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APPLICABILITY OF TECHNOLOGIES IN THE AREA OF PHYSICAL THERAPY AND REHABILITATION: INTEGRATIVE REVIEW

APLICABILIDADE DE TECNOLOGIAS NA ÁREA DE FISIOTERAPIA E REABILITAÇÃO: REVISÃO INTEGRATIVA

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ABSTRACT: **Aim**: The objective of the study was to analyze characteristics of the application of technologies in the area of Physical therapy and rehabilitation. **Methodology**: This is an integrative literature review study, carried out in the SciELO, LILACS, MEDLINE and PubMed databases, composed of review articles, in Portuguese and English, published between 2013 and 2023. The articles were submitted to the reading of titles and abstracts, aiming to exclude duplicates or articles without relevance, and evaluation of methodological quality. The selection and evaluation processes were carried out by two researchers with disagreements resolved by a third party. A narrative analysis was performed to describe and summarize the results. **Results**: The search returned 421 studies, after the selection processes, 33 articles made up the final sample. It is noteworthy that 60.6% came from Europe and 15.2% from North America. 21.2% addressed Neurological Rehabilitation and 18.2% the Older Adult Health. Regarding the type of technology addressed, 18.2% addressed Mobile Technologies and 15.2% Telehealth. **Conclusions**: The trend in studies towards the exploration of digital and electronic technologies incorporated into resources aimed at rehabilitation stands out.

KEYWORDS: Physical Therapy Modalities. Biomedical Technology. Medical Informatics.

RESUMO: **Objetivo**: O objetivo do estudo foi analisar características da aplicação de tecnologias na área de Fisioterapia e reabilitação. **Metodologia**: Trata-se de um estudo de revisão integrativa da literatura, executada nas bases Scielo, Lilacs, Medline e Pubmed, composta por artigos de revisão, em português e inglês, publicados entre 2013 e 2023. Os artigos foram submetidos à leitura dos títulos e resumos, visando excluir duplicados ou sem pertinência, e avaliação de qualidade metodológica. Os processos de seleção e avaliação foram realizados por dois pesquisadores com divergências resolvidas por um terceiro. Realizou-se uma análise narrativa para a descrição e síntese dos resultados. **Resultados**: A busca retornou 421 estudos, após os processos de seleção, 33 artigos compuseram a amostra final. Destaca-se que 60,6% foram oriundos da Europa e 15,2% da América do Norte. 21,2% abordaram a Reabilitação Neurológica e 18,2% a Saúde do Idoso. Sobre o tipo de tecnologia abordada, 18,2% abordaram Tecnologias móveis e 15,2% Telessaúde. **Conclusões**: Destaca-se a tendência nos estudos da exploração de tecnologias digitais e eletrônicas incorporadas aos recursos voltados à reabilitação.

PALAVRAS-CHAVE: Modalidades de Fisioterapia. Tecnologia Biomédica. Informática Médica.

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INTRODUCTION

In today's society, the health area has stood out for its dynamism, which is very much related to innovation, with scientific and technological development becoming faster and faster in search of new products and processes [1]. The longevity of the population impacts the demand on health systems, the increase in the prevalence of chronic diseases and funding limitations. In this context, the introduction of technologies can help improve the efficiency of the health system and the care provided to patients/users [2].

According to an international patent database, the filings of records in the area of Physical therapy devices in 2021 totaled 41,221, at the height of the measures of care and restriction of the pandemic, demonstrating that countries such as China, Japan and the United States, potentiated research and technological production in this period [3].

The implementation of technological solutions during the COVID-19 pandemic contributed decisively to the reduction of agglomeration in health spaces, speed and ease of access to assistance services, especially in countries that already had technological advances in the area of e-Health [4].

As part of the specialties working in rehabilitation, the physical therapist began to experience a disruptive process in his traditional assistance with the beginning of the pandemic, identifying the need to implement measures and resources to maintain the operation of services and professional assistance in a non-presential way to users [5].

The use of technological information tools has contributed to the conduct of the rehabilitation process of a wide range of patients. As an example, they mention home technologies, which have the advantage of providing flexibility of location and time in rehabilitation therapy and enabling remote feedback [6].

The impact of technological demands in that period is also seen in the educational sector. If before the pandemic period the use of communication and information technologies in university education in Physical therapy was already the object of great interest of science and society, with the advent of the pandemic, there was a jump in the importance of these aspects and several studies began to be carried out in order to understand the technological transformations that occurred and their academic impacts [7].

Health technologies (HTs) can be classified according to Merhy (2007) as light, light-hard and hard technologies. Light HTs are understood as relational technologies, with bonding, welcoming, accountability and empowerment being the main focuses. Light-hard HTs are related to the use of structured knowledge or knowledge-technologies. Finally, hard HTs correspond to equipment, such as mechanical fans, infusion pumps and devices in general [8].

Another classification of HT is that of Nietzsche et al. (2005), which is divided into Educational, Managerial and Assistance Technologies. Educational Technology consists of a set of knowledge aimed at planning, controlling and monitoring the formal and informal educational process. Management Technologies are theoretical-practical processes used in the management of health care in the professional practical context, seeking to improve quality. And finally, Assistance Technology, which includes the construction of technical-scientific knowledge resulting from investigations, application of theories and professional experience for the provision of qualified assistance [9].

In this scenario, it is increasingly essential to invest in innovation and health technology in emerging countries, aiming to adapt needs to available resources and reduce external technological dependence. It is in this sense that the research has undeniable epidemiological relevance, seeking to

base studies and projects of technological innovation on real demands for health promotion, disease prevention and improvements in the quality of life of the population.

Thus, the present study seeks to analyze the current characteristics and the recent evolution of the application of technologies in the area of Physical therapy addressed in scientific studies, identifying areas of expertise, technologies addressed and research gaps. Thus, it is expected to contribute with bases for the development of educational products aimed at facilitating teaching, research and technological innovation activities in the area of Physical therapy and rehabilitation.

METHODOLOGY

ETHICAL ASPECTS

Approved by the Research Ethics Committee (REC) of the State University of Pará (UEPA) with opinion number 5,956,698.

TYPE OF STUDY AND STAGES

This is an integrative literature review study, which according to Sousa, et al., (2017), is defined as an investigation method through syntheses of various types of scientific studies that incorporate research results on a given topic, following rigid and detailed protocols for its construction, in order to obtain critical results [10]. The first stage in the design of the systematic review was to define the research question, which consisted of: "What are the current characteristics of the use of technologies in the area of Physical therapy?"

BASE SEARCH

The initial search was performed on April 24, 2023 in the Scielo, LILACS, Medline and Pubmed databases, and consisted of complete review articles, in Portuguese and English, published between 2013 and 2023. The definition of search terms was made from the Descriptors in Health Sciences (DeCS) base, obtaining as results the selected descriptors in Portuguese and English:

- *Health Care Technology*
- *Biomedical Technologies*
- *Physical Therapy*

Based on the descriptors, the search strategy was built by combining the search terms with the Boolean operators, obtaining the sentence in Portuguese and English:

((Health Technology) OR (Biomedical Technology)) AND (Physical therapy)
((Health Care Technology) OR (Biomedical Technologies)) AND (Physical Therapy)

SELECTION PROCESS

The articles resulting from the initial search were organized using Zotero software version 6.0.27. The evaluation and selection of publications in this phase of the study was carried out by two independent evaluators, using a third in view of the need for guidance. The articles were submitted to the reading of titles and abstracts, in order to identify and exclude duplicate publications or without thematic relevance.

The articles resulting from the first filtering were submitted to full reading, in which a new filtering of publications by methodological quality was performed. Disagreements between evaluators were resolved with the participation of a third evaluator.

To evaluate the methodological quality of the studies, an adapted version of the Assessment of Multiple Systematic Reviews (AmStar) instrument was used [11]. The articles that obtained a minimum score of 10 points in AmStar were selected, considering the arithmetic mean between the evaluators.

DATA EXTRACTION

The variables of interest for the study were extracted and recorded in a specific form and stored in a Microsoft Office Excel 2010™ spreadsheet, as follows: Article title; language; year and place of publication; area of concentration; journal; chronological scope; objectives; type of study; type of technology; inclusion and exclusion criteria; measurement instruments; main results; conclusion.

DATA ANALYSIS

A narrative analysis was performed to describe and summarize the results of the review. The health technologies addressed in the included studies were classified by Merhy as light, light-hard and hard technologies [8]. The studies were also classified according to the Nietzsche scale [9] in educational, managerial and care technologies. Quantitative data were analyzed using Microsoft Office Excel 2010™ software, represented by simple frequencies and percentages and organized into tables and graphs. To analyze the data distribution, the G-test of adherence was used, with a significance level of $p<0.05$.

RESULTS

The initial search obtained a total of 421 results, of which 243 were excluded due to duplication. Of the remaining 178 articles, 94 were excluded because they were not available in a free full version. The remaining 84 articles were submitted to full reading, 45 of which were excluded due to lack of relevance to the research topic, leaving 39 articles.

The next stage was the quality assessment, in which a mean score of 11.47 (±1.36) was obtained in AmStar. Only 6 articles were excluded for not obtaining the minimum score, resulting in 33 articles used as the final study sample, according to the flowchart below. The scheme of the search and selection process is shown in figure 1.

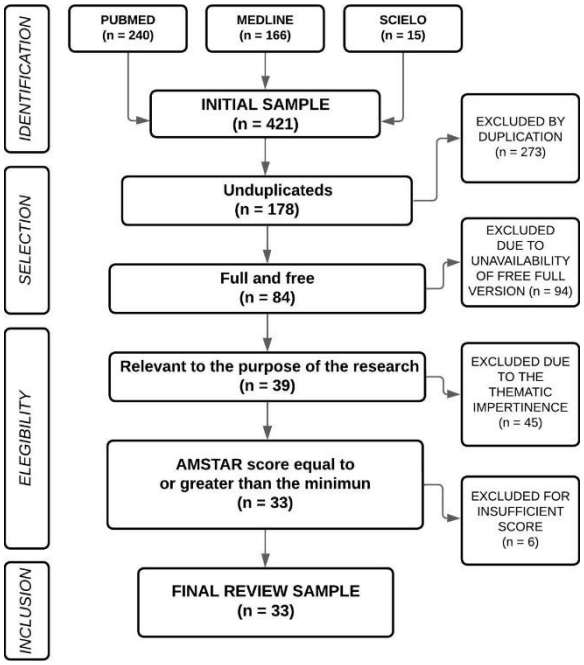

Figure 1. Outline of the process of searching and selecting articles
Source: Survey data, 2023.

Regarding the place of origin of the included studies, it is noteworthy that 20 (60.6%) came from Europe, followed by North America with 5 (15.2%) publications. Figure 2 shows the distribution of the included articles among the countries of origin. In the distribution of articles by year of publication, 12 (36.4%) were obtained between 2020 and 2021, and 11 (33.3%) from 2022 to 2023. Regarding the area of application of the studies, 7 (21.2%) addressed neurological rehabilitation and 6 (18.2%) the area of older adult health. Table 1 presents the complete general data of the included articles.

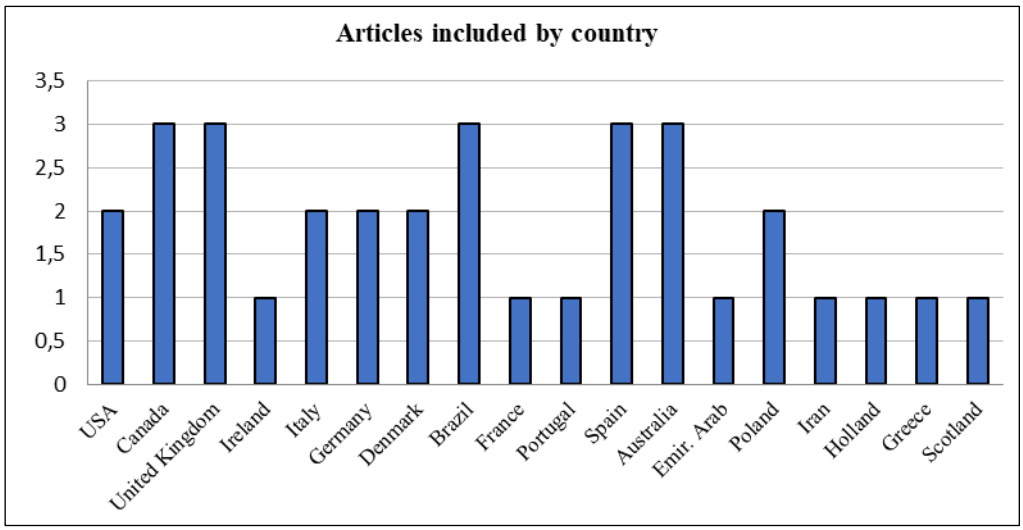

Figure 2. Number of studies included by country of origin.
Source: Survey data, 2023.

Table 1. General characteristics of the articles included in the study

Region of origin		
	n	**%**
North America	5	15,2
South America	3	9,1
Europe	20	60,6
Middle East	2	6,1
Oceania	3	9,1
	p< 0,0001*	
Year of publication		
	n	**%**
2016-2017	5	15,2
2018-2019	5	15,2
2020-2021	12	36,4
2022-2023	11	33,3
	p= 0,04*	
Application area		
	n	**%**
Orthosis/prosthesis	1	3,0
Mental health	1	3,0
Rehab. Musculoskeletal	4	12,1
Rehab. pulmonary/cardiovascular	4	12,1
Health of the elderly	6	18,2
Rehab. Neurological	7	21,2
Women's Health	3	9,1
Rheumatology	2	6,1
Burns	1	3,0
Health technology	4	12,1
	p= 0,18*	

*G-test of adherence
Source: Survey data, 2023.

Regarding the type of technology addressed in the 33 articles analyzed, 6 studies (18.2%) were related to Health Technologies in general (eHealth), 6 studies also addressed Mobile Technologies (mHealth), and 5 (15.2%) Telehealth or Telerehabilitation Technologies. The complete results on technology classification are shown in table 2.

Table 2. Classification of the technologies covered in the articles included in the study

Technology addressed		
	n	**%**
Evaluation systems	4	12,1
Motion Technology	1	3,0
Mobile technology (mHealth)	6	18,2
Orthopedic devices	1	3,0
Robotics	1	3,0
Health Technology (eHealth)	6	18,2
Physical activity monitors	3	9,1
Motor neuroprostheses	1	3,0
Telehealth	5	15,2
Exoskeletons	1	3,0
Virtual/Augmented Reality	3	9,1
Electronic Health Records	1	3,0
	p= 0,12*	
Merhy classification		
	n	**%**
Light Technology	1	3,0
Light-hard technology	25	75,8
Hard Technology	5	15,2
Technology in General	2	6,1
	p< 0,0001*	
Nietzsche classification		
	n	**%**
Educational Technology	11	33,3
Management Technology	2	6,1
Assistive Technology	17	51,5
Non-specific technology	3	9,1
	p= 0,0003*	

Source: Survey data, 2023.
*G-test of adherence

According to the Merhy classification, 25 studies (75.8%) are related to light-hard technologies, 5 (15.2%) articles addressed hard technologies and 1 (3.0%) light technologies. 6.1% of the studies addressed technologies comprehensively, being classified as "technology in general".

According to Nietzsche's classification, the following results were found: 17 (51.5%) related to assistive technology, 11 (33.3%) to educational technology and 2 (6.1%) to managerial technology. Regarding this classification, 3 (9.1%) studies addressed technologies comprehensively, being classified as "non-specific technology".

Methodological characteristics of included studies are presented in Table 3. We can highlight that, in relation to the type of study, 18 (54.5% consisted of simple systematic reviews and 12 (36.4%) of systematic reviews with meta-analysis. Regarding the general objective of the research, 15 studies (45.5%) were described as technological exploration (without a direct focus on clinical intervention); 8 (24.2%) efficacy studies (uncontrolled clinical intervention) and 10 (30.3%) comparative efficacy studies (controlled clinical intervention).

Table 3. Methodological characteristics of the included studies

Type of study		
	n	**%**
Systematic review	18	54,5
Sist rev. + Meta-analysis	12	36,4
Scoping Review	3	9,1
	p= 0,0025*	
Objectives		
	n	**%**
Efficacy	8	24,2
Comparative efficacy	10	30,3
Technological exploration	15	45,5
	p= 0,32*	
Method of analysis		
	n	**%**
Meta-analysis	12	36,4
Narrative synthesis	13	39,4
Other	3	9,1
Not informed	5	15,2
	p= 0.02*	

*G-test of adherence
Source: Survey data, 2023.

As for the results obtained in the 18 studies focused on the efficacy and comparative efficacy of the technologies, it is noteworthy that 11 (61.1%) presented a positive effect (clinical improvement in relation to the adopted control); 2 (11.1%) negative effect (effect lower than the control); and 5 (27.8%) inconclusive effect. Among the 12 studies that performed data meta-analysis, only 4 studies reported statistically significant results, 3 studies reported non-significant results; and 5 indeterminate results regarding significance.

DISCUSSION

This review gathers scientific information addressing technological applications in the area of Physical therapy and rehabilitation in the last 10 years, presenting findings of great interest, including studies focused on various specialties and various types of technologies adopted, with emphasis on digital resources.

Most articles came from Europe, which still demonstrates the prioritization of health technologies in this geographical block, despite the observed trend of depolarization, with productions coming from South America and the Middle East. Health represents an area of technology generation where the definition of agendas is mainly concentrated in developed countries, and mainly serves populations with greater purchasing power [12].

An example of this disparity is presented by applications to combat Urinary Incontinence, developed in Brazil, presenting lower reliability compared to others for pelvic muscle training, from New Zealand, which presented a higher quality score [13]. This variation occurs due to several factors, mainly due to the greater investment in research in developed countries.

When we observe the distribution of publications along the time frame, there was a notable increase in the number of articles in 2020 and 2021, coinciding with the beginning of the COVID-19 pandemic and the resulting restrictive measures. Even in the following years, with the relaxation of

isolation, the pace was maintained, demonstrating that the technological approach in the area of Physical therapy becomes a consolidated theme.

Regarding the area of application of the included studies, we found a prevalence of applications in Neurological Rehabilitation and themes related to older adult health, which demonstrates the importance of technological production in these areas, due, among other factors, to the high costs and long duration of health care and rehabilitation in these populations.

The intervention of mobile applications in diseases of the Central Nervous System presents evidence of efficacy, which allows a better monitoring of these patients, obtaining significant results regarding the improvement in the scope of physical and cognitive rehabilitations [14].

In this regard, robotic therapy has been shown to be particularly effective in treating patients with stroke sequelae who are unable to walk independently [15]. For these patients, the most important goal is to regain gait autonomy, which has been more easily achieved through robotic therapy in the form of electromechanical assistance.

In one of the reviews included, it is noteworthy that the wearable exoskeletons are an example of devices that allow the active interaction of the patient in the rehabilitation of gait; research related to this equipment has been growing significantly in recent years, as they allow assisting patients actively [16].

The technological resources addressed in most studies were related to digital health applications in general, which have assumed, in recent years, the name eHealth (Electronic Health), referring to several technological applications in health contexts [17]. Such studies start from the possibility of integrating patterns of activities in facilitating interfaces in information management, which would optimize the management and planning of health intervention strategies.

Another highlight is Mobile Technologies or mHealth (Mobile Health), which are resources intermediated by virtual reality platforms and mobile digital devices (smartphones or tablets). It is emphasized the possibility of using mHealth in the early detection of health demands, for example, through questionnaires and clinical monitoring software in hospitalized patients [18].

It also draws attention to the occurrence of studies that explore Telehealth or Telerehabilitation as a means of approaching users, alternatives that outline the breaking of the paradigm about the need for face-to-face contact between therapist and patient. Positive results are already pointed out in Telerehabilitation resources when compared to traditional therapeutic alternatives, with a significant reduction in symptoms and notorious adherence to treatment in children and adolescents [19].

Still from a remote perspective, state-of-the-art telehealth optimizes home exercise therapy and quality of life in people with stable Chronic Obstructive Pulmonary Disease (COPD), in addition to minimizing functional dyspnea, surpassing groups without therapy and resembling groups in outpatient/hospital or home care in the absence of technology [20].

The notoriety of these approaches points to a growing interest in remote forms of care, considering that, in addition to unburdening public and private health systems, it can reduce costs in physical care networks. According to a systematic review analyzed [21], due to the COVID-19 pandemic, physiotherapeutic care was limited, giving rise to the promotion of telehealth tools, with evidence of high acceptance and effectiveness in physiotherapeutic care.

In this sense, it is pertinent to mention Resolution number 516 of the Federal Council of Physical therapy and Occupational Therapy (COFFITO) [22], of March 20, 2020, which provides for Teleconsultation, Telemonitoring and Teleconsulting, emphasizing the autonomy and independence of the professional in determining the services that can be followed at a distance:

> The Teleconsultation consists of the clinical consultation registered and performed by the Physical therapist or Occupational Therapist at a distance. Telemonitoring consists of remote monitoring of patients previously attended in person, through technological devices - ***preserving and reducing bureaucracy in the professional-patient relationship***. In this modality, the Physical therapist (...) must decide on the need for face-to-face meetings for reassessment, (...). Teleconsulting consists of the communication registered and carried out between professionals, (...), in order to clarify doubts about clinical procedures, health actions and issues related to the work process (Emphasis added).

According to the analysis of the studies based on Merhy's classification, there was a higher occurrence of mild-hard technologies, which corroborates the included review in which most studies used mild-hard technologies, related to complications in the upper limb after breast cancer surgery [23].

It is understood that Merhy's classification relates to processes, technologies and ways of achieving improvements in health conditions. Light-hard technologies are related to the use of structured knowledge or knowledge-technologies, making it possible to visualize the individual, object of their intervention and understand their needs and demands [8]. According to Nietzsche's classification, most studies addressed Assistive Technologies, which points to a greater emphasis on technological applications aimed at Physical therapy and rehabilitation interventions.

The use of technologies for care was also seen in the objective of the studies that, for the most part, focused on the effectiveness of resources, including controlled and uncontrolled studies. The study that proves the benefit of information and distance communication technologies in balance training in older adults stands out, consequently reducing the risks of falls [24].

It should be noted that most studies on clinical application have obtained positive results in relation to the effects and effectiveness of technologies, even taking into account the great methodological variability. As an example, we cite the study on the rehabilitation of balance assisted by technology in individuals with spinal cord injury, involving strength platforms and robotic gait trainers [25]. However, it should be noted that most of these studies did not report statistically significant results.

The data analyzed reiterate the potential applicability of technological resources in the area of Physical therapy and rehabilitation, with emphasis on electronic and digital media, such as Virtual Reality and mobile applications, as well as tele-rehabilitation resources. An excerpt from this reality is the research in which Augmented Reality, combined with conventional therapies, proved to be effective in improving the balance and gait of patients with Parkinson disease, even considering the lack of homogeneity in interventions [26].

According to data from the World Intellectual Property Organization (WIPO), emerging technologies related to rehabilitation, notably mobility, have benefited from the use of digital components such as sensors, artificial intelligence, advanced neuroprostheses, advanced gait aids, advanced wheelchairs, exoskeletons and other enabling technologies [27].

Several resources addressed in the studies can be characterized as Assistive Technologies (AT), although the specific term is not adopted in most publications. AT devices are an important factor of environmental intervention in the construction of the health framework, which aims to adapt the Activities of Daily Living (ADLs) of individuals to their specific demands, such as children with neurofunctional disabilities [28]. AT resources are also important in the functional inclusion of people with disabling comorbidities and chronic diseases [29].

The limitations in this review highlight the possibility of expanding the scope of searches, such as: number of databases accessed, the refinement of keywords, in order to allow a more comprehensive search, as well as the general nature of the exploration of the theme, which limited the deepening in

specific areas of technology in Physical therapy, which can be justified by the objective of the study's panoramic analysis.

It should also be noted a limitation on the possible loss of inclusion of important studies on the subject due to the inclusion and exclusion criteria adopted, which could even influence data such as the geographical distribution of the studies and the types of technologies addressed. It is noteworthy, however, that the methodological criteria of the review aimed to guarantee the quality of the included studies and preserve the property of the analyses.

The practical implications of the study involve the conception that educational products aimed at the process of technological development in Physical Therapy can achieve greater insertion in health promotion if they emphasize resources directed to areas with demand and scientific basis, notably the areas of neurological rehabilitation and older adult health, as well as highlighting applications for mobile devices and Telehealth resources.

The electronic and digital resources highlighted in the study represent an adaptation of health research and care to the current digital world. More quality studies are needed on the technological application in specific areas of Physical therapy and rehabilitation, exploring, above all, the theoretical and technical requirements of resources, as well as the therapeutic effects of interventions.

CONCLUSION

The analysis of the current characteristics of the technological application in Physical therapy allowed the identification of several areas highlighted in the scientific studies analyzed, such as neurological rehabilitation and older adult health, as well as the potential of specific resources such as applications for mobile devices and Telehealth resources. The trend in the exploration of digital and electronic technologies incorporated into resources aimed at rehabilitation stands out here. It is expected that the information gathered will contribute by providing a basis for future research in the area of technological innovation and development in Physical therapy, as well as awakening the need to insert the technological theme in professional health education and training activities.

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