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A Systematic Literature Review About Application of Pervasive Games in Rehabilitation

Jeferson Arango-López [1], Luis Fernando Castillo Ossa [1], Francisco Luis Gutiérrez Vela [2], Cesar A. Collazos [3], Habib M. Fardoun[4]

[1] Universidad de Caldas
Calle 65 # 26-10, Manizales, Caldas, Colombia
E-mail: jeferson.arango@ucaldas.edu.co, luis.castillo@ucaldas.edu.co

[2] Universidad de Granada
Calle Periodista Daniel Saucedo Aranda, s/n, 18071 Granada, Spain
E-mail: fgutierr@ugr.es

[3] Universidad del Cauca
Calle 5 Nº 4-70, Popayán, Cauca, Colombia
E-mail: fgutierr@ugr.es

[4]Ahlia University
Manama, Bahrain
E-mail: hfardonn@ahlia.edu.bh

Abstract. Videogames have gained great interest in the computer science community, to such that this interest has expanded to the area of health. This situation is due to the results obtained with gaming experiences that have supported the rehabilitation therapies of people with physical and mental difficulties. Most rehabilitation activities (such as physical and mental exercises) are monotonous and boring for patients. From there, it is essential to generate and maintain the motivation of patients in rehabilitation processes. The Pervasive Games (PG) is a proposal that helps patients to increase and maintain their motivation. Previously, patients managed to improve their performance only through intense and frequent exercises with elements of the real world. This article presents an exhaustive review of 101 final studies (with a base of 1849) which seeks to identify the specific use of PGs in the rehabilitation processes of patients and the results obtained through the implementation of spatial, temporal and Social expansion. This research will help to propose a basis and strengthen the use of PG as a rehabilitation tool in some procedures.

Keywords: Rehabilitation, Pervasive Games, Health Technologies, Game.

1. Introduction

This is an extended version from a paper presented at the conference Rehab 2019. The rehabilitation of patients with physical and mental problems is an important process in the immediate future for the quality of life of these people. The purpose of rehabilitation is to improve the movement of patients, so, they can independently perform daily tasks on their own (Shapi'I, Bahari, Arshad, Zin, & Mahayuddin, 2015), for instance, the exergames propose as a potential tool to improve the current practice of musculoskeletal rehabilitation (Tannous et al., 2016). In the field of health sciences, rehabilitation is considered a transcendent point since it depends on how a person will recover after a surgical procedure or how it will evolve in the middle of a therapeutic treatment.

Physical problems are the most common in rehabilitation, since they can be caused by work accidents, home accidents, sports injuries, among others. What leads to having a negative psychological impact with the change of leading a normal life – with the possibilities of continuous mobility without restrictions –, to have the limitations given by an accident where fractures can be generated in upper or lower extremities, head, abdomen, among others. These mental processes are limiting that a patient may have, which can directly affect their performance in the rehabilitation process.

On the other hand, videogames have gained great interest in the computer science community, to such that this interest has been extended to other areas of knowledge such as health. This is the positive consequence of the use of these gaming experiences as support for rehabilitation therapies for people with physical and mental difficulties. The majority of traditional rehabilitation activities (such as physical and mental exercises) are monotonous and boring for patients (Garcia & Navarro, 2014; Tageldeen, Elamvazuthi, Perumal, & Ganesan, 2017; Torres, López, & Guerrero, 2016), which generates a decrease in the execution of these, which does not allow these people to advance in recovery. For this reason, it is essential to generate and maintain the motivation of patients in rehabilitation processes.

PGs allow patients have a better user experience than traditional therapies, avoiding boredom and monotony each day in the processes of rehabilitation. thus, PG support these processes and increase motivation by the inclusion of technologies such as sensors, augmented reality, virtual reality, robots, tabletops, among other devices.

Videogames, and even more PGs promise to provide a better user experience, which generates greater motivation in the interaction. In addition, this type of games allows in different ways the incorporation and integration of the real world and the virtual world. This generates an increase in the patient's motivation to perform rehabilitation activities through the use of technological tools.

For this reason, we want to carry out a systematic literature review (SLR) to understand the way in which games are used in rehabilitation. In this specific case we want to evaluate the use of PGs (including all the technologies associated to these games such as sensors, robots, tabletops, etc) as a support tool in rehabilitation processes. In addition, it is planned to identify the rehabilitation processes that most use PG and the associated technologies with this type of games. It is also important to identify the levels of pervasiveness in which most of these PGs are immersed.

The objective of this study is to perform an SLR that allows obtaining information about the objectives stated in the previous paragraph. Thus, we want to provide a basis for researchers in this area of knowledge to understand and be clear about the state of research fields and can support each of these. Previous studies have carried out successful searches that have generated this impact in the scientific community in a general field (Arango-López, Collazos, Gutiérrez Vela, & Castillo, 2017) and in an educational context (Arango-López, Ruiz, Taborda, Gutierrez Vela, & Collazos, 2017).

This article is structured in the following way. In section 2, we describe the main concepts that are used in rehabilitation through games. In section 3, we present the methodology that was used to carry out this study. In section 4, the results of the study are discussed. Finally, the conclusions and future work are established in section 5.

2. Background

The concepts of rehabilitation, game and PGs are presented below. In addition, we indicate the analysis carried out and the discussion about the research problem. Finally, we describe the different works related to the classification and application of PGs in-patient rehabilitation environments.

2.1 Rehabilitation

Rehabilitation assists patient to achieve functional Independence, and improve their motor skills (Kwakkel, Boudewijn, & Lindeman, 2004). The rehabilitation is known with the set of techniques and methods that serve to recover a function or activity of the body that has been reduced or lost due to an accident or illness. This process is performed on patients to improve their quality of life, whether in mobility and / or mentality. The traditional way in which the recovery activities of a patient are carried out becomes boring and annoying for many of them, which generates a decrease in the rehabilitation activity.

Rehabilitation centers can adopt various types of technologies and tools that support the therapies of patients. In consequence, these therapies can be carried out in closed, open spaces, specialized centers and / or in the patient's home. Also, there are supervised and not supervised therapies considered by specialists. Recent approaches that involve the use of interactive video games have shown positive results in exercising as users engage in physical activity while playing a game (Garcia & Navarro, 2014).

2.2. Games

Games have been present in the lives of people for a long time. Traditional games involved the use of physical elements by players. Time passed and videogames generated a revolution in this field and attracted a good number of new players. Some of the keys to the success of videogames with respect to traditional games are: the creation of the illusion of being immersed in a virtual world with graphics and sound by computer, the definition of objectives typically more interactive than those of traditional games and the design of games with an optimal level of complexity, which can provoke the curiosity of the players in an easy way.

In the area of health, games have been widely used as a support tool in different rehabilitation and treatment processes. These have been implemented with the support of sensors, computers, consoles, robots and other elements. The games significantly increase the motivation of patients in their recovery processes. But, like rehabilitation techniques, these games also evolve and that is one of the main motivators for this study.

2.3. Pervasive Games

Pervasive games represent a radically new game form that transfers gaming experiences out into the physical world, weaving ICTs into the fabric of players' real environments (Kasapakis & Gavalas, 2015). Many different forms of gaming have been grouped under the concept, including the massively collaborative troubleshooting games (The A.I. Game), the location-based mobile games (Botfighters), the games augmenting the reality with ludic content (Visby Under) and the games staged with a combination of virtual and physical elements (Montola, 2005).

Some authors consider a pervasive digital game as a game in which the player's experience is extended to the real world. That is possible through the use of device's sensors (Viana, Ponte, Trinta, & Viana, 2014). These games are a recent form of entertainment that brings the game experience out of the device and into the physical world, integrating both virtual and physical realms (Valente, Feijó, & Leite, 2015). In addition, it introduces a new game experience that is possible to play wherever and whenever the user wants, this combines virtual and real objects, places and people, and even the gaming time with real events. Pervasive games break the boundaries of the circle that is around classic games (Montola, 2005).

In this study, we want to delve into the field of PGs used in rehabilitation processes to identify their impact, their characteristics and the main areas that are used by doctors and physiotherapists.

2.4. Discussion

In different studies (Baranyi, Willinger, Lederer, Grechenig, & Schramm, 2013; Eckert, Gómez-Martinho, Meneses, & Martínez, 2017; Guneysu, Siyli, & Salah, 2014; Prahm, Kayali, Vujaklija, Sturma, & Aszmann, 2017; Shah, Basteris, & Amirabdollahian, 2014) it has been identified that traditional rehabilitation processes are boring and monotonous for people, which generates demotivation in patients who perform the activities proposed by physiotherapists, and even more, when these sessions are due perform from home through self-supervision. The games have been used as tools that support these processes. To identify the advantages of the use of these technologies, it is necessary to carry out studies that allow knowing the current status of the progress of patients in their treatments with and without the use of the devices name above.

We need to identify the appropriate functionalities for the devices, and how these together with the PG can provide additional motivation to patients that will positively impact their treatments improving in their quality of life. In addition, we are interested in knowing the results with gaming experiences and technological devices in the rehabilitation of patients with different age range within a specialized center or at home.

3. Systematic Literature Review

A SLR is a method to analyze, evaluate and interpret the relevant studies in a specific field of knowledge in which you want to investigate. Despite being a method used in medicine, it has been extended to other areas, while in the area of engineering several approaches and methodologies have been proposed to direct this process. Kitchenham and Charters (Kitchenham & Charters, 2007) formulated a set of guidelines to perform an SLR with a model of trust, rigor and continuous auditing in the field of engineering. This methodology was chosen to perform this SLR.

3.1. Literature Review Need

A consequence of the current wide adoption of mobile computing is the emergence of mobile and pervasive gaming (Soute, Bakker, Magielse, & Markopoulos, 2013). Which generates new opportunities in different fields of action of the PG as is the field of health. Patients who must perform monotonous activities get bored during this process. Therefore, it is necessary to analyze the current state of the application of these new technologies and their results, with the aim of proposing new options for the application of this type of games in the rehabilitation of patients. Thus, the need for this SLR is focused on studying the current status of PGs applied in rehabilitation processes and be the basis to propose new research that leads to improve the quality of life of patients.

3.2. Research Questions

The purpose of this work is to identify the use that PGs are given within the field of health, specifically in the physical and mental rehabilitation of patients. In this way, we want to define the state of art of PGs in the area of patient rehabilitation. In addition, to carry out a categorization of the technologies used in the PGs for each of the rehabilitation processes. Finally,

taking into account the different expansions that are part of the pervasiveness, we want to specify the health areas that use each one of these with greater frequency. In this way, the research questions were formulated in Table 1.

Table 1. Research Questions for the systematic literature review.

ID	Research Question
RQ1	Are the PGs used in the patient rehabilitation processes?
RQ2	If the PGs are used, What are the most used technologies for this purpose and how are they implemented?
RQ3	What are the areas of health that commonly use PGs as a support tool and how they relate to each level of pervasiveness?

Continuing with the methodology phases given by (Kitchenham & Charters, 2007) and conducting this review, we considered to apply PICOC model (Chamberlain, Martínez-reyes, Jacobs, Watkins, & Shackford, 2013) to define the main concepts (Table 2).

Table 2. Definition of concepts using PICOC.

ID	Concepts
Population	Researchers, Doctors, Medicine Students, Physiotherapists.
Intervention	PG used in the rehabilitation process.
Comparison	Traditional techniques used to support the rehabilitation patients.
Outcome	Categorization of PG, devices and rehabilitation types.
Context	Academic level, research level and medical level.

3.3. Search Terms

With PICOC analysis, arise a set of general concepts. These concepts are defined as related terms between them. Next list shows the terms:

1. Pervasive games
2. Game
3. Rehabilitation
4. Healthcare
5. Therapy

3.4. Data Origin

In order to search for relevant information in the research, it was necessary to

evaluate the specialty of a set of digital databases. The specialties considered to filter the databases were the areas of videogames, technology, computer science, therapies, health and rehabilitation. The chosen databases are shown in Table 3.

Table 3. Digital databases list.

ID	Digital Databases.	URL
DB1	Scopus	https://www.scopus.com/
DB2	ACM Digital Library	https://dl.acm.org/
DB3	Directory of Open Access Journal – DOAJ	https://doaj.org/
DB4	Springer Link	https://link.springer.com/
DB5	IEEE Xplore	http://ieeexplore.ieee.org/
DB6	Web of Science	https://webofknowledge.com/

3.5. Query Strings

For the search of information in the databases defined in the Table 3, it was necessary to incorporate in the research the search chains to be executed in each of these, specifying the syntax for each database, and thus obtain the best results. The strategy for the construction of the chains is based on the definition of the main terms and their synonyms. Jointly, the search has been limited in articles published since 2013 to the present, in order to better analyze the most recent results. The search chains that were built are exposed in Table 4 and are based on the logical combinations of the previously mentioned terms.

Table 4. Query strings for each database.

ID	Database	Query String
SS1	DB1	TITLE-ABS-KEY (“Pervasive Game” OR “Game”) AND TITLE-ABS-KEY (("Healthcare" OR "Therapy") AND "Rehabilitation") AND (PUBYEAR > 2012) AND (LIMIT-TO (LANGUAGE , "English "))
SS2	DB2	((acmdlTitle:("Pervasive Game" "game") OR keywords.author.keyword: :("Pervasive Game" "game") OR recordAbstract:("Pervasive Game" "game")) AND ((acmdlTitle:("healthcare" "therapy") OR keywords.author.keyword: :("healthcare" "therapy") OR recordAbstract:("healthcare" "therapy"))

		AND (acmdlTitle:("rehabilitation") OR keywords.author.keyword: :(" rehabilitation ") OR recordAbstract:(" rehabilitation ")))
SS3	DB3	Game Rehabilitation
SS4	DB4	((game OR pervasive) AND ((healthcare OR therapy) AND rehabilitation) with filters: English, Health Informatics, Conference Paper.
SS5	DB5	(((((((("Document Title":"Game") OR "Author Keywords":"Game") OR "Abstract":"Game") OR "Document Title":"Pervasive Game") OR "Author Keywords":"Pervasive Game") OR "Abstract":"Pervasive Game") AND ((((((((p_Title:"Healthcare") OR "Author Keywords":"Healthcare") OR "Abstract":"Healthcare") OR "Document Title":"Rehabilitation") OR "Author Keywords":"Rehabilitation") OR "Abstract":"Rehabilitation") OR "Document Title":"teraphy") OR "Author Keywords":"teraphy") OR "Abstract":"teraphy")))
SS6	DB6	(TI=(("Pervasive Game" OR "Game") AND (("Healthcare" OR "Therapy") AND "Rehabilitation")))

The search chains shown in Table 4 were executed in the corresponding database on January 10th, 2018.

3.6. Research Selection Criteria

To select the main articles of the searches and analyze the most relevant, inclusion and exclusion criteria have been generated. Which are shown below.

Inclusion Criteria

1. Paper published between 2013 and current date.
2. Paper published as result of conferences, congress or journals.
3. Paper written in English.
4. Paper included into databases shown on table 3.

5. Paper associated with these topics: Health, Pervasive Games, Rehabilitation and related.

Exclusion Criteria

1. Paper only with content table or resume.
2. Paper not related to a research.
3. Paper not related to Health, Pervasive Games, Rehabilitation and related.
4. Paper which does not fulfill at least one of inclusion criterions.
5. Short papers.

3.7. Extracting Information

The execution of the search chains yielded a total of 1849 records. Which are distributed in the different databases as shown in Table 5 and Figure 2.

Table 5. Initial results of the execution of query strings.

Digital Database	Amount of Papers
DB1	769
DB2	82
DB3	12
DB4	326
DB6	351
DB5	309
Total	1849

The most representative amount is presented in the Scopus search engine (41%), this is logical because this search engine indexes a large number of scientific journals related to the health area. In a smaller proportion (slightly less than 50% with respect to Scopus) and almost equivalent to each other are Web of Science (17%), IEEE XPlore (19%) and Springer (18%). Finally, in a smaller amount is ACM Digital Library with 4% and DOAJ with only 1%.

4. Data Analysis and Results

In the first place, having the complete list of results, we analyze each of them to identify the first indications to filter the articles. The length of these was verified to separate short articles, tables of contents and indexes, and duplicate articles. With this process, 615 articles were discarded (Figure 1).

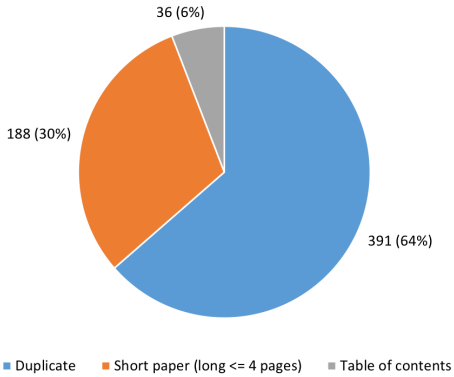

Figure 1. Number of items discarded in the filter of short articles, tables of contents and duplicates.

In Figure 1 it is evident that the same paper is indexed in different databases, which generates duplicity, these duplicate items represent 64% (391) of the articles rejected in the first filter. Secondly, we find the number of papers rejected for their length, those were 188 (30%) short articles were found. Finally, 6% (36) of the articles in this first filter were rejected as tables of contents or indexes.

4.1. Applying Aditional Filters

According to Table 5, where total results are presented, we analyzed each paper evaluating its title and abstract. We read these sections, checking that each one had relation with the topic research. Results are shown in Table 6.

Table 6. Results later title and abstract filters were applied.

Database	Initial Amount	Title Filter		Abstract Filter	
		Rejected	Accepted	Rejected	Accepted
DB2	407	181	226	178	48
DB4	312	16	23	4	19
DB5	263	1	8	3	5
DB6	204	258	54	33	21
DB3	9	96	167	98	69
DB1	39	66	138	94	44

Total	1234	618	616	410	206

The numbers obtained in the execution of the title and abstract filters are represented in comparison with the initial number of articles after applying the first filter explained in before. In each database the decrease in similar proportions in each stage of the search. Being IEEE Xplore (69), Scopus (48) and Web of Science (44) the most representative, and with less quantity are Springer (21), ACM DL (19) and DOAJ (5).

Subsequently, when the filtered articles were taken (in total 206), the full text review was initiated. In this way, the characteristics and fields of application that each of them described in their content were identified. Thus, the number could be reduced to 101 articles, this because the content of many of these articles was not related to our field of research. The number of papers filtered in each database with respect to the full-text filter is shown in Figure 2.

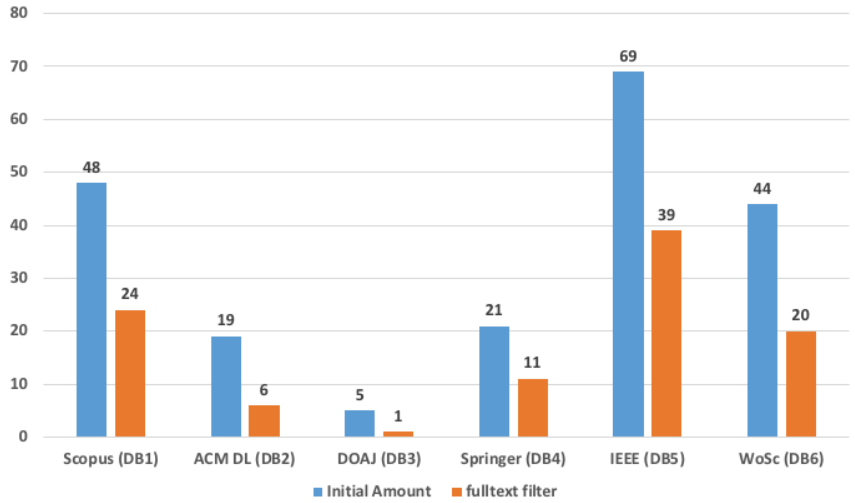

Figure 2. Cantidad de artículos descartados en el filtro de texto completo para cada base de datos.

4.2. Process Description

In summary, after the initial search where 1849 articles were found, we apply the first exclusion filter based on the characteristics of the article (table of

contents, length of the article and duplicity), which generated a list of 1234 articles. Subsequently, the filters of title and abstract were applied, these generated 616 and 206 articles respectively. Finally, 101 articles were obtained by applying the full-text filter. From this last amount a deep analysis was generated to solve the research questions. In this phase, we were sure of the relevance of each article.

With this process, we can define that the number of articles with the most relevance (101) corresponds to 5.5% of the initial number, and to 8.2% of the quantity after the first filter. Subsequently, based on these results, a classification of categories and subcategories of the main topics was made. Then, based on this classification, the tables shown below were generated (Table 7, Table 8 and Table 9), these are a summary, so to see the complete classification of the results, Appendix A should be revised.

Table 7. Summary data of the game category records.

Category	Subcategory	#	**Studies**
Game	Pervasive Game	31	0009, 0010, 0018, 0020, 0040, 0175, 0176, 0178, 0328, 0360, 0391, 0394, 0425, 0477, 0528, 0572, 0577, 0673, 0775, 0789, 0828, 0973, 0974, 0991, 1026, 1084, 1096, 1616, 1623, 1768, 1797
	Serious Game	5	0054, 0127, 0135, 0185, 0218
	Health Game	80	0004, 0009, 0010, 0019, 0023, 0033, 0070, 0087, 0096, 0127, 0135, 0164, 0167, 0171, 0176, 0180, 0191, 0204, 0205, 0218, 0231, 0232, …
	Space Expansion	6	0009, 0010, 0528, 0577, 0801, 1096
	Time Expansion	1	0577
	Social Expansion	10	0018, 0360, 0396, 0673, 0960, 0973, 0991, 1084, 1616, 1797

Table 8. Summary data of the rehabilitation category records.

Category	Subcategory	#	**Studies**
Rehabilitation	Wrist	3	0360, 0425, 1092
	Orthopedic	1	0364
	Stroke Patient	25	0004, 0010, 0019, 0024, 0033, 0049, 0054, 0070, 0096, 0135, 0185, 0218, 0328, 0394, 0396, 0496, 0574, 0775, 0778, 0801, …
	Ankle Sprain	5	0020, 0049, 0346, 1282, 1808

Table 9. Complete data of the devices category records.

Category	Subcategory	#	**Studies**
Devices	Microsoft Kinect	28	0018, 0033, 0070, 0096, 0127, 0205, 0231, 0232, 0318, 0323, 0394, 0474, 0477, 0496, 0520, 0775, 0778, 0801, 0828, 1015, 1026, 1059, 1163, 1203, 1366, 1429, 1573, 1653
	Gloves	1	0019
	Robot	35	0004, 0009, 0023, 0024, 0033, 0049, 0054, 0087, 0164, 0167, 0171, 0180, 0191, 0204, 0253, 0346, 0364, 0508, 0572, 0574, 0673, 0775, 0883,…
	Sensors	64	0010, 0049, 0054, 0070, 0096, 0164, 0175, 0178, 0180, 0204, 0205, 0218, 0232, 0253, 0272, 0279, 0312, 0318, 0328, 0346, 0360, 0364, 0391, 0425, 0435, 0454, 0477, 0496, 0508, 0528, ….

Game Controls	11	0010, 0054, 0087, 0178, 0396, 0425, 0789, 0960, 1165, 1616, 1797

The three categories defined in the previous figures correspond to the generalities that were found in the SLR. In addition, efforts were focused on answering research questions. In these figures, the findings of the revision of the complete text are shown, it is clear that an article can be contained in different categories and subcategories.

On the other hand, the study also allowed identifying the populations to which this type of advances in technology and rehabilitation are directed, which are shown in Figure 3.

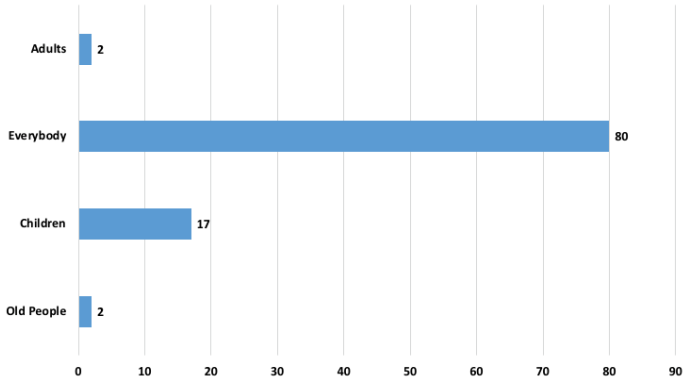

Figure 3. Studies categorized by the target population.

The previous figure shows that the child population has a great reception towards these implementations, perhaps because they are at the age where PGs are most liked and can have a better user experience. Regarding adults and older adults, it can be said that specific PGs are not developed for them, only a few studies of this type are visualized.

4.3. Results

Based on the SLR and the analysis of results, the answers to the research questions presented in this study are presented below.

RQ1

In the SLR, different studies were found that show the work that has been done in the rehabilitation processes with the support of the PGs. On many occasions, they are not named in this way, but through the analysis made based on the elements of pervasiveness identified in Figure 1, it can be affirmed that the selected studies have a level of pervasiveness that positively affect the real life of the patients. As can be seen in Figure 9, articles related to PGs in different areas of rehabilitation were found.

It is possible to distinguish the importance of PG in rehabilitation processes of stroke patients with 25% of the findings. Also, patients who are in general physical therapy are an important part of this study with 29%. Then aspects related with rehabilitation in the arms (16%) and patients with cerebral palsy (11%). In this way it can be stated that PGs are used in the rehabilitation processes of patients with physical and mental problems.

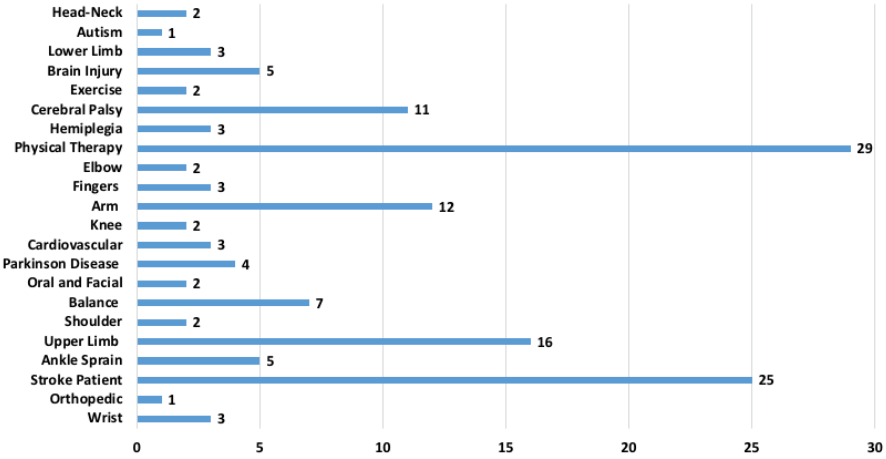

Figure 4. Amount of papers for each subcategory of the rehabilitation category.

Patients with lower limb problems are also benefited with this type of technology (Fusco & Turchetti, 2015; Imam, Miller, Finlayson, Eng, & Jarus, 2017; Palacios-Navarro, García-Magariño, & Ramos-Lorente, 2015; Punt, Ziltener, Monnin, & Allet, 2016), since their level of motivation is even lower because they are often unable to mobilize themselves, which puts a barrier between their mood and the goal of recovery. Thus, a patient who has an objective in the game, can indirectly have an increase in the real objectives

of his rehabilitation. Also, studies were found that support social pervasiveness, encouraging a group of patients to cooperate with each other to achieve individual goals.

RQ2

As mentioned in the RQ1 response, PGs are widely used in the rehabilitation processes of patients with physical and mental disabilities. Also, this study allowed us to classify the types of games that are most relevant in these rehabilitation processes (Figure 5). There, it is possible to identify types of PG and implementation technologies used to improve the user experience, as an example is the expansion of the game world: 1. Real world: 64, 2. Virtual world: 49, 3. Mixed world: 81.

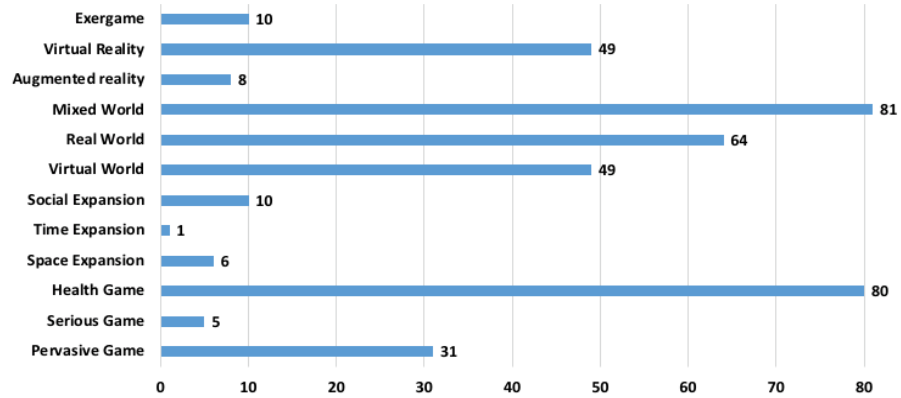

Figure 5. Amount of papers for each subcategory of the game category.

In this same line, several studies (Dehem et al., 2017; Goršič, Cikajlo, & Novak, 2017; Jaarsma et al., 2015; Novak, Nagle, Keller, & Riener, 2014; Prahm et al., 2017) have found studies related to the increase of motivation in therapy sessions and procedures related to rehabilitation. This is why the close relationship between these two areas of knowledge is demonstrated in order to improve the quality of life of patients and accelerate rehabilitation compared to traditional techniques.

On the other hand, according to the analysis carried out, the implementation of the PGs in the rehabilitation processes is done through the experience of the doctors and/or physiotherapists. There is no a general model

that allows defining the type of PG or pervasiveness recommended in a specific case of recovery. However, the success of this union of knowledge areas is undeniable. With the evidence of the use of PGs in the rehabilitation processes of patients, it was necessary to identify the most used technologies in this field. This is how we decided to classify the devices used. Consequently, it was possible to identify technological trends in this area (Figure 11). In Figure 6, it is evident the use of technologies based on sensors (64), robots (35), commercial consoles such as those presented by the Microsoft Kinect (28) and the Nintendo Wii (16) to support the activities of rehabilitation.

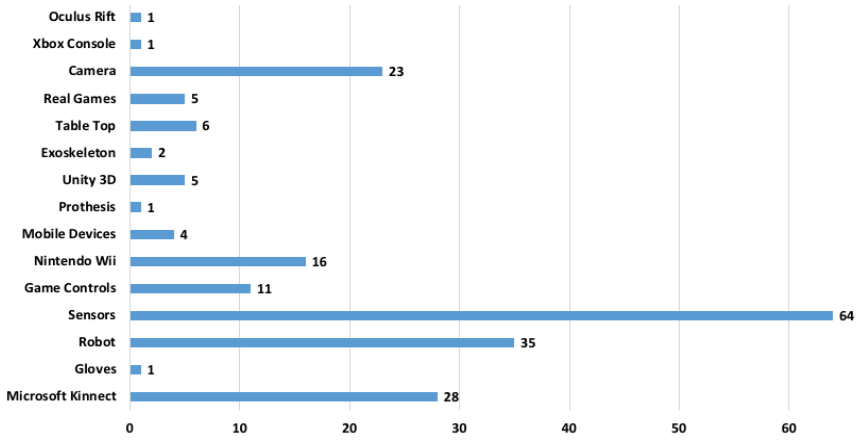

Figure 6. Amount of papers for each subcategory of the device category.

During the classification process, we could also identify an effort that is being made so that the rehabilitation activities are done from home. In this way, figures corresponding to the selected articles were obtained and are shown in Figure 7. There, it is demonstrated that although therapies were previously carried out in specialized centers, nowadays the comfort of the home is being sought to perform these activities, this among other technologies thanks to tele-rehabilitation.

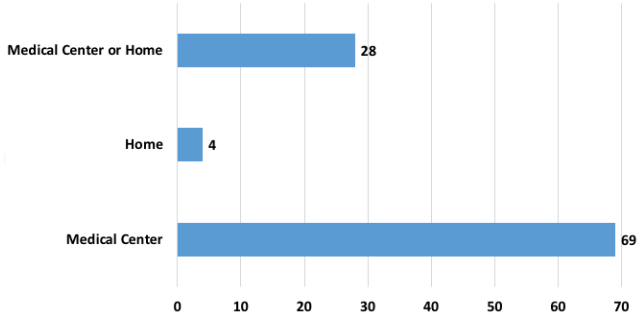

Figure 7. Amount of papers classified by place of activities.

RQ3

As aforementioned in the RQ1 response, PGs are widely used in the rehabilitation processes of patients with physical and mental disabilities. In that section, Figure 9 is shown, which shows the different parts of the body that are rehabilitated with the support of the PG. However, if there are differences between the amounts of studies carried out between some areas and others, thus, it is possible to affirm that the largest number of studies (identified throughout the investigation) focus on problems related to the rehabilitation of patient stroke, cerebral palsy patients and rehabilitation of upper limbs. This can be detailed in the Figure 8. That figure shows the relationship between each rehabilitation field and the different pervasiveness expansion and technologies.

These special cases, in general, are related to spatial and social pervasiveness, leaving aside the temporal pervasiveness (only 1 study considered it). This can also be evidenced in the way a therapy session is developed, where there is social interaction with other patients and with therapists. Taking a look at the technological devices used (Figure 6), the characteristics of the implemented PGs can also be defined, where the sensors are a fundamental part of these for the location and identification of the movements of the patients.

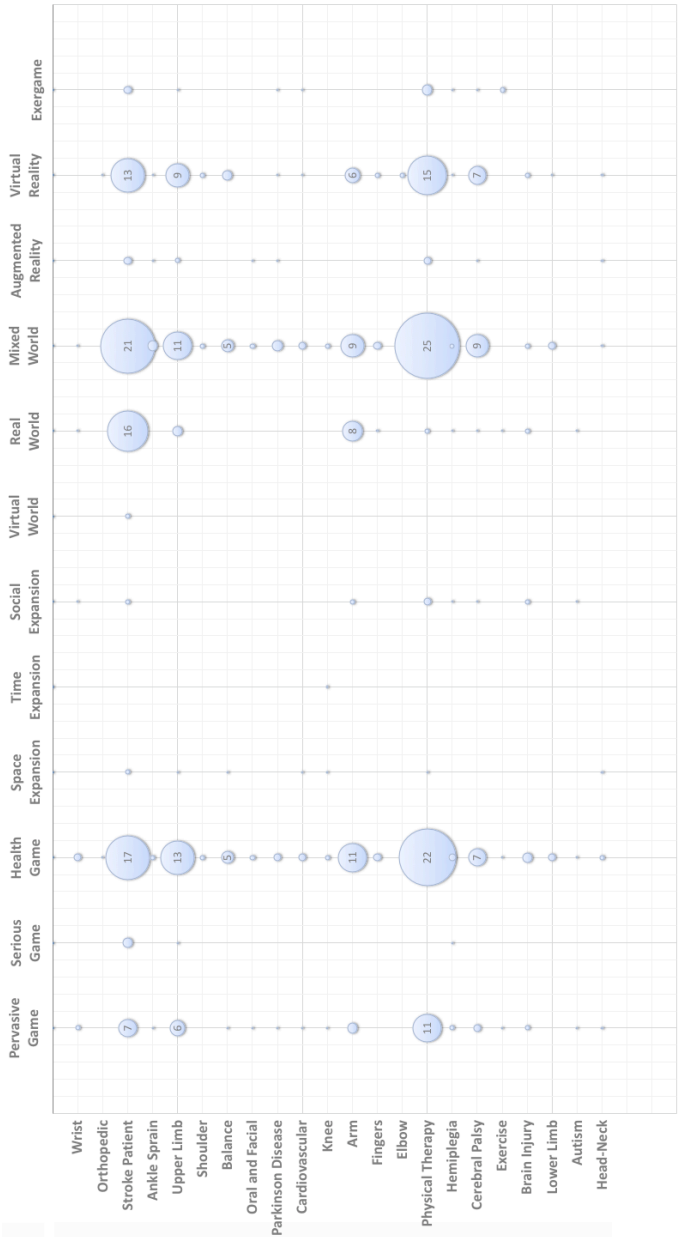

Figure 8. Relationship between rehabilitation areas and pervasive games.

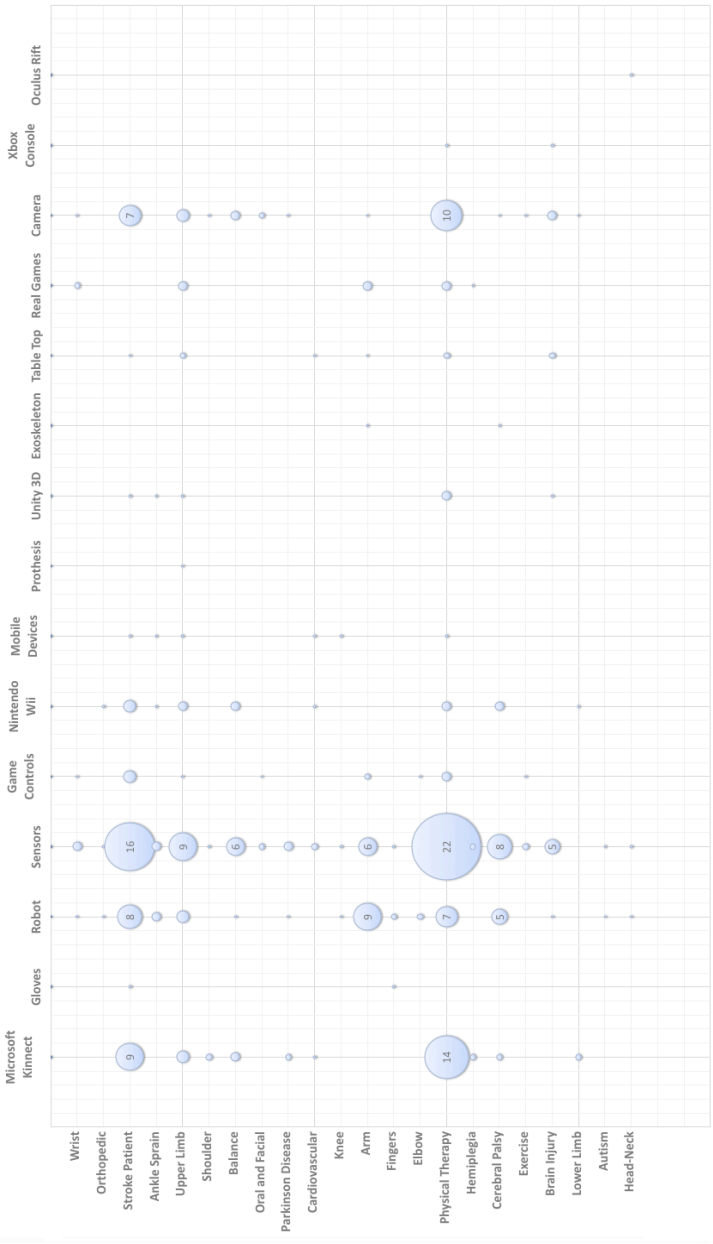

Figure 9. Relationship between rehabilitation areas and devices used in the pervasive games.

Finally, in Figure 9 the relationship between the different rehabilitation areas and the devices is shown. We can see that devices associated with sensors, robots and camera are very used. Specifically, the Microsoft Kinect is the commercial device most used to build PG to support the rehabilitation in patients. According to the Figure 8, it is possible to confirm that upper limb rehabilitation, stroke patient and physical therapy are the most important fields in rehabilitation for the pervasive games.

5. Conclusions and Future Work

In this article, we have performed an SLR on the processes, devices and application of PGs in the rehabilitation activities of patients with physical and mental disabilities, which have strongly attracted the interest of researchers in the fields of computing and health. Advances and collaborative work have given successful results in terms of improving patients. In this way, the evolution of technology and PGs have allowed people from the health area to apply them as an interaction tool to increase motivation in rehabilitation activities.

In this line, it can be concluded that PGs are widely used in the rehabilitation processes of patients, in addition, the specificity that occurs in the use of technological devices is important, each of these associated with the processes that are carried out in different parts of the body and in the mental part of the patient. Also, forms of pervasiveness have been identified that are used in the vast majority of the studies found. This allows us to provide a basis on which new research can be conducted in order to optimize the results of the rehabilitation processes, leading to an improvement in the quality of life of patients, especially, stroke patients, patients with cerebral palsy, and disabilities in upper limbs, which according to the study are those that most use this type of progress in their therapies.

With the progress that is evident in the rehabilitation processes, there is no doubt that it is a field of research where pervasiveness should be deepened and applied to a greater degree, which would provide a higher level of motivation to patients, positively impacting their results of recovery. As future work, it is proposed to carry out an investigation with experts in the area of rehabilitation with the objective of identifying and classifying the optimal PG options for each case of therapy. In this study we must consider the elements previously identified, and the experience of these people. In

addition, it is important to delve into the impact that is had in the use of these technologies in each of the age ranges, because each individual can react differently to the same technology. This should be accompanied by a proposal of levels of pervasiveness and categorization of these to be adapted to the needs of the health area.

On the other hand, the need to conduct research on how to complement rehabilitation processes through the implementation of PG in older adults with the support of young people has been raised. This is directed towards a pervasiveness of social interaction between different generations to support the adaptation of technology in this group of people.

Finally, there is evidence of the need to evaluate short-term and long-term rehabilitation in different ways, with which different strategies can be proposed that lead to a successful rehabilitation process. For the second case, it is recommended to consider the pervasive narrative or expanded narrative to generate a story during the rehabilitation process.

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