/Aportaciones-del-Diseño-Universal-para-el-Aprendizaje-y-de-los-materiales.pdf>
- [6] F. Aragall, *Diseño para todos: Un conjunto de instrumentos*. Madrid, España: Design For All Foundation, 2013. [Online]. Available: <https://avilesmasaccesible.files.wordpress.com/2013/01/disec3b1o-para-todos-un-conjunto-de-instrumentos.pdf>
- [7] C. Rodríguez-Porrero, *Discapacidad y calidad de vida*, 2020. [Online]. Available: <http://www.ardilladigital.com/DOCUMENTOS/CALIDAD DE VIDA/CALIDAD DE VIDA Y BUENA PRACTICA/Discapacidad y calidad de vida - Rodriguez Parrera - articulo.pdf>. (Accessed: Jan. 1, 2020).
- [8] R. Proveda et al., "Facilitación de la vida cotidiana mediante el diseño y la selección adecuada de tecnologías de apoyo para personas mayores con dependencia funcional," *Rev. Multidiscip. Gerontol.*, vol. 15, no. 3, pp. 155–164, 2005. Available: [https://sid.usal.es/idocs/F8/ART11659/facilitacion\\_vida\\_cotidiana\\_mediante\\_el\\_diseño.pdf](https://sid.usal.es/idocs/F8/ART11659/facilitacion_vida_cotidiana_mediante_el_diseño.pdf)
- [9] A. Morales-López, "Artritis reumatoide," *Rev Med Cos Cen*, vol. 70, no. 607, pp. 523–528, 2013. Available: <https://www.medigraphic.com/pdfs/revmedcoscen/rmc-2013/rmc133y.pdf>
- [10] D. M. Prada-Hernández et al., "Evaluación de la calidad de vida relacionada con la salud en pacientes con artritis reumatoide en el Centro de Reumatología," *Rev. Cuba. Reumatol.*, vol. 17, no. 1, pp. 48–60, 2015. Available: [http://scielo.sld.cu/scielo.php?script=sci\\_arttext&pid=S1817-59962015000100008](http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S1817-59962015000100008)

- [11] IMSS, *Guía de Práctica Clínica GPC. Diagnóstico y Tratamiento de Artritis Reumatoide del Adulto. Guía de Referencia Rápida*. México: Instituto Mexicano del Seguro Social, 2016. [Online]. Available: <http://www.imss.gob.mx/sites/all/statics/guiasclinicas/195GRR.pdf>
- [12] I. G. de Boer, A. J. Peeters, H. K. Ronday, B. J. A. Mertens, T. W. J. Huizinga, and T. P. M. Vliet Vlieland, "Assistive devices: Usage in patients with rheumatoid arthritis," *Clin. Rheumatol.*, vol. 28, no. 2, pp. 119–128, 2009, doi: 10.1007/s10067-008-0989-7.
- [13] W. C. Mann, D. Hurren, and M. Tomita, "Assistive devices used by home-based elderly persons with arthritis," *Am. J. Occup. Ther.*, vol. 49, no. 8, pp. 810–820, 1995, doi: 10.5014/ajot.49.8.810.
- [14] I. Shipham, "Rheumatoid arthritis: hand function, activities of daily living, grip strength and essential assistive devices," *Curationis*, vol. 26, no. 3, pp. 98–106, 2003, doi: 10.4102/curationis.v26i3.857.
- [15] H. Tuntland, I. Kjekken, L. Nordheim, L. Falzon, G. Jamtvedt, and K. Hagen, "The Cochrane review of assistive technology for rheumatoid arthritis," *Eur. J. Phys. Rehabil. Med.*, vol. 46, no. 2, pp. 261–268, 2010, doi: 10.7916/D8BK1C6M.
- [16] G. S. Sol, *La trama del diseño: por qué necesitamos métodos para diseñar*, 1st ed. México: Editorial Designio S. A. de C. V., 2009.
- [17] C. Flores, *Ergonomía para el diseño*, 1st ed. México: Librería, S. A. de C. V., 2001.
- [18] DINNGO, "Design thinking." Designthinking.es. <http://www.designthinking.es/inicio/> (accessed Oct 17, 2019).
- [19] V. Ariza et al., *Usuario, diseño, entorno*, 1st ed. Ciudad Juárez, México: Universidad Autónoma de Ciudad Juárez, 2010.
- [20] J. V. García et al., *¡Pregúntame sobre accesibilidad y ayudas técnicas!*, 1st ed. Madrid: IMSERSO, 2005. [Online]. Available: <https://gestion.ibv.org/gestoribv/index.php/productos/descargables/97-preguntame-sobre-accesibilidad-y-ayudas-tecnicas/file>
- [21] J. Hernández and K. Gómez, *Manual de prácticas de antropometría biomecánica y fisiología*, 1st ed. Ciudad Juárez, México: Universidad Autónoma de Ciudad Juárez, 2015.
- [22] S. Vinaccia, H. Fernández, E. Moreno San Pedro, and G. V. Padilla, "Spanish Quality of Life Measure for Rheumatoid Arthritis (QOL-RA) Tested in Colombia," *Rev. Colomb. Reumatol.*, vol. 13, no. 4, pp. 264–270, 2006.
- [23] F. J. Ballina-García, "Medición de la calidad de vida en la artritis reumatoide," *Rev. Española Reumatol.*, vol. 29, no. 2, pp. 56–64, 2002.
- [24] "La Matriz de Pugh Para La Toma de Decisiones y Otras," Nov. 28, 2018. Accessed on: Jan. 1, 2020. [Online]. Available: <https://es.scribd.com/document/394400029/La-Matriz-de-Pugh-Para-La-Toma-de-Decisiones-y-Otras>
- [25] R. B. Salter, "Trastornos inflamatorios de huesos y articulaciones," in *Trastornos y lesiones del sistema musculoesquelético*. Barcelona, España: Masson, D. L., 2013, ch. 10.
- [26] J. H. Klippel and P. A. Dieppe, *Practical Rheumatology*, 1st ed. London: Mosby, Ltd., 1995.