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Abstract— **The functional tests are essential to test the functionality of different types of people, and specialty for older adults. The primary purpose of this paper is to create a method for the automatic measurement of the results of the different functional tests. These are the Heel-rise Test, Functional Reach Test, Timed Up and Go Test, Ten Meter Walk Test, Eight hop test, Up-down hop test, Side hop test, Single hop test, Chair Stand Test, Arm Curl Test, and Chair Sit and Reach test. The use of sensors may increase the accuracy of the measurements of these tests. These tests may identify several diseases, and it will be subject to further research in the future.**

Keywords— Functional tests, physical therapy, mobile devices, automatic measurement, diseases.

I. INTRODUCTION

The mobile devices used daily have embedded in their hardware several types of sensors, including accelerometer, magnetometer, gyroscope, microphone, Global Positioning System (GPS) receiver, among others [1], [2]. These sensors allow the acquisition of several physical and physiological parameters during the various physical functional tests, allowing us to quickly assess the condition of individuals [3], [4].

Physical functional tests are essential to understand the functional kinesiological conditions of everyone in functional evaluation. These tests can be used in clinical assessments and consultations with medical specialists and even in judicial expert tests [5].

Within the judicial context, the distinct definition and orientation regarding functional tests are even more critical since their understanding, evaluation, and clarity of the results must be appropriately defined, under the risk of error. Thus, the physiotherapists appears as a reference in the application of these tests [6], [7].

In the literature, functional tests are described as a way of quantifying the individual's functionality [3], [4], that is their ability to use muscle strength, range of motion, neuromuscular control, joint stability and other physical capacities necessary to perform activities of daily living, such as walking, climbing and descending stairs, or performing sporting tasks, despite not identifying a specific change.

All individuals who suffer injury or surgical intervention can use these instruments, duly accompanied by a health professional, as a safe way to return to the activity, that is, either to assess their condition or to the physical train [8], [9].

There are several physical functional tests, such as Functional Reach Test [31], Heel-rise Test [32], Timed Up and Go Test [33], Ten Meter Walk Test, Eight hop test, Up-down hop test, Side hop test, Single hop test, Chair Stand Test, Arm Curl Test, and Chair Sit and Reach test [10]. These tests allow the treatment and diagnosis of various diseases, such as chronic venous disease, dysfunctions of the leg muscles (twins), rupture/tendinitis of the Achilles tendon, sports injuries, neurological pathologies, degenerative pathologies, lesions of the upper limbs, changes balance and, lower limb injuries, and Balance Changes [11], [12].

There are different types of functional tests and, although some tests are easy and quick to apply, others require a set of economically unreliable equipment for health services, and they are often only available in laboratories, where scientific research is performed.

These tests are an integral part of the individual's assessment by the multidisciplinary team and in the treatment plan. Thus, it is necessary to remove as much information as possible from its application, such as the number of repetitions, speed, angle, and height, ensuring the best possible follow-up for the individual [13].

These mobile applications allow, from a scientific point of view, to bring health professionals' clinical practice, reliable and valid measurement instruments until then are required research of scientific articles not only on the form of application but on the expected results for each condition [14].

They are adapted to the latest technological devices on the market, which facilitates access to any healthcare professional

or typical user who can interact with them. Thus, it is expected that the mobile app as no operating limitations [15], [16].

Finally, it would be essential to create an online platform available to all health professionals with standard values, case studies, forms of application, expected values for each condition, among others, as it would allow not only the exchange of information between different professionals, but also the creation of a database of each individual in particular, which facilitates the monitoring of their condition anywhere.

In addition to the creation of a method for the automatic measurement of the results of the different functional tests, including Heel-rise Test, Functional Reach Test, Timed Up and Go Test, Ten Meter Walk Test, Eight hop test, Up-down hop test, Side hop test, Single hop test, Chair Stand Test, Arm Curl Test, and Chair Sit and Reach test. This paper also proposes creating a database with sensor data acquired during the different tests, studying the ideal positioning of data acquisition devices, including the smartphone. At the same time, the state of the art of each of the tests must be carried out, considering the use of technological equipment. Then, several experiments must be carried out to create methods of automatic diagnosis of diseases that will help health professionals.

This paragraph ends the introductory section, and the related work is presented in section II. The methodology of this study was presented in section III, showing the preliminary results in Section IV. In the end, the discussion and conclusions are presented.

II. RELATED WORK

Mobile computing technologies are now used to support new healthcare solutions. Today, mobile devices, such as smartphones and tablets, include high-capacity processing properties and incorporate a few non-invasive sensors that are used to develop cost-effective and efficient healthcare solutions. Applications for mobile devices are already used to support various medical procedures where they even help the patient's participation in the prevention and management of their diseases. Also, mobile devices incorporate several short- and long-range communication protocols. On the one hand, Bluetooth, NFC, and Wi-Fi technologies are supported by most devices and can be used for short-distance communication and, particularly, for interfacing with external medical devices. These devices also support GPRS, 3G, and 4G technologies that allow the use of mobile data to send and receive data in situations where the Wi-Fi network is not available. Additionally, future devices will support 5G technologies, would allow usage of more sophisticated sensors, and even use the high-speed transfer to get processed results almost instantaneously and make decisions in real-time. However, creating labelled datasets for machine learning application faces several challenges in real environments [34].

Wearable devices currently incorporate the same sensors as smartphones and, consequently, can be used to monitor physiological signals such as cardiac beat non-invasively.

Mobile devices and wearables incorporate an accelerometer, magnetometer, and gyroscope that can be used for multiple applications in the context of enhanced health care, such as physical activity assessment. These devices also have a considerable memory capacity that allows the

collection and storage of body movement data in real-time or can be sent later when the device has access to the Internet.

Currently, with the aging of the population, there is also a significant increase in mobility-related diseases that have an impact on their postural stability and result in disturbances in their mobility that significantly reduce their independence.

The basis of this project focuses on the development of technological solutions on the following physical functional tests, such as Heel-rise, Functional Reach Test, Timed Up and Go Test, Ten Meter Walk Test, Eighth hop test, Up-down hop test, Side hop test, Single hop test, Chair Stand Test, Arm Curl Test, and Chair Sit and Reach test.

The studies available in the literature are not directly focused on the development of solutions with the equipment commonly used daily, but on the use of specific devices to collect data from different sensors.

Some studies about the Heel-Rise test have been carried out that relate its execution with the sensors embedded on a mobile device [32]. Still, most of the studies found are not carried out to see people's physical problems, taking into account the different tests. However, there are some preliminary studies on the execution of the Heel-rise test with several sensors, capturing some parameters related to it [17]. The Heel-Rise test can assist in measuring the level of ease of walking [18].

In turn, the Functional Reach Test has already been implemented in a pilot test on mobile devices and to detect the risk of falls, using the sensors of these devices [19][31]. However, much progress is possible in the use of sensors and mobile devices to calculate the results of this test.

However, the Timed Up and Go Test is one of the most implemented in the literature using sensors and even mobile devices, as mentioned in the studies [20], [21], [33]. However, many improvements are possible in this area.

Then, the implementation of the Ten Meter Walk Test with mobile devices and sensors was analyzed to analyze the problems of walking and fatigue [22]. Other purposes of this test can and should be explored to facilitate the work of health professionals and promote people's self-diagnosis.

Other physical functional tests, such as the Eighth hop test and the Up-down hop test, have never been explored using mobile devices and sensors, opening the way to explore the different parameters here. Regarding the Side hop test and the Single hop test also did not carry out implementations directly related to it.

The Chair Stand Test has been implemented using sensors from mobile devices [23] to calculate the different parameters about the test, including the test time, and falls. This test can also be used to detect falls.

In [24], the Arm Curl Test, and Chair Sit and Reach tests were implemented with the older adults to detect their physical condition.

The implementation of all these tests allows the creation of a Personal Digital Life Coach [35] to measure the physical condition of people using these tests. These solutions are especially important for older adults, allowing the improvement of quality of life, allowing them to act at the right time to correct specific health problems. These tests have been mostly implemented by people related to sports and the

older adults, although they are useful for the general population to assess their physical condition.

Other works related to the identification of the different movements were already performed by this team [25], [26].

III. METHODS

There are different types of functional tests and, although some tests are easy and quick to apply, others require a set of economically infeasible equipment for health services, they are often only available in laboratories, where scientific research is carried out.

As stated earlier, these tests are an integral part of both the assessment/reevaluation of the individual by the multidisciplinary team, or the treatment plan. Thus, it is necessary to remove as much information as possible from your application (number of repetitions, speed, angle, height, etc.), ensuring the best possible follow-up for the individual.

For the Heel-rise Test that assesses the muscular resistance of the leg muscles is simplified for any user, including health professional and other persons.

These applications allow, from the scientific point of view, to bring health professionals' clinical practice, and reliable and valid measurement instruments, that until then required to research scientific articles about the form of application and the expected results for each condition.

From a technological point of view, these applications are adapted to the latest technological devices on the market, which facilitates access to any professional/ordinary user who, with access to existing technology, can interact with them. Thus, it is expected that there are no limitations on the understanding/functioning of the application.

Also, the market available in this area is null, there is no product in the field, and therefore, as a novelty, you will have the entire sales market available to explore.

Finally, it would be essential to create an online platform available to all health professionals with standard values, case studies, forms of application, expected values for each condition, among others, as it would allow not only the exchange of information between different professionals, as the creation of a database of each individual in particular, which facilitates the monitoring of their condition anywhere.

The tests should be performed with older adults because they have more problems related to mobility, and its functionality should be tested. It is intended to use the sensors available in the mobile device and other low-cost sensors to evaluate the different parameters of the various functional tests.

Mobile devices increase the facility to acquire the different types of data from sensors with a mobile device in a waistband, collecting the movements of the centre of mass. The data will be analysed at real-time, and the results are stored in a server for further visualization of a professional healthcare. Based on this data, and our previous work [27]–[30], these data allows the identification of different diseases with machine learning and/or statistical methods.

IV. PRELIMINARY RESULTS

To provide better health/sports services and better clinical follow up its essential to create medical applications based on the functional tests apply by the multidisciplinary.

From the Scientific point of view, bring to the clinical practice of health and sports professionals, reliable and valid measuring instruments that previously required research papers not only on the application form as the expected results for each condition.

The applications found are adequate for the latest technological gadgets in the market, which facilitates access to any professional/typical user that, with access to existing technology, can interact with them.

Finally, it would be essential to create a web platform available to all health professionals (with default values, case studies, application forms, expected values for each condition, history of patient's tests, among others), since it would not only be an exchange of information between the different professionals, the creation of a database each individual in particular, which facilitates the monitoring of their condition anywhere at any time.

Also, the market available in this field is not developed, as we could explore with the methodology presented in [37]. There is no reference to other products of the area from previous research about functional tests and how to apply them. Therefore, as a novelty, has wholesales market available to explore.

These tests can identify some diseases with the characterization of the activities performed by the people. A cheaper mobile device used daily by people in the world is possibly improving the quality of life and the treatment of some health diseases. Different studies are already performed by some research people to try to identify the various activities of daily living using different sensors embedded in a mobile device. The detection of the activities performed in research studies related to the health are very studied. The validation of the automatic methods for the detection of different movements performed in medical treatments, tests or area is challenging, but it is needed for the validity of the methods and enlarge the viability for the market.

This project's variant was presented in other challenges, and it has been accepted with different suggestions. This project can be validated with communication with research laboratories located in the universities. In general, the standard tests used are the Heel-rise, Functional Reach Test, Timed Up and Go Test, Ten Meter Walk Test, Eighth hop test, Up-down hop test, Side hop test, Single hop test, Chair Stand Test, Arm Curl Test, Chair Sit and Reach test. Some research studies have already been by other authors using different sensors and by authors of these ideas using accelerometer and pattern recognition techniques for the Heel-Rise test.

The other tests have other studies with mechanical and electronic equipment, but the research on the different tests is tiny, and mobile technologies are very few used. The idea is to facilitate the work of the professionals and improve life's quality of the people.

As presented in Table I, these tests are related to different health diseases. The various tests have different defined activities that can be identified using different sensors. The sensors can detect the movement of different members related to the position of it. The mobile device to capture the movements should be positioned in a static position of the user's body.

The tests are used by different people, such as Physicians (P) from different specialties, such as Physical Medicine,

Orthopedics, Vascular Surgery, Sports Medicine, Geriatrics, among others, Nurses (N), Physiotherapists (Ph), Coaches (C), and Occupational Therapists (O).

On the other hand, these tests can identify some related health diseases, as verified in Table II. The associated conditions are Chronic Venous Disease (CVD), Disorders of the leg muscles (DLM), Break/tendinitis of the Achilles tendon (BAT), Sports injuries (SI), Neurological Pathologies (NP), Degenerative Pathologies (DP), Upper limb injuries (ULI), Balance Changes (BC), Injuries Member inferiors (IMI), Injuries of the lower limbs (ILL) and Injuries of the upper limbs (IUL).

TABLE I.   RELATION BETWEEN THE TESTS AND PEOPLE THAT ARE EXPECTED TO USE

	P	N	Ph	C	O
Heel-rise	Yes	Yes	Yes	Yes	No
Functional Reach Test	Yes	Yes	Yes	Yes	Yes
Timed Up and Go Test	Yes	Yes	Yes	No	No
Ten Meter Walk Test	Yes	Yes	Yes	Yes	No
Eighth hop test	Yes	Yes	Yes	Yes	No
Up-down hop test	Yes	Yes	Yes	Yes	No
Side hop test	Yes	Yes	Yes	Yes	No
Single hop test	Yes	Yes	Yes	Yes	No
Chair Stand Test	Yes	Yes	Yes	Yes	No
Arm Curl Test	Yes	Yes	Yes	Yes	No
Chair Sit and Reach test	Yes	Yes	Yes	Yes	No

TABLE II.   RELATION BETWEEN THE DIFFERENT TESTS AND SOME HEALTH DISEASES

	CVD	DLM	BAT	SI	NP	DP	ULI	BC	IMI	ILL	IUL
Heel-rise	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No
Functional Reach Test	No	No	No	Yes	Yes	Yes	Yes	No	No	No	No
Timed Up and Go Test	Yes	No	No	No	Yes	Yes	No	Yes	Yes	No	No
Ten Meter Walk Test	Yes	No	No	No	Yes	Yes	No	Yes	Yes	No	No
Eighth hop test	No	No	No	No	Yes	No	No	Yes	No	Yes	No
Up-down hop test	No	No	No	No	Yes	No	No	Yes	No	Yes	No
Side hop test	No	No	No	No	Yes	No	No	Yes	No	Yes	No
Single hop test	No	No	No	No	Yes	No	No	Yes	No	Yes	No
Chair Stand Test	No	No	No	No	Yes	No	No	Yes	No	Yes	No
Arm Curl Test	No	No	No	No	Yes	No	No	No	No	No	Yes
Chair Sit and Reach test	No	No	No	No	Yes	No	No	No	No	Yes	Yes

V. DISCUSSION AND CONCLUSIONS

This project aims to develop web and mobile applications, from existing tests in the literature, to evaluate the functionality of the individuals, identifying the degree of disability and analyzing physical condition in general or specific pathologies.

The functionality is the ability to use muscle strength, range of motion, and another physical capacity to carry out activities of daily living (as walking up and down stairs or perform tasks). To evaluate this critical component, a set of uneconomical equipment for health services is necessary. However, in clinical practice, patients should be assessed for functionality levels so that these applications can be used both by professionals and the public in general for assessment and monitoring.

The functional tests are fundamental to understand and comprehend the functional kinesiological conditions of each functional assessment. These tests can be used in clinical evaluations and consultations of medical specialties and even judicial expert tests. In the literature, the functional tests are described as a way to quantify the individual functionality,

i.e., its ability to use muscle strength, range of motion, neuromuscular control, joint stability, and another physical capacity to carry out activities of daily living, such as, walking, running or perform sports tasks (amateur or high competition), although not identify a specific change.

All individuals suffering injury or surgical intervention may use these instruments adequately monitored by a health care professional such as a secure way to return to work, or to assess whether their condition or to return workout.

These tests are an integral part either in the assessment/reassessment of the individual by the multidisciplinary team, either in the same treatment plan and therefore, should not be exempted. However, there are different types of functional tests and, although some tests are easy and quick application, others require a set of uneconomical equipment for health services, which are only available in laboratories of scientific research. That's why it's important to create mobile applications, to simplify and ensure individuals assessment.

Due to the existence of different tests and the capability of the sensors embedded in the mobile devices to capture the different characteristics of the activities performed during the tests, this project has an excellent viability to facilitate the measurement of the tests, using only a conventional mobile device with a mobile application instead of specific and sophisticated equipment. The vast data being collected with the proposed activities, will require significant analytics on Big Data scale, which in turn, might require appropriate approaches to extract valuable insights [36]. This project should implement the different tests in mobile apps, and it offers the possibility to monitor the various tests performed with a Web Platform. It promotes the realization of the tests more interactively, and the professionals can supervise their patients remotely. These tests can be used to identify different health problems, and the professionals can monitor the evolution of the health problems with the various tests.

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