

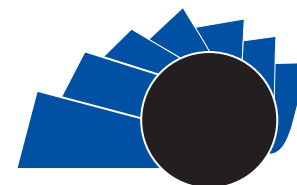


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Visión Electrónica

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<https://doi.org/10.14483/issn.2248-4728>



VISIÓN ELECTRONICA

A CURRENT VISION

State of the art at mobile applications for facial paralysis: information, diagnostic and rehabilitation

Estado del arte en aplicaciones móviles para parálisis facial: información, diagnóstico y rehabilitación

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INFORMACIÓN DEL ARTICULO

Historia del artículo

Envíado: 23/09/2018

Recibido: 25/09/2018

Aceptado: 23/10/2018

Palabras clave:

App,
eHealth,
mHealth,
parálisis facial,
rehabilitación facial,
Smartphone

Keywords:

App,
eHealth,
mHealth,
facial paralysis,
facial rehabilitation,
Smartphone.

RESUMEN

En este artículo se presenta un estado del arte de las aplicaciones móviles orientadas a pacientes y profesionales respecto a la parálisis facial. Se establece una ventana de exploración entre los años 2009 y 2019, geolocalizada en países que han promovido el desarrollo de tales aplicaciones. El objetivo es proporcionar un marco de referencia de las implementaciones y que sirva, en perspectiva, como línea de base para investigaciones del grupo de Robótica Móvil Autónoma (ROMA) adscrito al Centro de Investigaciones y Desarrollo Científico de la Universidad Distrital Francisco José de Caldas –CIDC– y categorizado en COLCIENCIAS. Se realizó una búsqueda bibliográfica en los motores de búsqueda: Google Scholar, Microsoft Academic, Bielefeld Academic Search Engine (BASE); bases de datos: Dialnet, Directory of Open Access Journals (DOAJ), PubMed, Redalyc, Scientific Electronic Library Online (SciELO) y Scopus; y fuentes de información propias del campo de las aplicaciones móviles: Google Play (Android), App Store-Apple (iOS) y Windows Store (Windows Mobile/ Windows Phone). Se concluye que las aplicaciones móviles disponibles en el mercado actual de tales plataformas son pocas, de carácter informativo y de diagnóstico y para la rehabilitación facial; se destaca que existen proyectos en universidades de Latinoamérica, Estado Unidos, Europa y Asia enfocados en comercializar los productos generados con fines terapéuticos.

ABSTRACT:

This paper presents a state of the art of mobile applications aimed at patients and professionals around facial paralysis. A window of exploration is established between 2009 and 2019, geolocated in countries that have promoted the development of such applications. The objective is to provide a frame of reference for the implementations and to serve, in perspective, as a baseline for research of the Autonomous Mobile Robotics group (ROMA for its Spanish acronym) attached to the Scientific Research and Development Center of the Francisco José de Caldas District University -CIDC- and categorized in COLCIENCIAS. A bibliographic search was carried out in the following search engines: Google Scholar, Microsoft Academic, Bielefeld Academic Search Engine (BASE); databases: Dialnet, Directory of Open Access Journals (DOAJ), PubMed, Redalyc, Scientific Electronic Library Online (SciELO) and Scopus; and information sources specific to the field of mobile applications: Google Play (Android), App Store-Apple (iOS) and Windows Store (Windows Mobile/ Windows Phone). It is concluded that the mobile applications available in the current market of such platforms are few, informative and diagnostic and for facial rehabilitation; it is noted that there are projects in universities in Latin America, the United States, Europe and Asia focused on marketing products generated for therapeutic purposes.

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Cite this article as: F. N. Gómez-Cuarán and G. A. Higuera-Castro, "State of the art at mobile application for facial paralysis: information, diagnostic and rehabilitation", *Visión electrónica*, vol. 2, no. 1, Special edition, january-june 2019 <https://doi.org/10.14483/issn.2248-4728>

1. Introduction

The continuous development of Information and Communication Technologies (ICT) has had a significant impact on health. In this sense, the terms eHealth and mHealth have burst forth with force, [1]: the practice of health care supported by ICT is called eHealth, [2]; mHealth - or mobile health - is the most advanced interpretation of eHealth, as it has systematically incorporated the use of mobile in the field of health, or health care applications in mobile devices, [3].

On the other hand, mHealth has included, in addition to the use of the main functions of mobile phones - voice and text messaging (SMS) - other more complex functionalities that include the general radio package service (GPRS), the third and fourth generation of mobile telecommunications (3G and 4G systems), the global positioning system (GPS) and Bluetooth technology [4].

Now, as time goes by, mobile devices evolve and are capable of executing more demanding processes, the irruption of numerous applications for the different presentations of these devices has been unleashed, [5]. This has given rise to the term app -abbreviation of application-, [2]. An app is a program with special features that is installed in the mobile device, either Tablet or smartphone, which usually have a small size to accommodate the power and storage limitations, [2], [6]. In recent years, the development of these apps has entered the field of medicine, both for professionals and patients, [7]. For example, for facial paralysis, which is a weakness or complete paralysis of the facial musculature, the information presented by the current apps orient the user towards muscular re-education and thus facial rehabilitation.

However, the number of such apps for facial paralysis for both target groups - professionals and patients - is relatively low in the main mobile application operating systems on the market: Android (Google Play); iOS (App Store-Apple); and Windows Mobile / Windows Phone (Windows Store) without apps specific to this type of paralysis.

In addition, there are academic projects from different

universities aimed at this topic but which are not circulating in the market. It is interesting that the available bibliography on the subject evidences little information, for that reason the present bibliographic review is justified on the way to establish a base line for future investigations in the area of mobile applications on facial paralysis.

The present paper is structured as follows: initially an appropriate explanation of facial paralysis is given; then, in the methodology, the index method is described, the exploration window and the search sources for the review are established; then the compiled sources are interpreted; subsequently an alternative solution is given and, finally, the conclusions are established.

2. Facial paralysis - general framework

The main contributor of evolution in the knowledge of facial paralysis was Charles Bell who presented his discovery of the VII cranial nerve and its role in the innervation of facial muscles, [8]. Peripheral facial paralysis or Bell's paralysis is a complete weakness or paralysis of the facial musculature, acute and generally unilateral, consistent with facial nerve dysfunction of unknown cause, [9]. The most likely cause of this syndrome is suspected to be involvement of the facial nerve by the herpes virus, [10]. It affects men and women equally and is associated with the following risk factors: pregnancy, pre-clampsy, obesity, high blood pressure, and diabetes. 60% to 75% of peripheral facial paralysis are idiopathic or no cause is found, [11].

This condition of the peripheral branch of the facial nerve causes loss of voluntary motor activity in all facial muscles on the affected side, [12]. Patients may have variable inabilities of facial muscle functions and facial expression, with inability to close eyes, elevate eyebrows, smile, speak, eat, [13], and decreased taste in the anterior two-thirds of the tongue, [14]. Numerous classifications have been described for the clinical evaluation of facial paralysis, the most widely used and accepted being House-Brackmann, [8], [14], [15], [16].

Facial paralysis has an annual incidence of 13 to 52 cases per 100,000 inhabitants, [17]. It has been referred in patients of all ages, with 2 peaks of maximum

incidence between 30 and 50 years, and between 60 and 70 years, [11], [16]. This type of paralysis presents a high degree of spontaneous recovery and although about 85% are completely resolved, some of these patients are referred to physical medicine and rehabilitation services for treatment [18]. Peripheral facial paralysis or Bell's paralysis can be seen in Figure 1



2.1. Treatment

Among the proposed treatments, pharmacotherapy and

physical therapy stand out, although the application of botulinum toxin has also been described [20]. A study conducted at Mexico's National Rehabilitation Institute in 2011 concluded that two of the most important factors in patients' recovery are care within 72 hours of the first symptoms and rehabilitation therapy [21]. The most commonly used medications are anti-inflammatory drugs and the use of facial massages, as well as self-therapy through mime exercises performed in front of the mirror [22]. With reference to therapeutic times, some authors point out that recovery from facial paralysis is a complicated and slow process, and some clinical trials even suggested periods of treatment lasting more than three months [23]. Figure 2 shows 16 facial exercises that the patient can perform for facial rehabilitation, some of them are: closing eyes, raising eyebrows, joining eyebrows, wrinkling the chin, smiling, blowing very slowly, elevating the upper lip dilating the wings of the nose, clenching the teeth. When the patient is performing these exercises in front of the mirror, they should be as symmetrical as possible, [24].

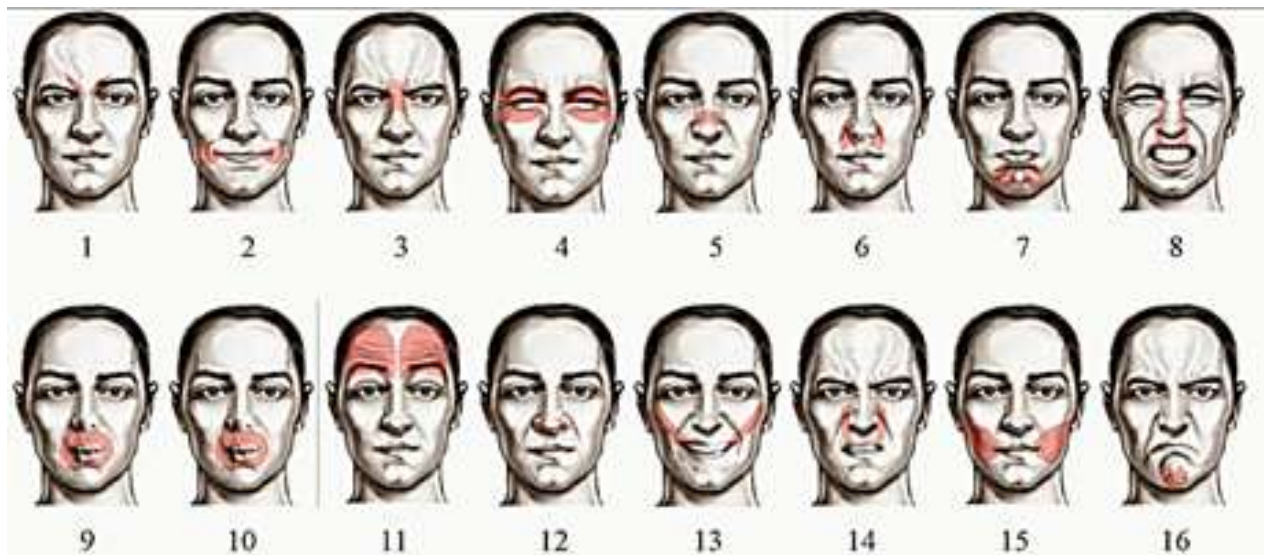


Figure 2. Facial exercises for the rehabilitation of patients with facial paralysis, [24].

3. Methodology

The present review on mobile applications for facial paralysis used the index method for its construction (vertebrate from a general index), [25], in which categories and subcategories are established, and which is endorsed by the ROMA research group. The categorization is observed in Figures 3 and 4. Consequently, the bibliographic review was carried out through a search in Spanish and English using: search engines, databases and information sources specific to the field of mobile applications.

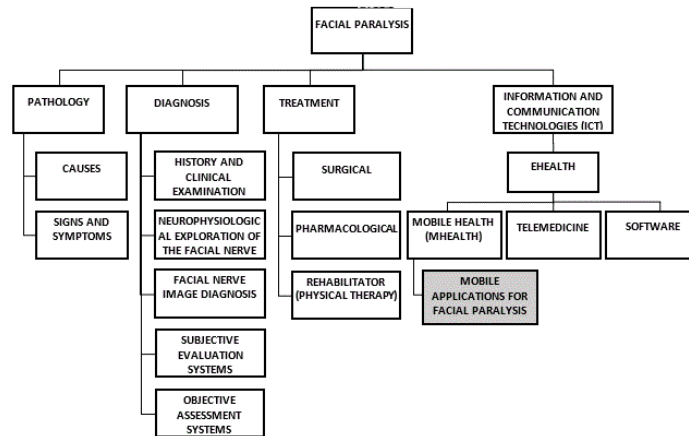


Figure 3. Vertebation process of the general index. Source: own.

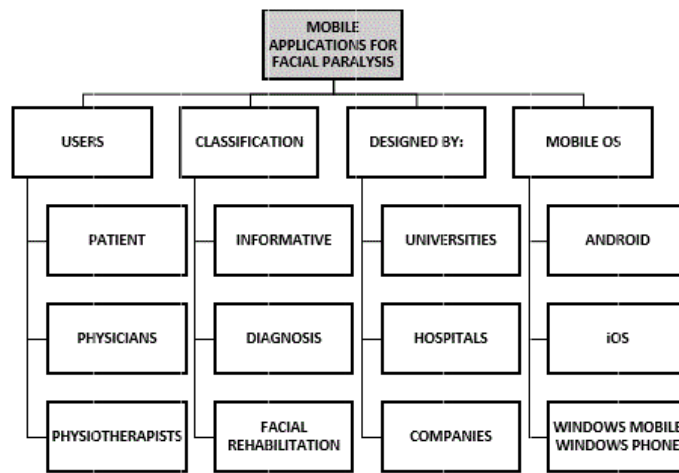


Figure 4. Subcategory mobile applications for facial paralysis. Source: own.

3.1. Bibliographic data search in databases and search engines

The following keywords were considered in both Spanish and English: 'apps', 'eHealth', 'mHealth', 'facial paralysis', 'facial paralysis and apps', 'facial paralysis and Smartphone', 'facial rehabilitation and apps', 'facial rehabilitation and Smartphone'. Bibliographic research was conducted on: 1) the search engines Google Scholar, Microsoft Academic, BASE; 2) the databases Dialnet, DOAJ, PubMed, Redalyc, SciELO and Scopus, bearing in mind an exploration window from January 2009 to September 2019. Because of the search were found 11 relevant documents that contribute to the review, which are exposed in the results section. These include: articles, theses, monographs, research papers and websites. For the selection of the documents, the following aspects were first used: title, authors, summary and results; then the evaluation of these was carried out for which an analysis of variability, reliability and validity was carried out [26].

Additionally, the previous search found documents with exclusively medical and informative information on facial paralysis that were used in the introductory and conceptual part of this paper.

3.2. Search with other data sources

In parallel with the search for bibliographic information in databases, the following data sources specific to the field of mobile applications were used: Google Play (Android), App Store-Apple (iOS) and Windows Store (Windows Mobile/Windows Phone). For this search the following keywords are used in both Spanish and English: 'Bell's paralysis diagnosis', 'facial paralysis diagnosis', 'facial paralysis', 'Bell's paralysis', 'facial rehabilitation', 'Bell's paralysis rehabilitation', 'facial paralysis rehabilitation'. Because of the search a total of 13 apps for facial paralysis were found in the current market; the characteristics of these mobile applications are exposed in the results section of this paper.

4. Results

4.1. Results in databases and search engines

From the beginning of 2014, a new and revolutionary software for iPad was intended to help the rehabilitation of patients with facial paralysis, including those derived from cerebrovascular accidents. It was presented at the Cosmetic and Reconstructive Clinical Exhibition in London, Olympia. The project, which is partially funded by Wellcome Trust, is a collaboration between researchers at Queen Victoria Hospital in East Grinstead, Brighton-based technology company Sense Innovation, and Image Metrics, a leading computer graphics company in Manchester. The Sussex-based research team, led by plastic surgeon consultant Charles Nduka, applied the latest technology in facial movement tracking to create a mobile application that helps patients relearn muscle control and improve facial symmetry. The mobile application allows patients to receive live feedback about their recovery via their smartphone or Tablet, [27].

On the other hand, for this same year, Azoulay et al. presented an objective mobile application based on learning for the diagnosis and classification of facial nerve paralysis. The algorithm is based on the analysis of a set of nine facial expressions and is designed to be used on a mobile device with the Android operating system. The mobile application score exhibits a high correlation with subjective qualification scores and high computational efficiency. The mobile application provides an interface that guides the user through the process of acquiring the required videos, and then locally applies the rating algorithm, [28].

By 2015, professionals at the Seoul National University-South Korea-proposed a fast, portable, smartphone-based, automatic diagnostic system that discriminates facial nerve paralysis from normal subjects. Facial reference points are located and tracked using an incremental parallel cascade of the linear regression method. An asymmetry index is calculated using the ratio of displacement between left and right sides of the forehead and mouth regions during three movements: resting, raising the eyebrow, and smiling. Linear discriminant analysis (LDA), support vector machine (SVM), and Leave-one-out-out cross validation (LOOCV) were used to classify facial nerve paralysis. The automatic system is designed to help both patients and physicians diagnose facial nerve paralysis quickly and easily in everyday life, similar to the use of videophone functions, [29].

By 2016, a mobile application that helped patients with facial paralysis won the health hackathon award at the

BDL Accelerate conference in Lebanon. The mobile application helps people with strokes by using gamma elements that, instead of showing their faces in the mobile application - which can be distressing - show cartoons or other adaptations of their selfie images, [30].

In 2017, students of the Computer Engineering curricular project of the Politecnica de Puebla University - Mexico - proposed two mobile applications in their professional stay projects that would complement each other in the future: the first was focused on the control of records that doctors make about their patients; and the second was oriented to be used by patients. The first mobile application was proposed by E. Campos Dolores: *Analysis, design and implementation of a database for the administration and control of patients with facial paralysis through an Android app*. The SQL Power Architect tool was used to design the database [31]. On the other hand, the second mobile application was proposed by E. Xicale Montes titled *Development of an app in Android to generate and control sessions of rehabilitation exercises for people with facial paralysis*, in its design and development the OpenCV library was used, [32].

On the other hand, at the Faculty of Sciences of the Autónoma University of San Luis Potosí, Mexico, work is currently being done exclusively on the design of prototypes. One of them is the development of a mobile application that assists the therapy of people with facial paralysis. This project works under the multidisciplinary scheme with the National Institute of Astrophysics, Optics and Electronics (INAOE) of the Morelos University, with the Engineering Faculty of the Guanajuato University as well as collaborators from the United States of America. The project aims to generate a system so that through a Tablet the patient can learn and perform facial physical therapy exercises, as well as monitor their therapy. Professor and researcher J. L. Tecpanecatl Xihuitl indicates that: *in this way, the patient will be able to see his progress and have a better perspective so that in the future he recovers the functionality of the affected facial hemisphere*, [33].

In the line described above, a team made up of four software engineering students from Shamoon College of Engineering (SCE) -Israel- created a mobile therapeutic application for patients with facial paralysis where the patient photographs himself making various expressions. By processing and analyzing objects, the mobile application finds the relevant points on the face. At the touch of a button, the results can be sent to the therapist who can remotely examine the patient's condition and the progress of the facial paralysis. The

mobile application also helps the patient mentally by providing relevant information about the neurological disorder; it even visualizes the progress of his recovery, [34].

On the other hand, the Mayor University of San Andrés -Bolivia-, in the faculty of pure and natural sciences, for the year 2018, V. I. Rojas Rivero in his degree thesis *Model of augmented reality for the stage of physiotherapy in patients with facial paralysis*, tries by means of a mobile application to help the patients with the physiotherapeutic exercises in the medical treatment. For the development of the model, it uses the Unity tools, the Vuforia platform -which allows the implementation of augmented reality- and Blender for the modeling of 3D objects. The mobile application is developed for Android OS mobile devices, [35].

Currently, Emteq located at the Sussex University - United Kingdom - with the support of Nominet Trust, is developing the mobile application *Mirror* for mobile devices and thus offer patients a new perspective by providing interactive rehabilitation 'games' and treating facial paralysis through physiotherapy comments in real time. The mobile application can measure successes, identify poor recovery and keep patients committed to treatment, [36]. The mobile application converts the iPad into a facial feedback mirror, the iPad camera acts as a facial scanner and automatically locates specific reference points and documents movement over time. It is important to note that its improved symmetry is tracked over time and its progress can be visualized on a graph. For those who feel uncomfortable looking at themselves in the mirror, their face can be transformed into a character or an animation that even allows them to receive comments from the mirror, [37].

Finally, the HealtheHealth company based in Navarra - Spain- is developing several mobile applications to help patients with different pathologies in their neurorehabilitation process. These mobile applications are grouped in Neuroplatform, a cloud platform that collects all the data provided by the apps. Among these mobile applications is NeuroFace, which is aimed at patients with facial paralysis, to perform autoexercises, using their mobile device. The patient photographs the side affected by the facial paralysis, and by establishing an axis of symmetry and comparing with the other side

the mobile application generates an image of the 'correct face', for the patient to work the muscles to reach the desired situation, [38]. The user, by recommendation of his doctor, chooses exercises that adjust to his clinical condition and develops a planning of execution of these. The mobile application is technologically accessible and economical for mobile devices with the operating system iOS or Android, [39].

As can be seen, the data found is relatively little compared to other areas of health. Most are provided by universities around the world.

There are also emerging companies that have entered the mobile application field for facial paralysis. It is important to highlight that the information found and used in this review is exclusively available in Spanish and English and was found using 6 databases and 3 search engines; consequently, there may be documentary data that is not detected for the review but that is available in a language other than the one consulted or that is found in sources of information other than those used.

Now, most of the documentary data found presents mobile applications for informative purposes, diagnosis and facial rehabilitation. Most of these, for their functionality, make use of the camera of the mobile device as they use photographic records, videos and digital image processing. As for the users to whom these mobile applications are directed, they are both patients and professionals. Regarding the mobile operating system for which they are designed, most of them are enabled to be used in iOS or Android. It is evident from the consultation that mobile applications for facial paralysis have been proposed and developed in different parts of the world. Among them are: Bolivia, South Korea, United States, Spain, Israel, Mexico, Lebanon and United Kingdom. The main characteristics of the mobile applications described above are shown in Table 1.

Source	Users	Category	Brief description
<i>Hollywood Treatment for the Rehabilitation of Facial Paralysis and Stroke Patients</i>	Patients	Rehabilitation	The <i>app</i> allows patients to relearn muscle control and improve facial symmetry, [27].
<i>Mobile Application for Diagnosis of Facial Paralysis</i>	Patients and professionals	Diagnosis	The <i>app</i> performs an analysis of a set of nine facial expressions. The obtained score exhibits a high correlation with the subjective qualification scores and a high computational efficiency, [28].
<i>A Smartphone-Based Automatic Diagnosis System for Facial Nerve Paralysis</i>	Patients and professionals	Diagnosis	Fast and portable automatic diagnostic system, based on smart phones, which discriminates facial nerve paralysis of normal subjects through three movements: rest, brow lift and smile, [29].
<i>App aiding facial paralysis wins 10K at BDL Accelerate hackathon</i>	Patients	Rehabilitation	The <i>app</i> helps patients in their physical therapy through the use of gamma elements, [30].
<i>Análisis, diseño e implementación de una base de datos para la administración y control de pacientes con parálisis facial a través de una app en Android</i>	Professionals	Informative	The <i>app</i> is focused on the record keeping that doctors make about their patients, [31].
<i>Desarrollo de una app en Android para generar y controlar sesiones de ejercicios de rehabilitación a personas con parálisis facial</i>	Patients	Rehabilitation	The purpose of the <i>app</i> is to detect the human face in a state of: rest, brow lift, contracted lips, smile, eyes closed with force, each of these movements are used by patients with facial paralysis during their rehabilitation sessions, [32].
<i>Aplicación para apoyar a pacientes con parálisis facial y paraplejía</i>	Patients	Rehabilitation	The project aims to generate a system so that through a Tablet the patient can learn and perform facial physical therapy exercises, as well as follow up their therapy, [33].
<i>New app improves rehabilitation from Bell's paralysis</i>	Patients	Rehabilitation	The patient photographs himself making different expressions. The records are sent to the therapist who can examine the patient's condition and the facial paralysis progress, [34].
<i>Modelo de realidad aumentada para la etapa de fisioterapia en pacientes con parálisis facial</i>	Patients	Rehabilitation	The <i>app</i> aims to help patients with physiotherapeutic exercises in the treatment of the condition, [35].
<i>Mirror Facial Rehab App</i>	Patients	Rehabilitation	The <i>app</i> can measure successes, identify poor recovery, and keep patients committed to treatment, [36]. App turns iPad into a facial feedback mirror, [37].
<i>Neuroplatform, aplicaciones móviles para pacientes en neurorrehabilitación</i>	Patients	Rehabilitation	The <i>app</i> by a photograph of the patient generates an image of the 'correct face', for the patient to work the muscles until the desired situation is reached, [38]. The user, by recommendation of his doctor, chooses exercises that fit his clinical condition, [39].

Table 1. Main features of mobile applications aimed at patients and professionals when facial paralysis occurs. Information found in databases and search engines. Source: own.

4.2. Results in other data sources

As a result of the search in the data sources Google Play, App Store-Apple and Windows Store, a total of 13 apps for facial paralysis were found: 2 are found for both Android devices and Apple devices, 8 are for Android devices and 3 for Apple devices. For its part, the search in Windows Store did not yield specific apps for this type of paralysis. The apps found were classified as follows and with the following amounts: Informative (7), diagnostic (3), and rehabilitation (3). As for the language in which they are available, 7 are in English, 4 in Spanish. Although the search was conducted in Spanish and English, one app was found in Portuguese language and another app in Turkish language, but were added to the review as the current number of mobile applications in the area of facial paralysis are few. As far as the commercial price is concerned, 9 are free and 4 are paid. Considering the type of user they are aimed at, 9 of them are intended for patients, 2 for professionals, and 2 for both patients and professionals.

4.2.1. Apps found in Google Play

The informative apps aimed mainly at patients are the following: 1) "Parálisis Facial". Offered by Familia C.V, it contains information on general description, symptoms, causes, tests, treatment, exercises and healthy food recipes. Released: 11 August 2019, [40]; 2) "Parálisis Facial de Bell". Offered by Acume, it contains information on general description, symptoms, causes, diagnosis, treatment, House-Brackmann scale, exercises, specialists and testimonies of people who have or had facial paralysis. Released: 30 July 2019, [41]; 3) "Gimnasia facial – Tips". Offered by Things To Do, although the app is not specific to facial paralysis it contains information on how to prevent and treat this type of paralysis. Released: 6 February 2018, [42]; 4) "Parálisis Facial". Offered by Carmen Gómez Lescano, it contains information on general description, causes, symptoms, treatment, examples of exercises and healthy food recipes. Released: 17 November 2017, [43]; 5) "Paralísia Facial". Offered by Luís Ramalho, it contains information on general description, incidence, etiology, signs and symptoms, diagnosis, prognosis, treatment and facial exercises. Released: 25 February 2015, [44]. The first four of the previous apps are free and are in Spanish. The latest app is available in

Portuguese and is payable.

The apps for diagnosis and aimed at both patients and professionals are the following: 1) "FaCiPa: Facial Paralysis - Yüz Felci Erken Te hisi". Offered by FaCiPa, it is free and in Turkish language. It has an interface that informs the user of the result of the diagnosis that is obtained by performing an analysis of a snapshot of the user. The methods used in the diagnosis of facial paralysis are analyzed by supporting image processing techniques. Released: 29 May 2019, [45]; 2) "Facial Nerve Grading". Offered by JorgePierre, is free and in English language, it can be observed that facial nerve classification is widely used to characterize the degree of facial nerve function and provide reproducible information. Released: 8 May 2017, [46]. For facial rehabilitation and aimed primarily at patients is the app: "MyFace". Offered by Haining Zhu, it is free and in English language; it aims to assist in the recovery of patients through facial physical therapy. The app supports the following functions: chat, reminders, diary, summary, private data exchange and social support. It is designed and developed for a study by researchers from the Faculty of Data Science and Technology at Pennsylvania State University, USA. Released: 8 February 2019, [47].

4.2.2. Apps found in App Store-Apple

"FNPEval" Offered by Rachele Eljazzar, is free and in English language, it is for facial rehabilitation and aimed primarily at patients. It is the first and only app available to seamlessly track the progress of patients with facial nerve paralysis by measuring and recording facial angles. With this app, healthcare providers or patients themselves can objectively and accurately monitor the response to patient treatment. Released: 29 August 2018, [48].

"The eFACE". Offered by Massachusetts Eye and Ear Infirmary, it is a payment, English-language, diagnostic and primarily professional-directed program. Designed to provide a quick quantitative and graphical representation of facial function scores in patients suffering from unilateral facial paralysis, using visual analog scales. The instrument is divided into resting (static) readings, dynamic motion readings, and synkinesis (deviation) scores. During the real-time

examination of the patient, or after a video clip of facial movements, the app can be used to obtain physician-qualified scores for 16 separate facial function features. The graphs provide data on resting facial positions, dynamic facial movements, and synkinesis features. Released: 4 September 2015, [49].

It is important to note that the app "The eFACE", was used by experts in facial nerves to test the evaluation scale that uses the app, the results show that it is a reliable, reproducible and direct digital clinical measure that can evaluate facial function and disfigurement in patients with facial paralysis, [50], [51]. Similarly, La Paz Hospital in Spain has incorporated into its facial paralysis unit the evaluation scale used by the app "The eFACE" to evaluate the facial function of patients who have suffered this alteration, [52].

"Face It! Bell's Paralysis-Training." Offered by Ergonomhuset AB, it's paid, English-language, informative and primarily patient oriented, it provides information about Bell's paralysis and how can be started the patient training. It contains questions and answers about Bell's paralysis, some background on

how to do training, and specific exercises related to weakened muscles. Released: June 12, 2013, [53].

4.2.3. Apps found in both Google Play and App Store-Apple

"BAPRAS AEC in Plastic Surgery 3.8." Offered by The British Association of Plastic, Reconstructive and Aesthetic Surgeons (BAPRAS), is free and in English language, is informative, aimed primarily at professionals and shows an advanced educational course on facial paralysis. Released: April 12, 2017, [54], [55]. "Face2Face Facial Paralysis". Offered by Kapios LLC, is paid and in English language, it is for facial rehabilitation and primarily targeted to patients. The app reflects the healthy side of the face on the unhealthy side; allowing patients to exercise their facial muscles while seeing their face completely healthy. Mirror biofeedback therapy has been linked to positive results in the treatment of facial paralysis. Released: 16 September 2014, [56], [57].

The main characteristics of the apps found, exposed in sections 4.2.1 - 4.2.2 - 4.2.3, are shown in Table 2.

Name	User	Category	Platform	Price	Language
<i>Parálisi s Faci al</i>	Patients	Informative	Android	Free	Spanish
<i>Parálisi s Faci al de Bell</i>	Patients	Informative	Android	Free	Spanish
<i>Gi mnasi a faci al- Ti ps</i>	Patients	Informative	Android	Free	Spanish
<i>Parálisi s Faci al</i>	Patients	Informative	Android	Free	Spanish
<i>Parali si a Faci al</i>	Patients	Informative	Android	Paid	Portuguese
<i>FaCi Pa: Faci al Paralysi s Yüz Felci Erken Tęhi si</i>	Patients and professionals	Diagnosis	Android	Free	Turkish
<i>Faci al Nerve Gradi ng</i>	Patients and professionals	Diagnosis	Android	Free	English
<i>MyFace</i>	Patients	Rehabilitation	Android	Free	English
<i>FNPEval</i>	Patients	Rehabilitation	iOS	Free	English
<i>The eFACE</i>	Professionals	Diagnosis	iOS	Paid	English
<i>Face It! Bell's Paralysi s- Trai ni ng</i>	Patients	Informative	iOS	Paid	English
<i>BAPRAS AEC i n Plasti c Surgery 3.8</i>	Professionals	Informative	iOS and Android	Free	English
<i>Face2Face Faci al Paralysi s</i>	Patients	Rehabilitation	iOS and Android	Paid	English

Table 2. Main features of mobile applications aimed at patients and professionals when facial paralysis occurs. Information found in Google Play and App Store-Apple. Source: own.

5. Alternative proposal

Finally, it is evident from the consultation that to date there is no documentary data on a mobile application designed to be used by patients and professionals in the presence of facial paralysis in Colombia.

Therefore, a mobile application for the patient's rehabilitation with peripheral facial paralysis is proposed in perspective. This would have a series of facial exercises that allow the patient to develop a daily routine and adequate for facial recovery. Each one of these exercises will have corresponding information on: how to perform, number of repetitions, and additionally each time the patient performs each exercise can make use of the camera with the intention that the exercise could be observed and performed properly.

On the other hand, the mobile application would be based on the Android platform, using App Inventor, a software development environment created by Google Labs for the application development for the Android OS.

5.1. How it works

The mobile application would work in the following way: as a start the patient will have an interface that allows to know the general data: name, identification, medical center and physiotherapist; then the patient will proceed to another interface, which will ask the patient to determine what type of exercise is wanted to develop so that the mobile application proceeds to show the patient how to perform the exercise; at the time the patient selects the exercise the mobile application will ask how many series wants to perform. Finally, when the patient has finished doing the series or routine of exercises, the mobile application will show the generated records in a new interface.

Logs will be stored from the time the session starts until the time the session ends. The exercises included in the mobile application are as follows: 1) wrinkle the forehead (surprise face); 2) frown (brave face); 3) tighten the eyes; 4) open the nostrils (smell); 5) wrinkle the nose; 6) carry the upper lip up (forward); 7) join lips together and carry them forward (kiss); 8) smile without showing teeth; 9) smile showing teeth; 10) inflate cheeks and pass air from side to side; 11) carry lower lip forward and down.

5.2. Scope

It is intended that this mobile application be suggested to the patient by a professional physiotherapist in order to ensure that there is a guarantee in the evaluation of the patient's progress according to the data stored by the mobile application.

For this reason, the mobile application would initially be recommended by a single physiotherapist, who will advise it for his patients, and who will determine the progress through the use and analysis of the data stored by the mobile application: type of exercise performed per day, number of repetitions performed per day, number of days performing therapy and finally through a photographic record of the patient's face from the start of facial rehabilitation until the date on which the physiotherapist makes the study of the patient's progress.

With the mobile application proposed above, patients suffering from this facial paralysis will be allowed a rehabilitation that does not generate or represent: additional costs for travel to the medical center, payment for a series of sessions subject to availability, absence from work or change of agenda, among others. In addition, the patient will be able to perform his exercise routine at any place and time and will be able to observe his recovery through the photographic record. However, as always, it will be necessary for the patient to go to the medical center and the physiotherapist in order to have a professional endorsement in terms of facial rehabilitation.

6. Conclusions

The bibliographic review in databases and search engines results in the current number of mobile applications for facial paralysis being low considering the offer found in other areas of health. The search thus confirms the indications that there is an emerging market for mobile applications focused on patients and professionals. On the other hand, the search with other data sources allows to refer also that there are few existing mobile applications in the current market and specifically in the three consulted mobile operating systems such as: Android (Google Play), iOS (App Store-Apple) and Windows Mobile/Windows Phone

(Windows Store). It is also noteworthy that for the latter there are no specific mobile applications for this type of paralysis.

In the current mobile applications market there were a total of 13 apps for facial paralysis of which 7 are Informative, 3 Diagnostic, and 3 Rehabilitation. These apps are of great help for those people who for reasons of location, agenda or money cannot attend their face-to-face therapies and that if this resource did not exist, would remain without performing their respective facial rehabilitation in time, a key factor for recovery. It is important to mention that the mobile applications market is in constant development, consequently it is possible that not all the apps developed for facial paralysis have been registered or that there are new ones since the moment of the publication of this paper.

Although this review took as a window of exploration from January 2009 to September 2019, it is evident from the consultation made in the data sources specific to the field of mobile applications that the launch date recorded for the first mobile application for facial paralysis in chronological order is for "Face It! Bell's Paralysis-Training", dated 12 June 2013. For its part, the search made in databases and search engines brings as a result that by 2014 has its beginnings this type of mobile applications for facial paralysis. In the same way for both dates it is evident to emphasize that by means of the technologies of the information and communication is beginning to observe the growing interest in these mobile applications which help in a significant way for those people with facial paralysis.

References

- [1] A. Gómez Vélez, S. Nieto López, N. González Rey, and M. Ríos Lago, "El uso de los teléfonos móviles en la rehabilitación de las lesiones cerebrales," *Inf. psiquiátricas*, no. 229, pp. 53–77, 2017.
- [2] M. T. Sánchez Rodríguez, S. Collado Vázquez, P. Martín Casas, and R. Cano de la Cuerda, "Apps en neurorrehabilitación. Una revisión sistemática de aplicaciones móviles," *Neurología*, vol. 33, no. 5, pp. 313–326, 2018. <https://doi.org/10.1016/j.nrl.2015.10.005>
- [3] M. Rodríguez Mariblanca and R. Cano De la Cuerda, "Aplicaciones móviles en la parálisis cerebral infantil," *Neurología*, 2017. <https://doi.org/10.1016/j.nrl.2017.09.018>
- [4] D. C. Angarita Rodríguez and J. N. Castañeda Giaimo, "Use of mobile devices in physiotherapy," *Rev. Cuba. Inf. en Ciencias la Salud*, vol. 28, no. 2, pp. 1–13, 2017.
- [5] V. Villarreal, "Physical rehabilitation of patients: a mobile solution to facilitate basic physiotherapy exercises," *Rev. I+D Tecnológico*, vol. 12, no. 1, pp. 47–53, 2016.
- [6] L. Rodríguez Prunotto and R. Cano De la Cuerda, "Aplicaciones móviles en el ictus : revisión sistemática," *Rev. Neurol.*, vol. 66, no. 7, pp. 213–229, 2018. <https://doi.org/10.33588/rn.6607.2017380>
- [7] H. De la Cruz Regalado, C. E. López Barrera, E. E. Rodríguez López, L. M. Sandoval González, and A. Ramírez García, "Propuesta de un entrenador mioeléctrico basado en una aplicación móvil," *Pist. Educ.*, vol. 39, no. 128, pp. 395–411, 2018.
- [8] V. Cardos Millán, "Eficacia de la reeducación neuromuscular en la parálisis facial", thesis, University of Castilla-La Mancha, Spain, 2016.
- [9] M. A. Tovar Sánchez, J. G. Catacolí Samayoa, C. A. Echandía Álvarez, and J. G. Zapata Jaramillo, "Evaluation of facial nerve function index in patients with Bell's palsy," *Rev. Colomb. Medicina Física y Rehabil.*, vol. 26, no. 2, pp. 155–161, 2016. <https://doi.org/10.28957/rcmfr.v26n2a4>
- [10] P. Gómez González del Tánago, B. Navarro Vidal, R. Vallejo Hernandez, L. Panadero del Olmo, and F. Panadero Carlavilla, "Parálisis facial idiopática," *Panor. actual del Medicam.*, vol. 39, no. 389, pp. 980–984, 2015.
- [11] M. Lugones Botell, M. L. Bueno Hidalgo, and A. Jaime Álvarez, "Facial paralysis and preeclampsia," *Rev. Cuba. Obstet. y Ginecol.*, vol. 43, no. 1, pp. 1–13, 2017.
- [12] M. P. Mamani Pacari, Y. Mamani Ortiz, D. Illanes Velarde, and M. R. Rocha Albino, "Radiofrequency vs muscular Faradization to functional rehabilitation of peripheral facial paralysis patients," *Rev. Científica Cienc. Médica*, vol. 19, no. 2, pp. 5–13, 2016.
- [13] S. Benítez S, S. Danilla E, E. Troncoso O, A. Moya F, and J. Mahn A, "Multidisciplinary

- y management of facial paralysis,” *Rev. Médica Clínica Las Condes*, vol. 27, no. 1, pp. 22–28, 2016. <https://doi.org/10.1016/j.rmclc.2016.01.004>
- [14] E. Cáceres, M. Morales, G. Wulfsohn, and S. Montes, “Peripheral facial paralysis. Incidence and etiology,” *Rev. FASO*, vol. 25, no. 1, pp. 8–13, 2018.
- [15] T. Berg, “Medical Treatment and Grading of Bell’s Palsy”, thesis, University of UPPSALA, Sweden, 2009.
- [16] E. R. Gálvez Rojas, “Cuantificación del grado de parálisis facial mediante algoritmos basados en tracking facial”, thesis, University of Chile, 2017.
- [17] Á. M. Campos Mahecha and P. Villamor Rojas, “Recurrent Facial Paralysis: A clinical algorithm for diagnosis and management,” *Acta Otorrinolaringol. Cirugía Cabeza y Cuello*, vol. 46, no. 2, pp. 32–38, 2018. <https://doi.org/10.37076/acorl.v46i2.87>
- [18] A. Payá Rubio, R. Navarro Monsoliu, I. Climent Alberola, and M. Redondo Aguirre, “Recurrent and alternating peripheral facial palsy in a Rehabilitation department,” *Rehabilitation*, vol. 53, no. 1, pp. 60–64, 2019. <https://doi.org/10.1016/j.rh.2018.06.001>
- [19] Mayo Clinic, “Facial paralysis”, 2019. [Online]. Available: <https://www.mayoclinic.org/diseases-conditions/bells-palsy/multimedia/facial-paralysis/img-20008187>.
- [20] M. Padilla Guevara and R. Utsman Abarca, “Use of an acrylic shield for management of a compromised Upper lip due to peripheral facial palsy: clinical case report,” *Rev. Científica Odontológica*, vol. 11, no. 2, pp. 34–39, 2015.
- [21] I. R. Barrón Martínez, R. M. Aguilar Ponce, J. L. Tecpanecatí Xihuitl, and G. Mondragón Flores, “Medidas de Simetría para Evaluar los Efectos de la Rehabilitación en Pacientes con Parálisis Facial,” *Memorias del XXXVIII Congr. Nac. Ing. Biomédica*, vol. 2, no. 1, pp. 285–288, 2015.
- [22] D. Cera Barea, J. R. Martínez Pérez, R. Almaguer Pérez, and D. Ballester Domínguez, “Effectiveness of Acupuncture Treatment in Peripheral Facial Paralysis, Puerto Padre, Las Tunas,” *Rev. Electrónica Dr. Zoilo E. Mar. Vidaurreta*, vol. 38, no. 9, 2013.
- [23] S. B. Rios Rodriguez, “Electroestimulación muscular selectiva utilizada en el tratamiento kinésico de pacientes con parálisis facial periférica aguda y crónica,” *Rev. la Fac. Med. la Univ. Nac. Nord.*, vol. 36, no. 1, pp. 43–47, 2016.
- [24] Y. Pérez Castro, “Parálisis facial. Qué es, causas, síntomas y tratamiento en fisioterapia,” *Fisioonline*, 2018. [Online]. Available: <https://www.fisioterapia-online.com/articulos/paralisis-facial-que-es-causas-sintomas-y-tratamiento-en-fisioterapia>.
- [25] R. Hernández Sampieri, C. Fernández Collado, and M. del P. Baptista Lucio, *Metodología de investigación*, 5th ed. México: Subsidiary of The McGraw-Hill Companies, Inc, 2010.
- [26] O. Vera Carrasco, “Cómo escribir artículos de revisión,” *Rev Med La Paz*, vol. 15, no. 1, pp. 63–69, 2009.
- [27] Facial Palsy UK, “Hollywood Treatment for the Rehabilitation of Facial Palsy and Stroke Patients,” *Cision PR Newswire*, 2014. [Online]. Available: <https://www.prnewswire.com/news-releases/hollywood-treatment-for-the-rehabilitation-of-facial-palsy-and-stroke-patients-279783772.html>.
- [28] O. Azoulay, Y. Ater, L. Gersi, Y. Glassner, O. Bryt, and D. Halperin, “Mobile Application for Diagnosis of Facial Palsy,” *ResearchGate*, 2014. [Online]. Available: https://www.researchgate.net/publication/270887047_Mobile_Application_for_Diagnosis_of_Facial_Palsy.
- [29] H. S. Kim, S. Y. Kim, Y. H. Kim, and K. S. Park, “A Smartphone-Based Automatic Diagnosis System for Facial Nerve Palsy,” *Sensors (Switzerland)*, vol. 15, no. 10, pp. 26756–26768, 2015. <https://doi.org/10.3390/s151026756>
- [30] M. Ajjan, “App aiding facial paralysis wins 10K at BDL Accelerate hackathon,” *Wamda*, 2016. [Online]. Available: <https://www.wamda.com/memakersge/2016/11/app-aiding-patients-facial-paralysus-wins-bdl-accelerate-health-hackathon>.
- [31] E. Campos Dolores, “Análisis, diseño e implementación de una base de datos para la administración y control de pacientes con parálisis facial a través de una app en Android”, thesis, University Politénica de Puebla, México, 2017.

- [32] E. Xicale Montes, "Desarrollo de una app en Android para generar y controlar sesiones de ejercicios de rehabilitación a personas con parálisis facial", thesis, University Politécnica de Puebla, México, 2017.
- [33] Medular Digital, "Aplicación para apoyar a pacientes con parálisis facial y paraplejia". [Online]. Available: <http://www.medulardigital.com/?act=dnews&s=8&n=8105>.
- [33] Medular Digital, "Aplicación para apoyar a pacientes con parálisis facial y paraplejia". [Online]. Available: <http://www.medulardigital.com/?act=dnews&s=8&n=8105>.
- [34] J. S. Itzkovich, "New app improves rehabilitation from Bell's palsy," *The Jerusalem post*, 2017. [Online]. Available: <https://en.sce.ac.il/filestock/file/1532864303442-0.pdf>.
- [35] V. I. Rojas Rivero, "Modelo de realidad aumentada para la etapa de fisioterapia en pacientes con parálisis facial", thesis, University Mayor de San Andrés, Bolivia, 2018.
- [36] Emteq, "A fresh perspective on facial paralysis", 2019. [Online]. Available: <https://emteq.net/mirror>.
- [37] Facial Palsy UK, "Mirror Facial Rehab App", 2017. [Online]. Available: <https://www.facialpalsy.org.uk/research/current-projects/mirror-facial-rehab-app/>.
- [38] E. Suberviola, "Neuroplatform , aplicaciones móviles para pacientes en neurorrehabilitación," *Diario de Navarra*, 2016. [Online]. Available: https://www.diariodenavarra.es/noticias/negocios/dn_management/entrevistas/2016/05/26/neuroplatform_aplicaciones_moviles_para_pacientes_neurorrehabilitacion_458449_2543.html.
- [39] HealtheHealth, "Software para el ejercicio de pacientes con parálisis facial a través de su dispositivo móvil", 2019. [Online]. Available: <http://www.healthehealth.com/heh-neuroface-app/>.
- [40] Familia C.V, "Parálisis Facial," *Google Play*, 2019. [Online]. Available: <https://play.google.com/store/apps/details?id=com.paralisis.facial>.
- [41] Acume, "Parálisis facial de Bell," *Google Play*, 2019. [Online]. Available: <https://play.google.com/store/apps/details?id=com.acamue.paralisisfacialdebell>.
- [42] Things To Do, "Gimnasia facial - Tips," *Google Play*, 2019. [Online]. Available: <https://play.google.com/store/apps/details?id=com.proyectobeck14>.
- [43] C. Gómez Lescano, "Parálisis Facial," *Google Play*, 2019. [Online]. Available: <https://play.google.com/store/apps/details?id=com.paralisis.facial.recetas>.
- [44] L. Ramalho, "Paralisia Facial," *Google Play*, 2019. [Online]. Available: <https://play.google.com/store/apps/details?id=com.luisramalho.paralisiafacial>.
- [45] FaCiPa, "FaCiPa : Facial Paralysis - Yüz Felci Erken Te hisi," *Google Play*, 2019. [Online]. Available: <https://play.google.com/store/apps/details?id=com.facipa.yuzfelci>.
- [46] JorgePierre, "Facial Nerve Grading," *Google Play*, 2019. [Online]. Available: <https://play.google.com/store/apps/details?id=com.facial.nerve>.
- [47] Haining Zhu, "MyFace," *Google Play*, 2019. [Online]. Available: <https://play.google.com/store/apps/details?id=com.facestudio.emma>.
- [48] Rachele Eljazzar, "FNPEval. Facial Paralysis Evaluation," *Rachele Eljazzar*, 2019. [Online]. Available: <https://apps.apple.com/us/app/fnpeval/id1433640751>.
- [49] Massachusetts Eye and Ear Infirmary, "The eFACE," *App Store*, 2019. [Online]. Available: <https://apps.apple.com/us/app/the-e-face/id1032767378>.
- [50] C. Banks. et al., "Worldwide Testing of the eFACE Facial Nerve Clinician-Graded Scale," *Platic Reconstr. Surg.*, vol. 139, no. 2, pp. 491e-498e, 2017. <https://doi.org/10.1097/PRS.0000000000002954>
- [51] C. Banks, P. Bhamra, J. Park, C. Hadlock, and T. Handlock, "Clinician-Graded Electronic Facial Paralysis Assessment The eFACE," *Plast. Reconstr. Surg.*, vol. 136, no. 2, pp. 223e-230e,

2015.

<https://doi.org/10.1097/PRS.0000000000001447>

- [52] Hospital Universitario La Paz, “La Paz incorpora una nueva escala mundial de diagnóstico de la parálisis facial”, 2018. [Online]. Available : http://www.madrid.org/cs/Satellite?cid=1354692690397&language=es&pageid=1354754319138&pagename=HospitalLaPaz%2FCM_Actualidad_FA%2FHPAZ_actualidad.
- [53] Ergonomhuset AB, “Face It! Bell's Palsy-Training,” *App Store*, 2019. [Online]. Available: <https://apps.apple.com/us/app/face-it-bells-palsy-training/id658540102>.
- [54] BAPRAS, “BAPRAS AEC in Plastic Surgery 3.8,” *App Store*, 2019. [Online]. Available: <https://apps.apple.com/us/app/bapras-aec-in-plastic-surgery-3-8/id1212383971>.
- [55] BAPRAS, “BAPRAS AEC Plastic Surgery 3.8,” *Google Play*, 2019. [Online]. Available: <https://play.google.com/store/apps/details?id=com.bapras.aec38&hl=en>.
- [56] Kapios LLC, “Face2Face Facial Palsy,” *App Store*, 2019. [Online]. Available: <https://apps.apple.com/us/app/face2face-facial-palsy/id916197200>.