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Final Thesis

“Wearable devices for aging population”

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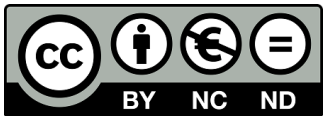

RESUMEN

Con este trabajo de fin de grado, lo que se intenta dar a conocer y analizar son los diferentes dispostivos de ayuda para personas mayores o personas que puedan padecer alguna enfermedad.
Para ello, analizaremos y estudiaremos los datos de diferentes modelos y dispostivos intentado proporcionar una visión global sobre estos nuevos instrumentos tecnológicos que nos ayudan en la actualidad. Primeramente, se examinaran los datos recogidos y se realizarán estadísiticas para ver su rendimiento en diferentes ámbitos como el ánalisis de la frecuencia cardiaca, medidor de calorías, detección de caidas... Finalmente, se estudiará el modo de transmisión de datos de cada modelo de dispostivo para dar a entender donde se almacen los datos y que mecanismo de transmisión se utilizan para recolectarlos.

ABSTRACT

With this final project, the aim is to present and analyse the different assistive devices for the elderly or people who may have some illness. To do so, we will analyse and study the data of different models and devices in an attempt to provide a global vision of these new technological instruments that are helping us nowadays. Firstly, we will examine the data collected and perform statistics to see their performance in different areas such as heart rate analysis, calorimeter, fall detection, etc.... Finally, the data transmission mode of each device model will be studied to understand where the data is stored and what transmission mechanism is used to collect it.

DEDICATION

To my family, especially my parents, my sister and my grandmother, thank you for the unconditional support you have always given me. For never letting go of my hand and for trusting me more than I trust myself.

I would like to thank my tutors, Laura Po and Javier Fabra, for their dedication and patience, without their help and corrections I would not have been able to finish this project.

To the great family that has given me this academic stage, thank you for being part of the best stage of my life, since I started as a kid with only 18 years old in Zaragoza until I ended up being a man with 22 in Modena.

Thanks to all the teachers who have transmitted me their knowledge and values to form me as a person and computer engineer, without you none of this would have been possible.

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1. INTRODUCTION

1.1. Project framework

This final degree project consists of the analysis and study of different devices that can help the elderly population to prevent illnesses and warn them of critical situations. Different data will be studied that can provide an idea of which is the best gadget for each person who is considering the possibility of acquiring one.
The study will focus on the analysis of health patterns such as behavioural temperature, heart and respiratory rate, blood pressure, blood oxygen level... Furthermore, the characteristics and specifications of each device will be analysed, compared and the results visualised in graphs and charts. In addition, the way of data transmission of each model will be collected, and where each type of device stores data will be studied.

1.2. Motivation

Nowadays, the health and welfare of elderly people is quite a big issue. Detecting an illness early or a strange pattern in the vital signs of our elderly can be vital for their lives, so if you have the necessary tools and correctly analyse the data from different information systems, you can act immediately after an injury has occurred or you can identify worsening of health very quickly.

In addition, many governments currently implement residences and homes for the elderly where the care of the elderly starts with technological devices such as sleep analysers, tools to detect heart rate and body temperature, breathing quality, etc... For this purpose, a good analysis and sampling with the necessary statistics will make it easier for them to choose the device that best suits them.
In addition, this thesis serves to complement and assist as much as possible the project of Lively Aging that is an innovative initiative funded by the Italian Ministry of Health that aims to improve the well-being and quality of life of older people. It focuses on establishing Living Spaces that promote the autonomy and safety of older adults, as well as on the prevention of cognitive decline and the improvement of cardiovascular health.
In this project, wearable devices will play an important role in creating a digital twin for each elderly resident, leading to improved living conditions and timely first aid and emergency services. Lively Aging aims to revolutionise elderly care and promote active and healthy ageing by combining interdisciplinary approaches and innovative use of technology.
To this end, the project has been carried out to analyse the data of each device and to choose the most suitable one for this type of population.

1.3. Objective of the project

The main objective is to compare a set of wearable devices based on their characteristics, their data transmission. Thus, it is easy to understand which device is best suited to each person's needs.
The project will start with the analysis of smartwatches and smartbands and other devices and will continue with the way of data transmission of these dispositives and the storage of the data of these gadgets in the network.

The aim of the work should be to be able to present the device that best suits the objectives of each person and to study all possible cases of the different technological tools that can help us to prevent illnesses and injuries and studying the transmission and storage format of each model .
For this purpose, we will separate the project into different sub-objectives.

1.Analyse the different devices, specification by specification to understand which device is best for each person depending on their age, social status and health values.
2.Study how data is transmitted and understand which method of transmission is the most efficient.
3. Identify where device data is stored and which device allows for better data management.

1.4. Structure of the project

In the second chapter we will briefly explain the devices that have been analysed in order to elaborate our results in the project.

In the third chapter we will study the beginning of these technological tools from their beginnings until the present day, detailing and showing the series of changes that these devices have undergone up to the present day.

In the fourth chapter we proceed to explain and analyse each device evaluated, looking at all its functionalities and advantages over other devices.

In the fifth chapter we proceed to study the data storage and data transmission of the most important brands by looking at their means of storing data in the cloud.

In the sixth chapter, the most important aspects of the work will be summarised and conclusions will be drawn.

2. SMART DEVICES FOR HUMAN WELL-BEING

Nowadays, technology is more and more in our lives, in the market you can find from different devices capable of making a simple call to communicate with a family member to technological tools capable of detecting the level of glucose in the body.

All of this is constantly evolving and every day we can find technological objects that make our lives easier. In recent years, technology has been responsible for an increase in life expectancy and the provision of better treatment at more affordable prices for a variety of infectious diseases, as technological tools and devices play a vital role in detecting diseases and abnormalities in parameters of a human being's health[1].
Due to significant improvements in productivity, the quality of intensive treatment and the means invested by governments in research and development, the use of technology in healthcare is expected to increase further in the coming years[2].In addition, the value of facilities using technology-enabled devices to enhance their offerings to the public is increasing significantly, with hospitals alone projected to reach approximately USD 84.38 billion by 2028 at a compound annual growth rate of 24.10% [3]. Moreover, the IT budget in each organisation is increasing considerably over the years due to the importance and benefits of these advances in healthcare.

Another clear example of the use of these devices in our daily lives and more focused on the project we are carrying out is the care of the elderly population in nursing homes, where telemedicine, that is, interactive communication between the nursing home user and the doctor in real time, has been implemented.In addition, devices with blood oxygen level meters, fall detectors, heart rate and body temperature detectors... are very common in these centres[4]. Our main objective will be to detail which device is best suited to each centre, in particular to the centres in the province of Emilia-Romagna, Italy.

Fig. 2.1. SmartDevices used in life

In the following, different devices that have been analysed in the project will be explained.

2.1. SmartWatches

A smartwatch is a wearable device that combines the functionality of a traditional wristwatch with features and capabilities of a smartphone or a fitness tracker. It typically includes a digital display and connects to a smartphone or other devices via Bluetooth or Wi-Fi.
There are two types of smartwatches within the market, Firstly, a general purpose smartwatch, such as the Apple Watch, these are designed to replace mechanical wristwatches and rely heavily on smartphones.
Secondly, there are watches intended for specific use cases such as physical activity. These devices often offer a more robust version of a fitness tracker, or a more secure GPS, i.e. they are specialised in a certain activity. For instance, diving watches, hiking watches, or flying watches...[5]

Smartwatches offer a range of features and functionalities, which may vary depending on the brand and model. Some common features 2.2 of smartwatches include:

Timekeeping: Smartwatches display the current time and can have various watch faces to customize the appearance.

Notifications: They can receive and display notifications from a paired smartphone.

Fitness Tracking: Many smartwatches have built-in sensors to track physical activity, such as steps taken, distance traveled, calories burned, heart rate monitoring, and sleep tracking. They often include dedicated fitness apps and GPS for accurate tracking.

Fig. 2.2. Features of a smartwatch

Communication: Some smartwatches allow users to make and receive calls directly from their wrist, using a built-in microphone and speaker or by connecting to a smartphone via Bluetooth.

Apps and Customization: Smartwatches often support a variety of apps that can be downloaded and installed, expanding their functionality.

Music Control: Many smartwatches offer music playback controls.

Payment and NFC: Some smartwatches support contactless payments through near-field communication (NFC) technology, enabling users to make payments with their watch.

Voice Assistants: Smartwatches may integrate voice assistants allowing users to interact with their watch using voice commands.

In addition to all these functionalities, many smartwatches have integrated functions to look after the well-being of their users.

2.2. SmartBands

Wearable devices worn on the wrist, they are usually more compact and lighter than wristwatches. They are usually equipped with a screen that allows you to control certain functions of your phone and track physical activity data2.3.
They are a technological tool that you wear on your wrist, usually much more compact and lighter than a watch and have similar functionalities.
Also known as smart bracelets, these devices work with sensors that capture information from the environment, this information is stored and analysed so that it is translated into concrete values, such as steps, calories burned or heartbeats per minute [6].

In the following, we will show some of the typical functionalities of these Smartbands.

Activity tracking: Smart bands typically track the number of steps taken, distance travelled and calories burned.
Sleep tracking: These bracelets can monitor your activity while you sleep, they can detect your sleep time and all the information you do while you sleep.
Heart rate: Many smartbands can analyse the heart rate of each user.
GPS and location tracking: Some smartbands are GPS-integrated and allow you to track your location at all times.

Fig. 2.3. Example of a smartband

In addition, some smartbands may also offer additional features such as blood oxygen saturation measurement , stress monitoring, menstrual cycle tracking, sedentary reminders, fall detection, among others.

Although they are similar devices to smartwatches, they have some differences that make them distinctive and both are used to satisfy different objectives. Firstly, smart bracelets are a cheaper and lighter device than a watch, so depending on the use we want to give it can be a more affordable option. However, smartwatches give the user a better response for the analysis of different activities such as physical activity and they can also answer calls and messages and can be used to play music. So depending on the use we want to make of it, one option will suit us or the other [7].

2.3. Sensors available on different devices

2.3.1. Hear Rate Sensor

A pulsometer, also known as a heart rate monitor, is a wearable device that allows you to track your heart rate in real time or store it for later analysis (2.4a). When performing different physical activities, it is mainly used to record heart rate data.
They typically use two types of methods to record cardiac signals. Electrocardiography (ECG) devices incorporate sensors that detect the biopotential generated by the electrical signals that regulate the contraction and expansion of the heart's chambers. These sensors are often used in medical devices.
PPG (Photoplethysmography) sensors use light-based technology to measure blood volume controlled by the pumping action of the heart[8].

2.3.2. Glucose Sensor

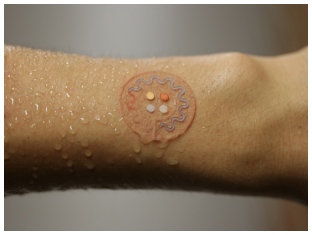
A glucose sensor is a device that measures glucose levels in the body and warns the user if he or she is in danger (2.4b). It consists of three parts: an electrode that is placed under the skin, a transmitter that sends blood readings at regular intervals, and a receiver that receives the data from the transmitter. These devices are often used by diabetics in order to detect if any abnormality occurs and these sensor is an increasingly adopted technology that has proven benefits for people with diabetes.¡

2.3.3. SweatPatch

Wearable and flexible sweat sensors enable continuous, real-time, non-invasive identification of sweat compounds, providing a deeper understanding of human physiology at the molecular level. These sensors have been a breakthrough in science thanks to their multiple applications in personalised health monitoring (2.4c).

(a) Chest heart sensor

(b) Glucose Sensor



(c) Sweat Sensor

Fig. 2.4. Heart Rate Sensor,Glucose Sensor, Sweat Patch

2.4. Smart Ring

Smart rings are devices that are very similar to the rings we use as a complement but with the difference that they have several added electronic functions that respond to to specific functions (2.5a).
These rings can be used for certain applications, such as health monitoring through heart rate analysis, step measurement, calorie measurement and blood oxygen level measurement. In addition, they can be used to perform physical activities and analyse the user's performance in these activities. They can also be used to monitor sleep or even to make payments via the NFC platform[9].

2.5. Smart Shoes

Smart shoes are shoes that go beyond just being comfortable or practical, technology gives them a plus in terms of functionality or innovation and is one of the key trends to think about in your designs (2.5b).
Among their functionalities are activity monitoring, these shoes usually count steps taken, distance travelled and calories burned; GPS and location tracking; gait analysis, as they can analyse the user's running or walking style.
Furthermore, smart shoes can be connected via Bluetooth or Wi-Fi to a smartphone or other devices, allowing data transfer and customisation of settings[10].

2.6. Smart Glasses

Smart glasses are wearable devices that are placed on the eyes or head and offer a variety of useful capabilities to the user (2.5c).
They can include displays that add information to the user's view. These glasses can collect information from internal or external sensors, monitor and retrieve data from other devices, and support wireless technologies such as Bluetooth, Wi-Fi and GPS.
Some models also function as wearable media players and have life logging and activity tracking features.

(a) Smart Ring

(b) Smart Shoes

(c) Smart Glasses

Fig. 2.5. Smart Ring, Smart Shoes and Smart Glasses

2.7. Smart Mask

Smart masks are a device that has been enhanced with additional technology and functionality to provide benefits and protect the wearer more effectively than a conventional mask (2.6).
Some of its functionalities are advanced filtration to remove impurities and dust residues from air particles, sensors to measure air quality, air purification functions... In addition to providing an ergonomic and comfortable design for the user.

Fig. 2.6. Smartmask

2.8. Smart T-Shirt

Smart T-shirts are garments equipped with integrated technology and sensors that offer different functionalities such as physical activity monitoring, posture analysis during any type of activity, sweat analysis, heart rate, respiration and body temperature measurement, providing valuable information about the user's health and well-being (2.7a).

2.9. Smart Socks

Smart socks are devices that can collect and transmit data related to physical activity, health and well-being (2.7b).
They are often equipped with motion sensors, accelerometers and gyroscopes that record foot activity and movement and send the data via Bluetooth or other technology to a mobile app or other device for analysis and tracking.

2.10. EGC device

An ECG device refers to an electrocardiography (ECG) device used to measure the electrical activity of the heart. These portable devices record the heart's activity and generate an electrocardiogram, which is a graphical representation of that activity (2.7c). They are used in the diagnosis and monitoring of cardiac conditions, as well as in sports performance monitoring .

(a) Smart T-shirt

(b) Smart socks

(c) EGC device

Fig. 2.7. Smart T-shirt, smart socks , EGC Device

2.11. Smart Pendant

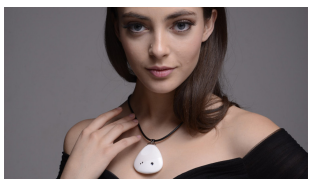
A smart pendant is a device similar to the necklaces we wear nowadays but equipped with technological functions to offer a certain type of service (2.8a).
These include activity tracking to track the number of steps, measure the distance travelled or the calories burned, sleep tracking and connectivity.
It is important to note that many smart pendants have a button for emergencies to notify warnings or detect falls.
Nowadays, many necklaces combine technology with fashion to offer the wearer an elegant and comfortable style, but at the same time, with technology.

2.12. Tracking sensor

A tracking sensor is a smart sensor that is used to collect information about the position, movement or activity of an object or person and are used for fitness tracking and navigation systems (2.8b).
These tools have built-in GPS to track the wearer's location at all times, accelerometers to measure the wearer's speed and direction, motion sensors and optical sensors to analyse and track movement, all of which collect accurate, real-time data on location, movement and activity, useful in a wide range of industries and application

2.13. Alarm device

An alarm device is a piece of equipment designed to detect danger, intrusion or other emergency situations and to emit an alarm signal. In a variety of environments, including homes, workplaces, automobiles and other places where security is needed, these devices are used to provide security and warning (2.8c).
These tools can be used by the population to warn when a fall occurs or when the user is in a risky situation.



(a) Smart Pendant

(b) Tracking Sensor

(c) Alarm Device

Fig. 2.8. Smart Pendant, Tracking Sensor and Alarm Device

3. HISTORY OF SMART DEVICES

The first smart devices date back to the 20th century, specifically to the 1980s, when the first attempts to combine electronics and computing in everyday devices started to appear.
One of the first intelligent devices was the "Seiko MessageWatch" (3.1c) launched in 1984. This watch had a small display and could store messages and reminders.
The first smart phone was designed by IBM in 1992 and was called Simon (3.1a). Apart from being a mobile phone, it contained a calendar, address book, world clock, calculator, notepad, e-mail, sent and received FAX and included games. To make calls you had to dial contacts on a touch screen as it had no buttons[11].
Later, in 1966, the Nokia 9000 (3.1b) appeared on the market, was branded as a communicator and was one of the first mobile devices to have an extended keyboard that allows sending and receiving e-mails[12].
The idea of smart homes began to gain popularity in the 1990s. Electrical devices can now be controlled remotely and home security can be monitored, thanks to home automation systems such as the X10.
As technology has advanced, more and more devices with greater functionality have emerged. In 1999, the company Blackberry launched a device that allowed users to access e-mail, surf the Internet and make phone calls in a single device.
This launch revolutionised smart devices and later companies such as Apple, Samsung and Nokia wanted to follow the smart phone model.
Since then, smart devices have become increasingly popular. Smart watches, voice assistant systems, smart bands, smart glasses, home security systems and many more have come to market, all connected via the Internet and capable of interacting with the user.

(a) IBM Simon (b) Nokia 9000 (c) Saiko MessageWatch

Fig. 3.1. First smart devices

3.1. Smart Watch

In the midst of history, many changes have occurred in watches. From their creation in Babylon, in 1400 B.C., which consisted of calculating the time it took for a drop of water to pass from one container to another, to the present day, when we have powerful clocks that have many more functions apart from calculating the time[13].
Subsequently, different types of watches emerged until reaching the one that predominates today, from sun watches to the so-called pocket watches.
It was in the 19th century when the wristwatch began to be used for its comfort and design, and it was transformed and adapted to the technological changes of the present day[14].

The first smartwatch dates back to 1972, when the Hamilton Watch Company launched the Pulsar watch. Pulsar became a brand that was later acquired by Seiko. In 1982 the Seiko TV Watch was launched, which could store 24 digits, making it the first watch with user-programmable memory. In 1994 the Timex Datalinks wristwatch was introduced and was one of the first smartwatches to have the ability to transfer data wirelessly from a PC. Seiko later released the Ruputer in Japan in 1998, considered one of the first smartwatches, with a monochrome graphic display and third-party applications. Then, in 1999, Samsung launched the world's first watch phone, the SPH-WP10, with an outstanding antenna, monochrome LCD display and basic phone functions. In June 2000, IBM introduced the WatchPad prototype, a wristwatch that ran Linux and was updated with features such as an accelerometer, vibration mechanism and fingerprint sensor. Subsequently, they collaborated with Citizen Watch Co. to create the WatchPad 1.5, which featured a touch screen, calendar software, Bluetooth, and RAM and flash memory.Afterwards, in 2009, Burg launched the first standalone smartwatch with its own SIM card, and Samsung introduced the S9110 Watch Phone with a colour LCD screen. The real smartwatch boom began in the 2010s with companies such as Apple, Samsung and Pebble entering the market. In 2010, Pebble launched its first successful smartwatch, with an e-ink display and the ability to connect to smartphones via Bluetooth. In 2014, Apple launched the Apple Watch, which marked a turning point in the smartwatch industry by offering a wide range of features and generating a great deal of interest. Other manufacturers such as Samsung, Huawei, Garmin and Fitbit also launched their own smartwatches with different features and approaches[15].

Over time, smartwatches became more compact, stylish and powerful, and offered additional functions such as fitness tracking, sleep monitoring, music playback and app launching.
Newer models are more independent of smartphones, offering built-in cellular connectivity for making calls, sending text messages and accessing the internet.

Smartwatches continue to evolve with new features, improvements in design and function-

ality, and have become a popular fashion accessory and an integral part of many people's daily lives.

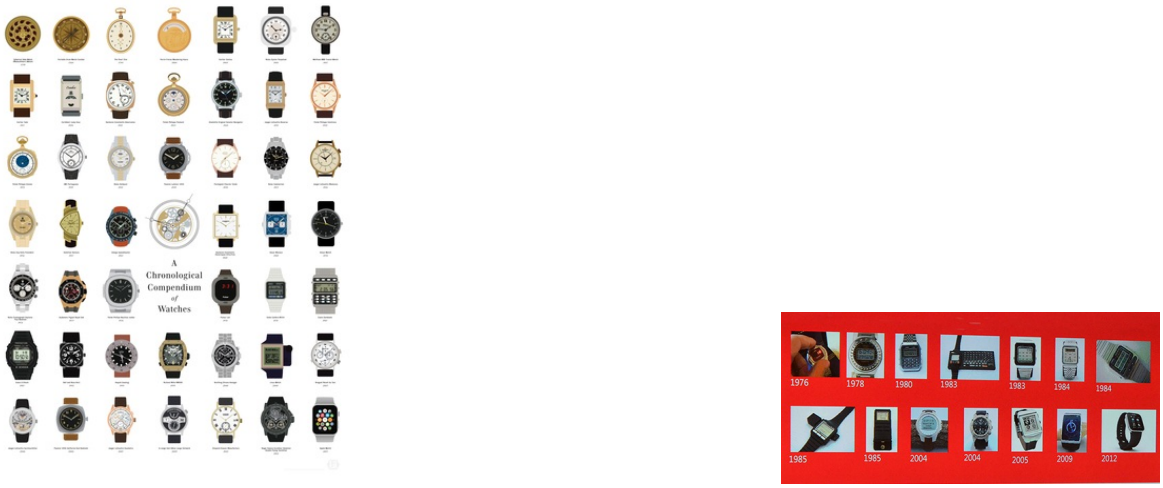


Fig. 3.2. Evolution of Smart Watch

3.2. Smart Band

The first smartbands hit the market in the 1980s, marking the beginning of the history of smart bands. The accessibility and convenience of these devices were limited by their size and location.
As a result of the gradual miniaturisation of electronic components made possible by technological advances, the first smart wristbands were created. These devices had the ability to monitor steps, heart rate and, in some cases, sleep quality.
In the late 20th and early 21st centuries, technological advances enabled the automation of monitoring and recording of physical activities, facilitating their integration into everyday devices. Early examples of this technology include watch bands for physical activities such as cycling that record data such as speed, duration and distance, which have been available since the early 1990s[16].

Fig. 3.3. FitBitFlex

However, the launch of Fitbit Flex (3.3), one of the first popular products on the market, gave a significant boost to the smart band industry in 2013. For a more complete fitness tracking experience, Fitbit Flex was the first to integrate state-of-the-art sensors and a mobile app. Since then, Fitbit has become one of the leading manufacturers of smart bands. This device continuously tracks movement 24 hours a day, including monitoring the quality of sleep. It has a simple display consisting of 5 LEDs that indicate the number of steps taken in a day, and emits vibrations to indicate when the set target has been reached, in addition, these

lights also show the battery charge level[17].
The market became more competitive in the following years thanks to the introduction of smart bands by companies such as Xiaomi, Apple and Garmin. These devices improved as technology progressed and added new features such as real-time heart rate monitoring, location tracking with integrated GPS and water resistance.
Smart bands have continued to develop as a result of the growing demand for wearable technology and ongoing technological advancement. There are now smart bands on the market that can track particular sporting activities such as swimming, cycling and running and have colour touch screens, contactless payment capabilities and blood oxygen saturation monitoring.

3.3. Heart Rate Sensor and EGC device

The first models of heart rate sensor included a monitoring device with a set of electrode cables connected to the chest strap. The first wireless heart rate monitor was developed in 1977 by Polar Electro.

In 1981, the first heart rate monitor for athletes, called the Polar Sport Tester PE 2000, was introduced to the market. This device consisted of a wristwatch as can be seen in the figure 3.4 connected to a sensor placed on the chest. The sensor detected electrical impulses from the heart and transmitted the information to the watch, where the heart rate was displayed in real time.
With technological advances, heart rate monitors became more accurate, compact and easier to use. Wireless models were introduced in the 1990s, eliminating wires and using wireless transmission.
Subsequently, brands such as Polar, Garmin, Suunto and Timex launched a variety of models with different advanced features[18].

Fig. 3.4. PE 2000

The first EGC devices date back to the 1980s. In 1872, a device called a capillary electrometer was created, which could measure the voltage changes on the surface of the body produced by the heart's pulses.

Later, in 1911, Willem Einthoven, who was working in the field, discovered the string galvanometer and improved on the previous process[19].
In recent decades, smaller and more convenient devices have emerged, such as hand-held electrocardiographs and portable ECG monitors that are capable of detecting changes in the heart very accurately and correctly.

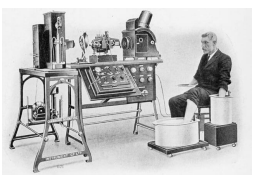


Fig. 3.5. First EGC

3.4. Smart Glasses, Glucose Sensor and SweatPatch

The idea of creating smart glasses began to emerge in the 1980s when initial concepts of augmented reality and information display on a handheld device were explored.

However, it was not until 2012 that the first smart glasses launched by Google, called Google Glass (3.6), came onto the market.They were equipped with a small screen in the user's field of vision, offering functions such as access to real-time information, navigation, photo and video capture, as well as the ability to receive notifications and make calls.
Later, companies such as Microsoft, Vuzix and Epson presented their own versions of smart glasses, targeting different audiences and use cases, such as enterprise and augmented reality applications [20].

Fig. 3.6. Google Glass

The first blood glucose meter was invented in 1971 and was able to give an approximate blood glucose number by reading the reflective light from a test strip that produced a colour after a drop of blood was applied.
Developments in technology led to the introduction of more sophisticated glucose sensors that allowed continuous, non-invasive monitoring of blood glucose levels.These sensors use electrodes that are inserted under the skin to measure glucose levels.
In recent years, significant advances have been made in the development of non-invasive glucose sensors, such as those based on optical or electrochemical technology [21].

The history of sweat sensors dates back to the early 2000s, when researchers began to explore the possibility of using sweat as a valuable source of information about the health and performance of the human body.
Today, sweat sensors have become more sophisticated and have broader applications, such as disease monitoring, sports performance monitoring, and stress and fatigue assessment. They continue to evolve and are integrated into wearable devices such as smartwatches and activity wristbands, enabling continuous, real-time monitoring of sweat levels and data analysis [22].

3.5. Smart Shoes, Smart socks and Smart T-shirts

The first smart shoes emerged between the 1980s and 2000s. In those early models, sensors and electronic devices were integrated into the sole or the inside of the shoes to provide basic functions such as tracking physical activity, distance travelled and step count.
Then, brands such as Nike, Reebook, Adidas and Puma started to manufacture such shoes,

with the Reebok Pump 2.0, Nike Air MAG, Adidas_1 range standing out.Nowadays, they are still in constant evolution, with new technologies and new changes in their products [23].

The history of smart socks is more recent, as they are still in constant development and are not as well developed as other devices. As technology advances, smart socks are expected to become more sophisticated and expand their scope in terms of benefits for users.

Like socks, smart t-shirts are constantly developing and it is expected that in the future smart t-shirts will become more sophisticated, comfortable and versatile, offering a wide range of benefits for users.

3.6. Smart Ring , Smart Pendant and Smart Mask

The history of smart rings dates back to the last few years, with the aim of offering a more discreet and elegant experience, in particular, in 2013 the first smart ring by McLear appeared. With the advancement of technology, smart rings are predicted to become more sophisticated and become even more integrated into people's everyday lives[24].

Like many other devices, smart pendants are constantly evolving and are only expected to continue to evolve in terms of functionality, battery life and more sophisticated designs. In the future, smart pendants are anticipated to be a popular choice for those looking to combine style and technology in a stylish and functional piece of jewellery.

The history of smart masks dates back to 2019, specifically due to the COVID-19 pandemic, these devices began to be developed in a more technological and precise way to offer greater care and less exposure to the virus.They are expected to continue to improve and provide additional benefits for people's well-being and safety.

3.7. Tracking Sensor and Alarm Device

In the 1960s and 1970s, optical sensors based on photodiode technology were used to monitor objects in a controlled environment. These sensors can detect changes in light reflected or emitted by objects and convert them into electrical signals for processing. Advances in computer and sensor technology have introduced other sophisticated tracking methods.
In the late 1980s and early 1990s, the use of passive and active infrared sensors to monitor motion became popular. These sensors use infrared transmitters and receivers to detect changes in the speed of light and determine the position and movement of objects.
Several types of tracking sensors are currently available, including those based on cameras, lasers, accelerometers, gyroscopes and magnetometers, among others.

The first instruments used as alarms were bells, drums, whistles or any instrument that made a loud sound to alert the population. In the 1950s, the first electronic alarm systems

came into use.
Later, devices similar to today's alarm systems began to appear, which could be used individually or collectively and could detect where the individual was located when the alarm was sounded[25].

4. ANALYSIS AND STUDY OF THE DATA

4.1. Analysis of smart watches

To choose the best smartwatch for the elderly population it is necessary to evaluate all its data and functionalities, obviously this type of population will want a simple and easy to use watch with a long battery life and capable of detecting the different vital aspects such as blood oxygen, heart rate, steps taken...
In addition, a GPS-enabled device will help your loved ones to know what you are doing at all times and to be on the spot in time if something untoward happens.
It is also important that the device is not excessively expensive, although depending on the needs and means of each user this aspect may be irrelevant.

The top-rated devices on the market have been selected and their various functionalities have been compared in order to provide a comprehensive approach to the public.

4.1.1. Compatibility

A watch is compatible when it supports the version of that operating system, i.e. when it can be used with a device running that operating system.
Some watches can only be used by iOS devices, such as the Apple Watch; others can only be used by Android devices, such as the Samsung Watch; although the vast majority have a system compatible with both versions.

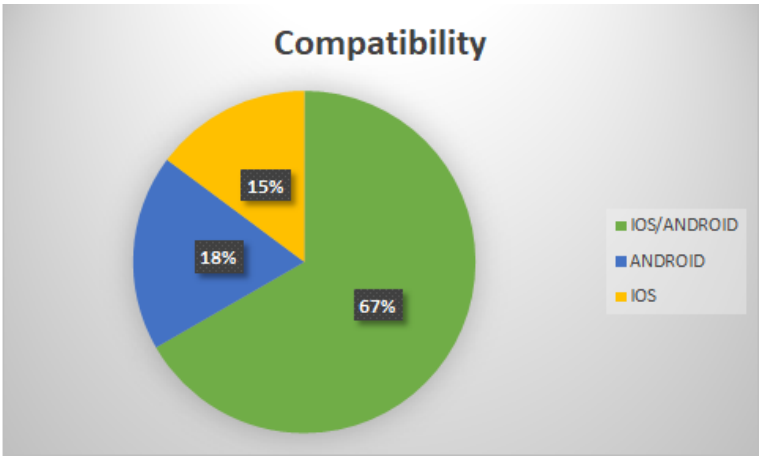


Fig. 4.1. Compatibility graph

As can be seen in Figure 4.1, 67% of smartwatches are compatible with both Android and iOS, 18% of devices are compatible only with Android environment and only 15% of watches work only with iOS platforms.
Broad compatibility will allow the device to connect to many operating systems, that is,

if a device can connect to ANDROID and IOS, it will be able to connect to devices that work with both services.
This factor can be a determining factor in determining which type of watch is best for each user, depending on the means of connection available to them, they will be interested in one watch or another.
As shown in the table 6.1, the watches that only allow connection with the IOS platform are the Apple Watches, while the Samunsug, Honor and Google Watch only allow connection with Android. However, all the other watches analysed allow connection with both platforms.

4.1.2. Launch Year

This aspect is less relevant than others, but it also has to be analysed because many watchmakers rely on the year of manufacture to choose one watch over another, as many people think that the newer a device is, the better it will perform.

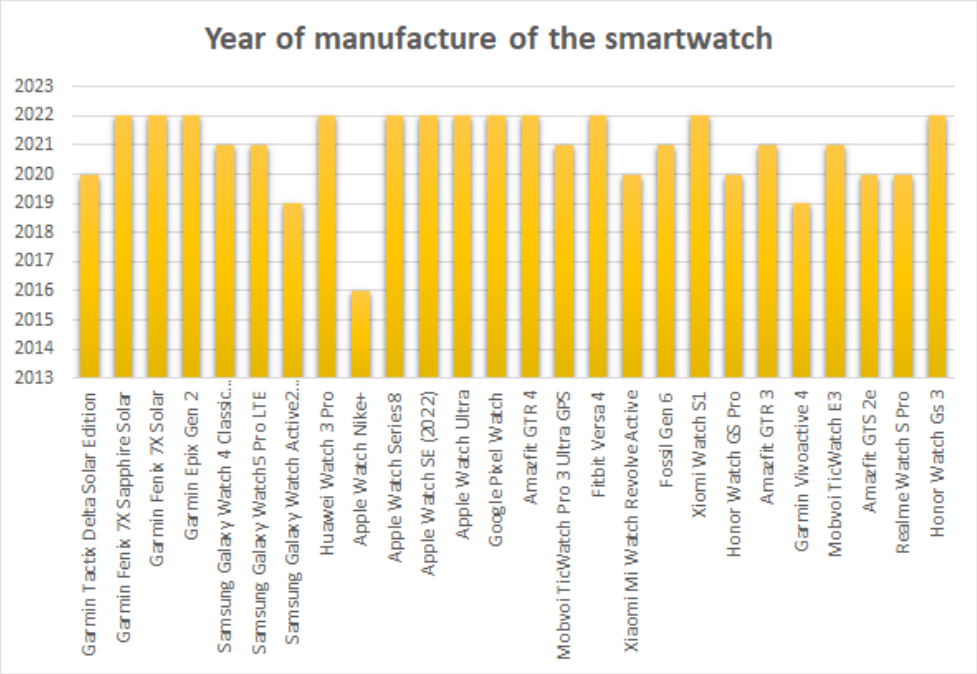


Fig. 4.2. Year of manufacture graph

In the figure 4.2 we can apreciate that the years of manufacture of these watches vary from 2016 when the Apple Watch Nike+ was released (a rather old device with few features and currently on very limited sale) to 2022 with the newest and best-valued watches on the market.

4.1.3. Battery life

The battery is one of the most important aspects when choosing a watch, especially for older people who need a device with a long battery life.
In the table 6.1 you can observe that you can rate the watches by 3 types of battery mode, firstly, the table shows the battery life with normal use, secondly, the table shows the battery life with Solar mode active, and finally the battery life with GPS activated is also analysed.
It is important to analyse the battery life with GPS enabled as the elderly population will by default have GPS enabled to know their location at all times.
Moreover, some watches have the functionality to last longer as they have a solar function that charges them during use. The table 6.1 shows the watches that have this functionality and their respective battery life.

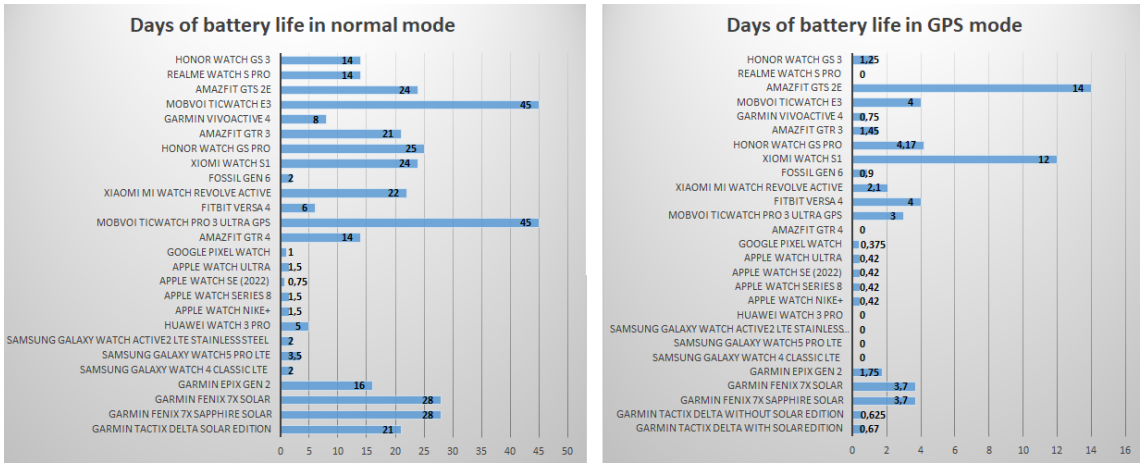


Fig. 4.3. Battery Life graph

As can be seen in the figure 4.3, the watches with the longest battery life in normal mode are those of the Mobvoi brand, however, it can be seen that if you activate the GPS it is not the same, as the Amzfit with 14 days of use and the Xiaomi with 12 days of use are the watches that last the longest with GPS.

4.1.4. Tactile screen

The touchscreen is one of the most important elements of the watch, providing greater usability and dexterity to the user.
Additionally, touchscreens provide the user with a number of advantages such as more space to display information, ease of use, precise control and intuitive interaction.
Therefore, buying a smartwatch with a touchscreen can be more beneficial for an elderly person as they can access their data more easily and interact with it more accurately.

In the table 6.1, you can see that nowadays almost all watches have a touch screen as it

is one of the most important aspects, but you can see that the Garmin Tactix Delta Solar Edition watch does not, being also one of the highest rated watches, probably because it is a sports watch that measures data very accurately and is not as interactive for the user as other watches.

4.1.5. Size of screen

Another important aspect when choosing a smartwatch is the size of the screen, a larger screen increases the readability and ease of viewing data for the user, but we should not overdo it when choosing a watch because for the elderly population a watch with a larger than normal screen can be uncomfortable or heavy on the wrist.
Therefore, a middle ground would be ideal, a watch with a display large enough to be readable but also comfortable to wear.

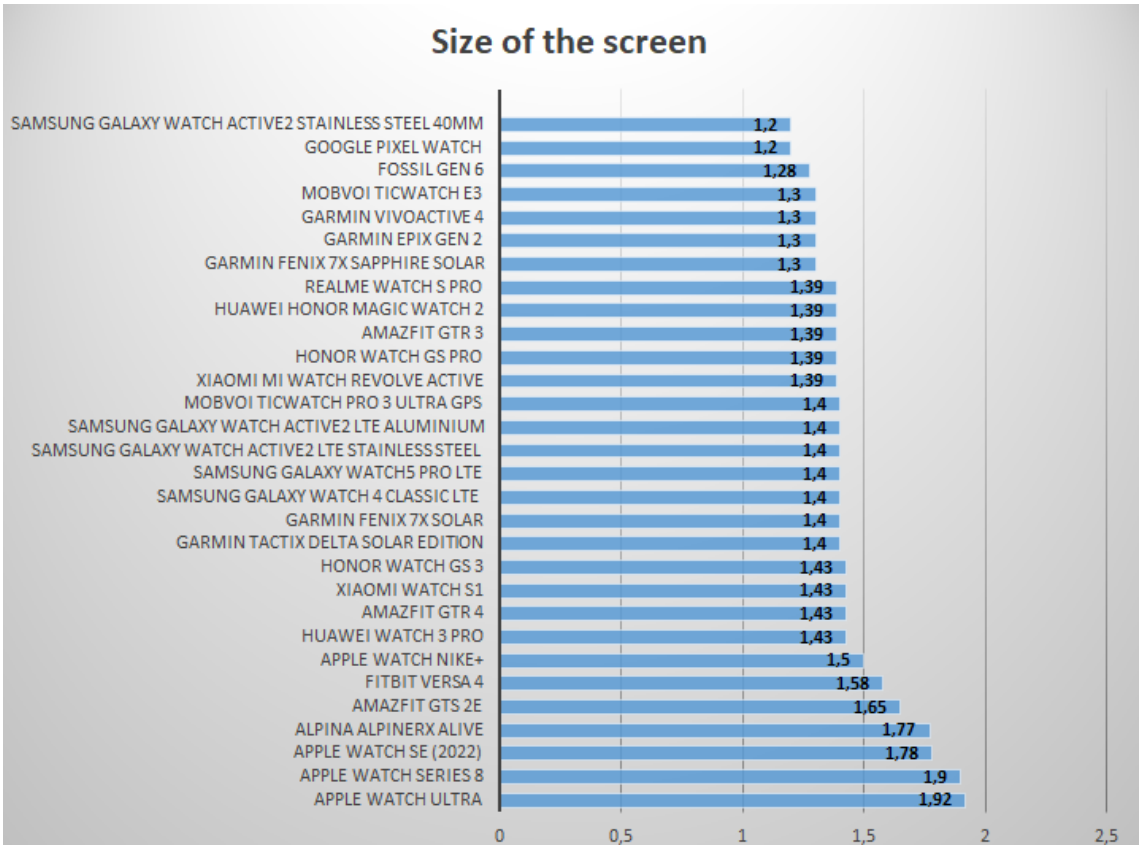


Fig. 4.4. Size of screen graph

We can see from the figure 4.4 that the number of inches of each screen does not exceed the norm, i.e. the screens are neither excessively large nor excessively small.
The watches that offer the largest screen are Apple watches, as the main purpose of this brand is to facilitate the user at all times.
On the other hand, the watches with the smallest screen capacity are those from Google and the so-called Samsung Galaxy Watch Active2 with 1.28 and 1.2 inches respectively.

4.1.6. Internal Storage

Internal storage is an important element in these devices as it refers to the storage space built into the device for storing data and related files.
It is important to note that the internal storage space in a smartwatch is also shared with the device's operating system and pre-installed applications. Thus, the amount of space available to the user may be limited, especially on older smartwatches or smartwatches with more basic features.
That said, we must choose a watch with as much storage as possible to be able to access all its functionalities and to be able to save the data correctly for later analysis.

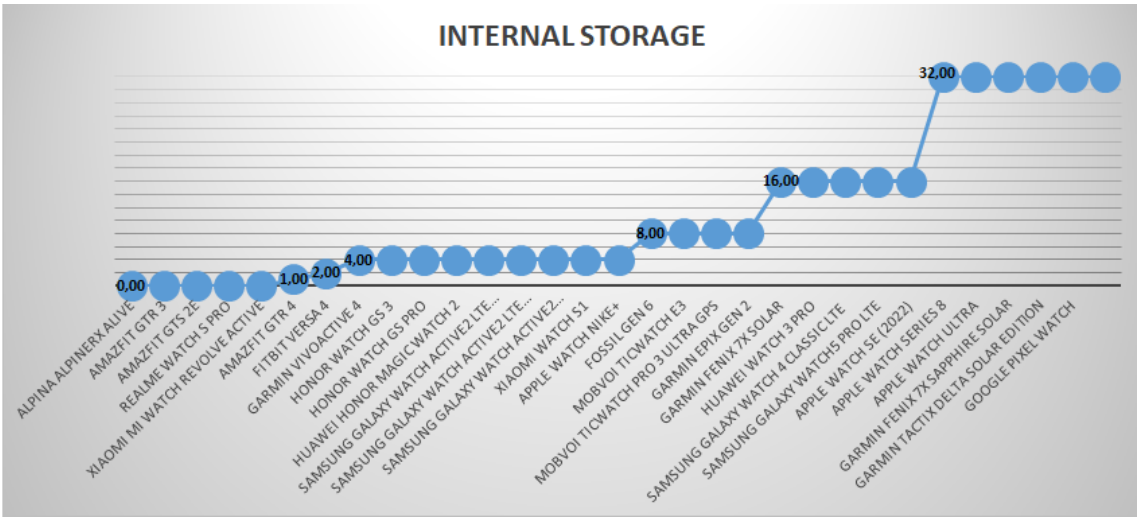


Fig. 4.5. Internal Storage graph

The figure 4.5 shows that the internal space ranges from 32GB for the devices with the most space to 0GB for those with the least. If the price allows it and the qualities of the watch are optimal, it is always better to opt for a watch with more space.

4.1.7. Price

Price is one of the most important aspects before proceeding to purchase such a device. The individual who wants to purchase one of these tools has to take into account its economic performance.
A watch that is too expensive may have a lot of functionalities but cannot be afforded by the whole population, while a cheaper watch may be equally suited to the requirements of the user. Therefore, before buying a smartwatch, the first thing to do is to look at the price and the functions you want it to have.
Before buying a watch we should look at its minimum and maximum price, because sometimes as we can see in the table 6.2 a simple manufacturing material can vary the price quite a lot, so, we should see if we are interested in paying the maximum price for the watch or if we are interested in buying another cheaper version of the watch.

In the table 6.2 can be seen the diferent prices for the same watch, in some cases we can see that the price variation is due to a type of material as is the case of the Apple Watch Series 8, in other cases we can see that depending on the version (Garmin Tactix Delta Solar or Amazfit GTR 4) the price varies, in addition there may also be price variation depending on the diameter of the screen (Garmin Fenix 7X Solar).

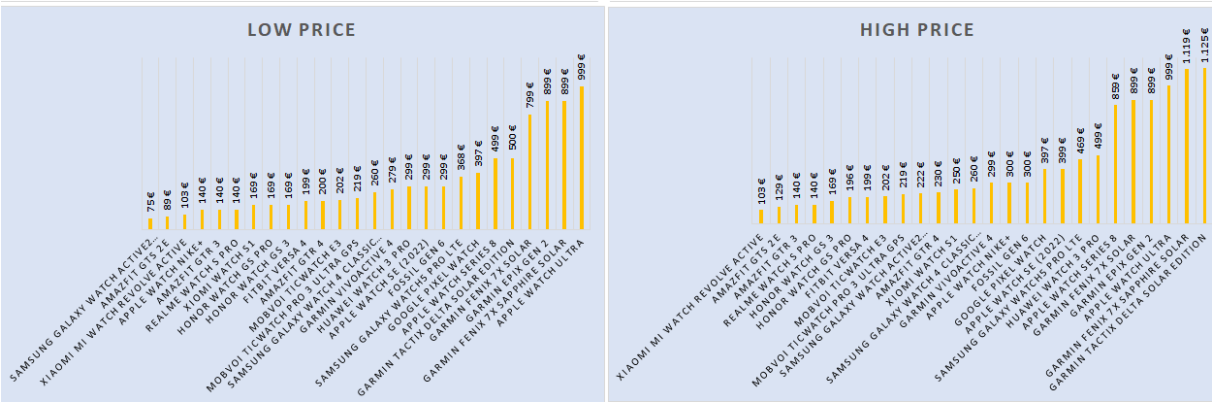


Fig. 4.6. Prize of smartwatch graph

It can be apreciated in the figure 4.6 that there are price of all kinds, in the low price graph , that is, the the cheapest version of smartwatches we can see that the cheapest smartwatch is Samsung Galaxy Watch Active2 LTE Stainless Steel and the most expensive is Apple Watch Ultra. However, if we look at the high price graph, we can see that the cheapest watch in this graph is the Xiaomi Mi Watch Revolve Active and the most expensive watch is the Garmin Tactix Delta Solar Edition (probably because of its Solar version).

4.1.8. Cardiac Monitor

The heart rate monitor is a must-have feature in smartwatches that are intended for the elderly population. Its function is to measure and monitor the wearer's heart rate. It uses optical sensors that detect changes in blood flow through the skin to determine the heartbeat.
The table 6.3 shows that 100% of smartwatches have this functionality. This is because most smartwatches nowadays have a built-in heart rate monitor to monitor the user's heart rate.

4.1.9. Blood oxygen level

Blood oxygen refers to the amount of oxygen that is dissolved in the blood and available for transport to the body's tissues.
This is a very important factor for the adult population because it is important for assessing respiratory function and oxygenation of the body. Nowadays, many devices have this type of functionality and it is becoming increasingly rare to find a smartwatch on the market

without them.
In the table 6.3 you can see that all devices except two Apple Watches and one Samsung watch have this capability.

4.1.10. Step Measure, Step Counter and Calories Burned

Counting steps and the number of steps is a capability that nowadays all watches have, as well as counting calories burned during the day.
Many watches have sensors that detect what kind of activity you are doing, so the accuracy of calorie counting is becoming more and more precise.
As can be seen in the table 6.3, absolutely all watches have these functionalities, as they are anti-rust factors that have been around for years and are being improved all the time.

4.1.11. Temperature Sensor

Some smartwatches have temperature sensors that can measure body temperature, these sensors use technologies such as infrared thermopile or thermistors to measure the temperature on the surface of the skin.
Body temperature measurement can be useful for monitoring health, especially in situations such as detecting fever or tracking changes in body temperature during physical activity or sleep.
The table 6.3 shows that most smartwatches do not yet have this feature built in and only a few of the watches shown in the table 4.1 have this functionality.

Model	Temperature Sensor
Garmin Tactix Delta Solar Edition	Yes
Garmin Fenix 7X Sapphire Solar	Yes
Garmin Fenix 7X Solar	Yes
Garmin Epix Gen 2	Yes
Samsung Galaxy Watch5 Pro LTE	Yes
Huawei Watch 3 Pro	Yes
Apple Watch Series 8	Yes
Apple Watch SE (2022)	Yes
Apple Watch Ultra	Yes
Garmin Vivoactive 4	Yes
Amazfit GTS 2e	Yes

TABLE 4.1. SMARTWATCHS WITH A TEMPERATURE SENSOR

4.1.12. Transpiration and Barometer

Sweating is a physiological response that occurs when the body needs to cool down. It can be triggered by a variety of factors, such as environmental heat, physical exercise, stress, intense emotions and illness.
By measuring perspiration, smartwatches can provide useful information about the level of physical activity, exercise intensity and hydration status of the wearer.
However, as the table 6.4 shows, most smartwatches do not have dedicated sensors to directly measure perspiration.
Only the Garmin Epix Gen 2, Xiomi Watch S1 and Huawei Watch 3 Pro contain sensors that measure the user's perspiration, which can detect changes in the electrical conductivity of the skin, which is related to the amount of sweat present.

The barometer is a sensor that measures atmospheric pressure, in a smartwatch the barometer is used for altitude tracking, weather forecasting and fitness tracking. Nowadays it is crucial that almost all smartwatches have this functionality.
Realme Watch S Pro is the only watch that does not have a barometer, this is because it has been on the market for a few years and there are better versions that are making it obsolete.

4.1.13. GPS and Sleep hours counter

GPS provides any watch with location tracking and navigation functions and allows you to determine your precise geographic location using satellite signals.

Many smartwatches have a built-in sleep sensor that records and analyses your sleep patterns. These sensors use a combination of accelerometers and optical sensors to monitor your movements during the night and determine different stages of sleep, such as light sleep, deep sleep and REM sleep.
As reflected in the table 6.4, all the watches we are analysing have both GPS and a sleep monitoring sensor.

4.2. Analysis of smartbands

4.2.1. Launch Year

As seen above with watches, the year of manufacture is important for many users who prefer a newer, more contemporary device. However, smart wristbands are not yet as popular as watches, so a wristband can be on the market longer without an improved version being released.
In the figure 4.7, it can be seen how the years of production vary between 2017 and 2022. New models are coming onto the market with better functionalities and wristbands are increasingly gaining market share over other devices.

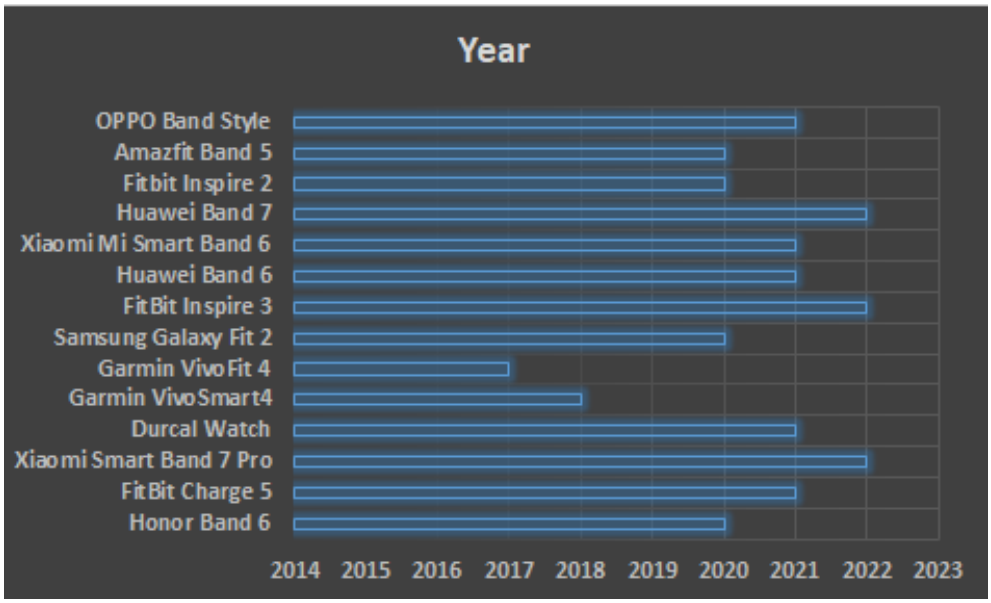


Fig. 4.7. Year of smartband

4.2.2. Size of screen

The size of the screen is not so important in wristbands, as several wristbands do not have a screen at all as they have other abilities. Still, a good display makes it easier for the user to read and understand the functionality of the wristband.
In the table 6.5, you can see the screen size of each device, you can see that some devices do not have a screen, this is because these devices are bands designed for specific functions and it is not necessary to show the results on the screen.

4.2.3. Battery Life

The battery of a smartband is one of the most important factors, especially for elderly people who need devices with a long battery life.

In the figure 4.8 a high maximum can be seen, this is because this bracelet uses a replacement battery, i.e. it is not a charging battery but every year you have to replace the battery with a new one.

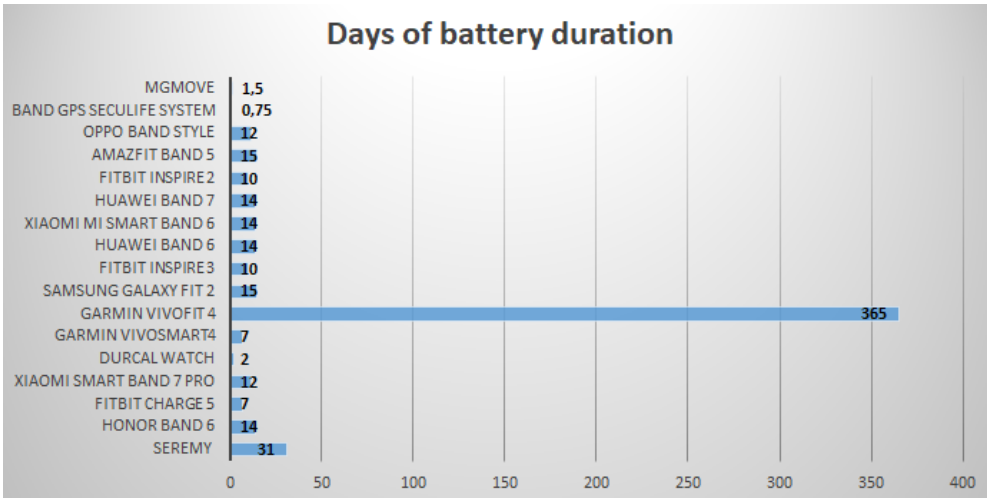


Fig. 4.8. Days of battery life in smartbands

4.2.4. Prize

The price of smartbands is a fundamental factor when it comes to choosing which one to buy. As it is not a very expensive device, the prices do not vary too much between one device and another.
In the figure 4.9 we can see that the price does not vary too much between the different products. It should also be noted that many wristbands contain an additional price to purchase a number of functionalities that can be paid monthly, also depending on the size of the wristband the price may vary slightly. All these values and extras of the initial price are reflected in the table 6.5

Fig. 4.9. Prize of smartbands

4.2.5. GPS

GPS in smartbands uses satellite signals to determine real-time location and can provide accurate data on distance, speed and pace during activity.
The GPS function in a smartband is useful for those who want to accurately track their outdoor activities without having to wear a separate tracking device such as a sports watch or smartphone.
Nevertheless, the table 6.6 shows that few of the activity trackers tested have built-in GPS, only Fitbit Charge 5 has a GPS, in addition to the aforementioned tracking wristbands such as the Seremy, MGMove...

4.2.6. Cardiac Monitor and Blood Oxygen Level

Being able to measure heart rate is a very important feature in many technological devices. Currently, most smartbands have this functionality but in the table 6.6 you can see how neither Garmin VivoFit 4, Band GPS SecuLife System and MGMove have this function. This is because the last two are wristbands for the safety of the user, i.e. to detect where he/she is at all times and to alert in case of emergency. And the first one is a simple wristband that acts as a watch and as a step and activity meter and calorie counter.

The same applies to the measurement of blood oxygen levels.As can be seen in the table above, Muvit I/O Health Tensio Lite and Samsung Galaxy Fit 2 join the three devices mentioned previously that do not have a blood oxygen level meter.

4.2.7. Step Counter and Calories Burned

The measurement of steps and calories burned is a very frequent aspect of all fitness devices. However, there are wristbands that are not intended to inform the wearer of their daily activity or calorie burn, as they have other purposes such as warning of a dangerous situation or location.
In the table 6.6, you can see that Band GPS SecuLife System is the only wristband that does not have a step meter, this is because it is used to know your location or the location of any object that contains it.
It can also be seen that only 4 bands do not have a calorie burned meter, this is because these wristbands may be remote assistance or location tracking wristbands, so they do not have this functionality built in.

4.2.8. Temperature Sensor of the Body and Sleep sensor

Temperature sensors can be useful for tracking your body temperature during exercise, monitoring ambient temperature, or even detecting changes in body temperature that may indicate fever or other health problems.

The table 6.6 reflects that currently few bands have such built-in sensors that use thermal technology to measure temperature and usually provide readings in Celsius or Fahrenheit. Only the two Fitbit models have these sensors, this may be because these bracelets are among the most sought after on the market and these newer versions would have added such functionality.

Sleep sensors in smartbands are functionalities that allow monitoring and analysing the quality of a person's sleep. These sensors use different technologies to detect and record various parameters related to sleep, such as duration, quality, sleep phases and movement patterns during the night.
The table 6.7 shows that all smart bracelets that are not used for geolocation or remote monitoring bracelets have a sleep sensor.
Normally, they use an accelerometer or an optical heart rate sensor to collect data during the night, the accelerometer records body movements, while the heart rate sensor can detect changes in heart rate during sleep.

4.2.9. Transpiration and Barometer

Today, only very few smart wristbands are able to measure perspiration, because the sensors needed to measure perspiration have not yet been developed for these smaller devices than watches. It can be seen from the table 6.3 that none of the wristbands studied have this functionality.

The barometer in smart smartbands is a sensor used to measure atmospheric pressure. As with perspiration, this sensor is not yet incorporated in most bands and it can be seen in the table 6.7 how only a few devices contain this functionality.

4.2.10. Emergency botton and fall detector

The emergency button on smart wristbands is a function that allows the wearer to send an alert signal or call for help in emergency situations. It is especially useful in situations where the user is in an urgent or risky situation.
By activating the emergency button, predefined contacts can be notified and help can be requested quickly and efficiently.

Fall Detector is a feature designed to automatically detect falls or accidents and send an alert to emergency contacts or an emergency response system.It is useful for the elderly, people involved in high-risk sports or people who have pre-existing medical conditions.
As can be seen in the table 6.7, only the assistance or support wristbands have these two functionalities.

4.3. Analysis of other devices

There are other devices that are used for specific functions such as heart rate monitoring, sweat detection, glucose detection, accelerometers...
These devices are not as general as watches and bracelets and do not have all their functionalities but the specific function they perform is done with higher precision and quality. In the following, these devices will be analysed and studied.

4.3.1. Launch Year

The year in which each device was released depends on the innovation of each device. Most of these services were launched from 2015 to the present.
In the table 6.8 you can see how smart shirts were launched in 2017, smart glasses made by Google were launched in 2012, but are currently very difficult to find, however there is another model of smart glasses that was launched in 2021.In addition, heart rate sensor were launched on the market between 2015 and 2020, the first glucose sensor tested was launched in 2014, followed by new, more modern and effective versions. In addition, it can be seen that the first EGC services were launched in 2008, although new units were also launched later.
To sum up, the year of market launch of each device varies depending on the device and can be clearly seen in the table 6.8.

4.3.2. Prize

The prices of these devices are very diverse, from the patch to analyse sweat for 25 € to the accelerometer to detect with very good precision the movement of different particles for 12700 €. It can see in the table 6.8 the variation in prices depending on the type of device, for example, smart shirts are priced at around 250 euros, heart rate sensors are around 80 euros, smart rings vary between 150 and 400 euros depending on how you want to pay and whether you want to add extra functionality.

4.3.3. Battery life

Like the price and year of release, the battery life of each device varies by type. The table 6.9 shows that heart rate sensors vary from 400 hours for the shortest to 3.5 years for the longest, smart rings vary from 7 to 14 days, glucose sensors vary from 20 hours to 7 days...
All this and more can be seen in the table above and we can see the difference in battery life between one service and another, as well as comparing it to the smartwatches and smartwatches reviewed above.

4.3.4. Weight and Size

The weight of each device is quite important to know because you need to know if a device is too heavy to carry. For example, you can see in the table 6.9 that heart rate sensors range between 50 and 100 grams, and smart shoes, which are the heaviest device, weigh more than 200 grams. Also, it can be seen that smart necklaces, rings and bracelets do not usually exceed 20 grams, so they are becoming increasingly used accessories.

The size of the devices is another aspect that must be known in order to be able to compare them and analyse which of them is best suited to each user.
It can be seen in the table 6.9 that the size varies according to the device. To illustrate, the diameter of the smart rings varies between 20 and 25 mm, and the length of the heart rate sensors varies between 60 and 135 cm.
In summary, to see all the weight and size data of each device, you can consult the table previously exposed

4.3.5. Waterproof and Bluetooth devices

In the table 6.8 it can be seen that most devices are submersible, however an exception must be made for devices such as sweat patches, EGC devices, accelerometers and some necklace and bracelet. Even if a device is waterproof, for most devices it is advisable not to submerge them in water.

Bluetooh connectivity is one of the most important aspects when choosing one of these devices, although it should be noted that not all devices need a Bluetooh connection for data transmission.
As can be seen in the table 6.8, not all tools need such connectivity, e.g. smart shoes, EGC devices, accelerometers or glucose and sweat monitors do not need such connectivity.

4.4. Comparisons

Having analysed these devices, we will now look at which one is best suited to the adult population. First of all, the economic factor plays a determining role, since each elderly person will have to see how much salary limit they have available for these devices. As for the price, smart bracelets are much more affordable than watches, although it is true that there are cheaper watches, bracelets are usually a more economical tool in these cases.

Secondly, a factor that is also very important is the ability of each device to detect diseases or problems, in this case, smartwatches have more functionalities adapted to prevent and warn when a problem may occur in the person.
Likewise, comfort and the ability to be updated from time to time are other factors that affect quite a lot when deciding which one is better, for the first feature a bracelet is much

more comfortable than a watch, however, a watch tends to suffer more updates and improvements as they are one of the most used technologies nowadays.
Furthermore, another quite relevant difference is the size of the screen, if a person has sight problems it is advisable to buy a smartwatch rather than a bracelet because the screen size is bigger and allows for better readability.

In conclusion, both devices offer a number of similar advantages, such as the fact that you have a device on your wrist that informs you of alerts and notifications, they usually have various health-oriented functionalities and are easy and convenient to wear. However, some smartwatches and all smartbands have a major disadvantage which is the total dependence on a smarthpone. Many smart watches do not need a smarthphone to have their smart functions as is the case of the Garmin, but it is advisable to have these devices associated with a cell phone to be able to contemplate all its functionalities.

5. DATA TRANSMISSION AND STORAGE.

In this section we are going to discuss where the devices store the data and how they transmit the data to get to these stores.
There are various forms of data storage such as cloud, local databases, federated databases, real-time databases... In addition, there are many ways of data transmission thanks to different technologies such as NFC, Bluetooh... We will proceed to analyse the type of storage and technology used by each brand of device owing to each brand usually has a unique method of storage and data transmission.

5.1. Data Transmission

Data transmission refers to the process of sending information from one place to another via a communication medium. It involves the transfer of data from a sending device or system to a receiving device or system[26].

Garmin devices use a variety of data transmission methods, such as connecting via USB cable to a computer or compatible device to transfer data. In addition, these devices support Bluetooth wireless connectivity and ANT+: ANT and Wi-Fi connectivity that makes it easy to upload activities to online platforms, such as Garmin Connect, and download software updates without the need for a physical wired connection [27].

Samsung devices use various methods to transmit data such as Bluetooth Wireless Connection in which Samsung devices have the ability to connect to other devices using this tool to transfer data. In addition, they allow Wi-FI wireless connection to access online services, download and upload files from Samsung Galaxy Store and USB cable connection to manually transfer files to other devices. Finally, some Samsung devices are equipped with NFC technology, which allows data transmission over short distances by touching or tapping the device to another compatible NFC tag [28].

Apple devices use different methods for data transmission such as the previously mentioned Bluetooth and Wi-Fi wireless connection, as well as being able to use USB or Lightning cable for data transmission. Furthermore, they have AirDrop, a wireless data transmission feature unique to Apple devices. It allows you to send and receive files, photos, videos and other data directly between nearby Apple devices without an internet connection. Finally, they have iCloud which is Apple's cloud service that allows you to store and sync data across multiple Apple devices [29].

Google devices can use a USB cable, they also use Wi-Fi and Bluetooth wireless connectivity to transmit data. Moreover, they have Google cloud services such as Google Drive, Google Photos and Google Play Music, which allow data to be stored and synchronised across multiple Google devices. Lastly, they can use Google Fit which is a fitness and

health tracking platform that collects data from wearable devices such as smartwatches and fitness bands and that data can be synced with the Google Fit app.
There are many brands that use Google's format, as Google has practically merged with them, as is the case with FitBit,Mobvoi,Fossil,Honor and many Android devices such as Samsung, Huawei, Xiaomi that use a system similar to that of Google.

These are the most common methods used by brands to transmit their data, many Android compatible devices follow Google's model for transmitting data, however those brands with iOS technology use Apple's data transmission model to transmit data.

5.2. Data Storage

Data storage refers to the process of storing and maintaining information in an organised manner for later use, and there are various ways of storing data which will be explained below.
We will now proceed to analyse the most popular brands to look at how they store data and whether they offer any applications for data storage.

Garmin devices store data in their internal memory or on removable memory cards, and to access this data, Garmin Connect software is generally used, which allows you to synchronise your device's data with an online account. Importantly, Garmin Connect offers cloud backup options, allowing you to back up your data online for added security and ease of access from different devices.

Samsung devices have built-in internal storage where data is stored, they also support storage expansion via microSD memory cards, and Samsung offers cloud services, such as Samsung Cloud, where users can back up their data and access it from other devices.

Huawei devices also offer internal and USB card data storage. In addition, Huawei offers cloud services, such as Huawei Cloud, where users can back up their data and access it from other devices [30].

Apple devices have built-in internal storage where it is possible to save data from applications, operating system... Likewise, Apple offers a cloud storage service called iCloud.Users can make backup copies of their data in iCloud. Finally, Apple device users can use iTunes (for older devices) or Finder (for newer devices) on a Mac to manage and sync data such as music, videos, photos, contacts and more between the device and the computer.

Google devices store data in different locations such as in their internal storage, Google Drive, Google Photos, Gmail, Google Calendar and Google Contacts...

Xiaomi devices store data in their internal storage, which includes the operating system and applications, as well as user-generated media files. In addition, Xiaomi offers cloud services, such as Mi Cloud and partnerships with other cloud services, to securely back up and synchronise data.

Honor devices store data on their internal storage, which includes the operating system and apps, as well as user-generated media files. In addition, Honor offers cloud services, such as Honor Cloud and partnerships with other cloud services, to securely back up and sync data.

Fitbit devices store data in their internal storage and use a wireless connection to sync with the mobile app and web dashboard. They also offer cloud storage through Fitbit Cloud to back up and access data from different devices.

Amazfit devices store fitness data in their internal storage and sync with a mobile app via Bluetooth. Data can be backed up and synced to the cloud via the Amazfit Cloud, allowing data to be analysed and viewed from other devices.

Mobvoi and Fossil devices store data in their internal storage and synchronise with a mobile application via Bluetooth. Data can also be backed up and synced to the service provider's cloud for easy access from multiple devices and continuous tracking of user activity and statistics.

5.3. Data privacy

Data privacy refers to the right of individuals to have control over the collection, use, and sharing of their personal data. It is the concept of keeping personal information safe and secure, ensuring that it is only used for its intended purpose, and preventing unauthorized access or misuse of the data [31].

Data privacy on Garmin devices is a key concern in protecting users' personal information. Garmin seeks explicit consent from users before collecting data and uses security measures to protect information. It offers privacy choices and uses data anonymisation and aggregation techniques. In addition, it complies with applicable data protection regulations in each country.

Apple ensures privacy on its devices through encryption, biometric data protection, permissions management, privacy settings, local processing, data anonymisation and aggregation, transparent policies, and a continued focus on improving user privacy and security.

Samsung uses encryption, biometric protection, security updates, Samsung Knox, Secure Folder and app verification to ensure the security of its devices. It also offers transparent privacy policies to protect users' privacy. Samsung Knox is an enterprise tool for configuring and managing mobile devices, offering efficient and personalised usage across multiple industries and keeping your mobile infrastructure connected, secure and productive[32].

Google devices use a number of tools and measures to ensure the security of their users, such as Google Play Protect to scan apps for malware, regular security updates, pre-launch app verification on Google Play, two-factor authentication, and protection of personal data through encryption and secure access. In addition, they implement Google Safe

Browsing to protect against dangerous websites and downloads, and offer a "Find My Device" feature to track and protect lost or stolen devices.

Huawei uses various tools and measures to ensure data security on its devices. Some of these tools include EMUI Security, Trusted Execution Environment (TEE), biometric authentication systems, security updates, cloud protection, app verification and data in transit protection. Data safety also depends on responsible user behaviour, such as using strong passwords and keeping security updates up to date.

Xiaomi uses tools such as MIUI Security, security scanner, data encryption, biometric authentication, security updates and cloud data protection to ensure the privacy and security of data on their devices and they also have transparent privacy policies to protect user information.

Finally, Honor, Amazfit and other brands use a technology called EMUI Security as does Huawei, and have developed a data encryption model, biometric authentication and security updates to ensure the privacy and security of data on their devices.

6. SUMMARY AND CONCLUSIONS

First of all, to draw the appropriate conclusions and summarise our analysis, we will list the 5 main characteristics of the devices.

High Batery Life	Highest number of features	Wider screen size	Lowest Price	Highest Internal Storage	Newest
Mobvoi TicWatch Pro 3 Ultra GPS	Apple Watch Series 8	Apple Watch Ultra	Samsung Galaxy Watch Active2	Apple Watch Series 8	Garmin Fenix 7X
Mobvoi TicWatch E3	Huawei Watch 3 Pro	Apple Watch Series 8	Amazfit GTS 2e	Apple Watch Ultra	Apple Watch Series 8
Garmin Fenix 7X	Garmin Epix Gen 2	Apple Watch SE (2022)	Xiaomi Mi Watch	Garmin Fenix 7X	Garmin Epix Gen 2
Honor Watch Gs Pro	Xiaomi Mi Watch	Alpina AlpinerX Alive	Apple Watch Nike+	Garmin Tactix Delta Solar Ed	Huawei Watch 3 Pro
Xiaomi Watch S1	Xiaomi Watch S1	Amazfit GTS 2e	Amazfit GTR 3	Google Pixel Watch	Xiomi Watch S1

Fig. 6.1. Top 5 essential characteristics of smartwatches

High Batery Life	Highest number of features	Wider screen size	Lowest Price	Cheapest monthly subscription	Newest
Garmin VivoFit 4	Xiaomi Smart Band 7 Pro	Xiaomi Smart Band 7 Pro	Muvit I/O Health Tensio Lite	Seremy	Xiaomi Smart Band 7 Pro
Seremy	Huawei Band 7	Xiaomi Mi Smart Band 6	Band GPS SecuLife System	Fitbit Inspire 2	FitBit Inspire 3
Samsung Galaxy Fit 2	FitBit Charge 5	Huawei Band 7	Amazfit Band 5	FitBit Inspire 3	Huawei Band 7
Amazfit Band 5	Honor Band 6	Huawei Band 6	MGMove	FitBit Charge 5	FitBit Charge 5
Honor Band 6 \ Xiaomi Band 6 \Huawei Band 7	FitBit Inspire 3	Honor Band 6	OPPO Band Style	Durcal Watch	Durcal Watch

Fig. 6.2. Top 5 essential characteristics of smartbands

After analysing and studying all of these devices and exposing all of their functionalities, the following conclusions have been drawn:

Before choosing which device you want to use, you will have to choose whether you prefer to wear a smartwatch or a smartband. If you want a more economical price and greater comfort on your wrist, you will choose the smart bracelet; however, if you want more availability, greater readability and greater capacity for updates, you will opt for the watch.

Firstly, as can be seen in the figure 6.1, the best rated watches are the Apple Watch Series 8 and the two Xiaomi watches.In order to choose one of them, we are going to study and observe its characteristics, for an elderly person who has made a living all his life and whose main concern should not be money, the price is not a very interesting factor, besides, the Apple Watch is not as expensive as other watches, although it is true that the Xiaomi watch is much more economical. Two very important factors in preventing illness and appreciating your body's data is the readability and the amount of functionality available, in this although Xiaomi watches are among the most advanced, the Apple Watch Series 8 is the most advanced and has some of the most significant improvements over the other watches.

Having said that, if the elderly person has sufficient means to be able to afford a smartwatch, this would be the best option, and an Apple Watch Series 8 offers very good functionalities and the cheapest version is not very expensive.In addition, if the elderly person is in a nursing home and they have sufficient means to afford such an investment, it would be best to buy a watch for each of them and for the administrator to observe the data of each elderly person in iCloud, analysing whether they are in good condition or have some values that are out of the ordinary.

However, If we choose the cheapest and easiest to carry option, we will have to look at the table 6.2 of smartbands.
As we can see there are three bracelets that stand out above the rest, such as the FitBit Charge 5, Xiaomi Smart Band 7 Pro and Huawei Band 7, these bracelets have very similar functionalities and the only difference apart from their shape is their price.

For this reason, if the residence or the elderly person does not have sufficient means to finance a smartwatch, the best option would be a smartband with similar capabilities to such watches and at a more affordable price.In this case we will choose Xiaomi Smart Band 7 Pro or Huawei Band 7 because their price is very cheap and their functionalities are spectacular.

Furthermore, it is important to note that if an elderly person is diabetic or has a problem with their heart, sweating, etc., it would be ideal for them to have a device oriented to that weakness so that they could connect it to their wristband or smartwatch and it would show them the most exhaustive data about their problem. Such devices are not particularly expensive, so anyone could afford a heart rate monitor, a sweat detector, a body temperature meter...

Finally, it should be noted that all the devices analysed have been extracted from the best databases and information systems, that is, they are the best rated devices on the market and each of them can more than fulfil the function of informing about the health status of an elderly person.

In summary, it is recommended that any elderly person who has sufficient means to buy a smartwatch, after analysing all of them, the one with the best performance, quality and price on the market is the cheap version of the Apple Watch Series 8 as it has almost all the features and for 500 € gives a great performance. If you are looking for a cheaper version with similar specifications, the Huawei Watch 3 Pro would be ideal, although both devices share the fact that their battery life is not very long. However, if we want cheaper options that are easier to wear, the Xiaomi Smart Band 7 Pro bracelet would be perfect since for only €60 it offers functions very similar to these watches and even offers longer battery life, although it does not offer a fall detector,while the Apple watch did offer them.Having said this, you can always buy a cheaper bracelet or watch and also buy an alarm device to notify the family or friends of the elderly person when a dangerous situation occurs.

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ANNEX

Model	Year	Compatibility	Battery life with normal mode	Solar Charge	Battery life with GPS in use
Garmin Tactix Delta Solar Edition	2020	IOS / ANDROID	21 days	24 days	15 hours without SC / 16 hours with SC
Garmin Fenix 7X Sapphire Solar	2022	IOS / ANDROID	28 days	37 days	89 hours wiht the GPS
Garmin Fenix 7X Solar	2022	IOS / ANDROID	28 days	37 days	89 hours wiht the GPS
Garmin Epix Gen 2	2022	IOS / ANDROID	16 days	No	42 horas with GPS.
Samsung Galaxy Watch 4 Classic LTE	2021	ANDROID	2 days	No	—–
Samsung Galaxy Watch5 Pro LTE	2021	ANDROID	3.5 days	No	—–
Samsung Galaxy Watch Active2 LTE Stainless Steel	2019	ANDROID	2 days	No	—–
Huawei Watch 3 Pro	2022	IOS / ANDROID	5 days	No	—–
Apple Watch Nike+	2016	IOS	36 hours in low mode	No	10 hours
Apple Watch Series 8	2022	IOS	36 hours in low mode	No	10 hours
Apple Watch SE (2022)	2022	IOS	0,75 day	No	10 hours
Apple Watch Ultra	2022	IOS	1,5 days	No	10 hours
Google Pixel Watch	2022	ANDROID	1 day	No	8-10 hours
Amazfit GTR 4	2022	IOS / ANDROID	14 days	No	—–
Mobvoi TicWatch Pro 3 Ultra GPS	2021	IOS / ANDROID	45 days esencial mode	No	3 days normal mode
Fitbit Versa 4	2022	IOS / ANDROID	6 days	No	4 days
Xiaomi Mi Watch Revolve Active	2020	IOS / ANDROID	14 days // 22 days long mode	No	50 hours sport mode
Fossil Gen 6	2021	IOS / ANDROID	2 days	No	Less then 1 day
Xiomi Watch S1	2022	IOS / ANDROID	24 days in energy saving	No	12 days in normal mode
Honor Watch GS Pro	2020	IOS / ANDROID	25 days	No	100 hours
Amazfit GTR 3	2021	IOS / ANDROID	21 days	No	35 hours
Garmin Vivoactive 4	2019	IOS / ANDROID	8 days	No	Up to 18 hr.
Mobvoi TicWatch E3	2021	IOS / ANDROID	45 days esencial mode	No	4 days normal mode
Amazfit GTS 2e	2020	IOS / ANDROID	24 days in base mode	No	14 days in normal mode
Realme Watch S Pro	2020	IOS / ANDROID	14 days	No	—–
Honor Watch Gs 3	2022	ANDROID	14 days	No	30 hour

TABLE 6.1. TABLE 1 SMARTWATCH

Model	Low Price	High Price	Tactile Screen	Size of the screen	Internal Storage
Garmin Tactix Delta Solar Edition	500€ without Solar Edition	1125€ with the solar edition	No	1.4"	32GB
Garmin Fenix 7X Sapphire Solar	1199€ 51 mm	899€ 47mm	Yes	1.3"	32GB
Garmin Fenix 7X Solar	899€ 51 mm	799€ 47mm	Yes	1.4"	16GB
Garmin Epix Gen 2	899 €	899 €	Yes	1.3"	16GB
Samsung Galaxy Watch 4 Classic LTE	260 €	260 €	Yes	1.4"	16GB
Samsung Galaxy Watch5 Pro LTE	Bluetooh 368€	Bluetohh + 4G 469€	Yes	1.4"	16GB
Samsung Galaxy Watch Active2 LTE Stainless Steel	75 € Stainless Steel	222 € Aluminium	Yes	1.4"	4GB
Huawei Watch 3 Pro	299€ Fluoroelastómero	499€ Ceramic	Yes	1.43"	16GB
Apple Watch Nike+	140 €	New versions can be round 300€	Yes	1.5"	8GB
Apple Watch Series 8	From 499€ with aluminum	859€ with stainless steel	Yes	1.9"	32GB
Apple Watch SE (2022)	From 299€	399€ depends the material	Yes	1.78"	32GB
Apple Watch Ultra	999 €	999 €	Yes	1.92"	32GB
Google Pixel Watch	397 €	397 €	Yes	1.2"	32GB
Amazfit GTR 4	200€ Superspeed Black	230€ RaceTrack Grey	Yes	1.43"	2GB
Mobvoi TicWatch Pro 3 Ultra GPS	219 €	219 €	Yes	1.4"	8BG
Fitbit Versa 4	199 €	199 €	Yes	1.58"	4 GB
Xiaomi Mi Watch Revolve Active	103 €	103 €	Yes	1.39"	1GB
Fossil Gen 6	From 299€	Until 300€ depends the type	Yes	1.28"	8GB
Xiomi Watch S1	From 169€ in offer	Until 250 €	Yes	1.43"	4GB
Honor Watch GS Pro	From 169€	Until 196€	Yes	1.39"	4GB
Amazfit GTR 3	140 €	140 €	Yes	1.39"	0GB
Garmin Vivoactive 4	279€ the version 4s	299€ the version 4	Yes	1.3"	4GB
Mobvoi TicWatch E3	202	202	Yes	1.3"	8GB
Amazfit GTS 2e	89 €	129 €	Yes	1.65"	0GB
Realme Watch S Pro	140	140	Yes	1.39"	0GB
Honor Watch Gs 3	169 €	169 €	Yes	1.43"	4GB

TABLE 6.2. TABLE 2 SMARTWATCH

Model	Cardiac monitor	Blood oxygen level	Step Counter	Step Measure	Calories burned	Temperature Sensor
Garmin Tactix Delta Solar Edition	Yes	Yes	Yes	Yes	Yes	Yes
Garmin Fenix 7X Sapphire Solar	Yes	Yes	Yes	Yes	Yes	Yes
Garmin Fenix 7X Solar	Yes	Yes	Yes	Yes	Yes	Yes
Garmin Epix Gen 2	Yes	Yes	Yes	Yes	Yes	Yes
Samsung Galaxy Watch 4 Classic LTE	Yes	Yes	Yes	Yes	Yes	No
Samsung Galaxy Watch5 Pro LTE	Yes	Yes	Yes	Yes	Yes	Yes
Samsung Galaxy Watch Active2 LTE Stainless Steel	Yes	No	Yes	Yes	Yes	No
Huawei Watch 3 Pro	Yes	Yes	Yes	Yes	Yes	Yes
Apple Watch Nike+	Yes	No	Yes	Yes	Yes	No
Apple Watch Series 8	Yes	Yes	Yes	Yes	Yes	Yes
Apple Watch SE (2022)	Yes	No	Yes	Yes	Yes	Yes
Apple Watch Ultra	Yes	Yes	Yes	Yes	Yes	Yes
Google Pixel Watch	Yes	Yes	Yes	Yes	Yes	No
Amazfit GTR 4	Yes	Yes	Yes	Yes	Yes	No
Mobvoi TicWatch Pro 3 Ultra GPS	Yes	Yes	Yes	Yes	Yes	No
Fitbit Versa 4	Yes	Yes	Yes	Yes	Yes	No
Xiaomi Mi Watch Revolve Active	Yes	Yes	Yes	Yes	Yes	No
Fossil Gen 6	Yes	Yes	Yes	Yes	Yes	No
Xiomi Watch S1	Yes	Yes	Yes	Yes	Yes	No
Honor Watch GS Pro	Yes	Yes	Yes	Yes	Yes	No
Amazfit GTR 3	Yes	Yes	Yes	Yes	Yes	No
Garmin Vivoactive 4	Yes	Yes	Yes	Yes	Yes	Yes
Mobvoi TicWatch E3	Yes	Yes	Yes	Yes	Yes	No
Amazfit GTS 2e	Yes	Yes	Yes	Yes	Yes	Yes
Realme Watch S Pro	Yes	Yes	Yes	Yes	Yes	No
Honor Watch Gs 3	Yes	Yes	Yes	Yes	Yes	No

TABLE 6.3. TABLE 3 SMARTWATCH

Model	Transpiration	Barometer	GPS	Sleep hours counter	Where the data are collected?
Garmin Tactix Delta Solar Edition	No	Yes	Yes	Yes	App Garmin Connect
Garmin Fenix 7X Sapphire Solar	No	Yes	Yes	Yes	App Garmin Connect
Garmin Fenix 7X Solar	No	Yes	Yes	Yes	App Garmin Connect
Garmin Epix Gen 2	Yes	Yes	Yes	Yes	App Garmin Connect
Samsung Galaxy Watch 4 Classic LTE	No	Yes	Yes	Yes	App Galaxy Health
Samsung Galaxy Watch5 Pro LTE	No	Yes	Yes	Yes	App Galaxy Health
Samsung Galaxy Watch Active2 LTE Stainless Steel	No	Yes	Yes	Yes	App Galaxy Health
Huawei Watch 3 Pro	Yes	Yes	Yes	Yes	HUAWEI Salud
Apple Watch Nike+	No	Yes	Yes	No	Health app
Apple Watch Series 8	No	Yes	Yes	Yes	Health app
Apple Watch SE (2022)	No	Yes	Yes	Yes	Health app
Apple Watch Ultra	No	Yes	Yes	Yes	Health app
Google Pixel Watch	No	Yes	Yes	Yes	Google Pixel Watch app
Amazfit GTR 4	No	Yes	Yes	Yes	Zepp app
Mobvoi TicWatch Pro 3 Ultra GPS	No	Yes	Yes	Yes	Mobvoi, TicTacSleep,TicExercise
Fitbit Versa 4	No	Yes	Yes	Yes	Fitbit
Xiaomi Mi Watch Revolve Active	No	Yes	Yes	Yes	Xiaomi Wear/Xiaomi Wear Lite App
Fossil Gen 6	No	No	Yes	Yes	Fossil Smartwatches
Xiomi Watch S1	Yes	Yes	Yes	Yes	Xiaomi Wear/Xiaomi Wear Lite App
Honor Watch GS Pro	No	Yes	Yes	Yes	HONOR Health
Amazfit GTR 3	No	Yes	Yes	Yes	Zepp app
Garmin Vivoactive 4	No	Yes	Yes	Yes	App Garmin Connect
Mobvoi TicWatch E3	No	No	Yes	Yes	Mobvoi, TicTacSleep,TicExercise
Amazfit GTS 2e	No	Yes	Yes	Yes	Zepp app
Realme Watch S Pro	No	No	Yes	Yes	Realme Link
Honor Watch Gs 3	No	Yes	Yes	Yes	HONOR Health

TABLE 6.4. TABLE 4 SMARTWATCH

Name	Year	Size of the screen	Baterry Life	Inicial Price	Final Price
Seremy	–	–	1 month	119	+ 9€/mes
Honor Band 6	2020	1.47"	14 days	49,9	49.9
FitBit Charge 5	2021	1.04 inch	7 days	149,99	+8,99€/mes (Premium)
Xiaomi Smart Band 7 Pro	2022	1.64"	12 days	59,99	59,99
Durcal Watch	2021		2 days	69	+ 15€/mes
Garmin VivoSmart4	2018	6.6 mm x 17.7 mm	7 days	74,99 Small/Medium Size	99,99 Big Size
Garmin VivoFit 4	2017	11x11mm	1 year (replaceable battery)	59,99 Small/Medium Size	79,99 Big Size
Muvit I/O Health Tensio Lite	–	0.96"	80mAh	From 17 €	Until 25 €
Samsung Galaxy Fit 2	2020	1.1"	15 days in normal use		
FitBit Inspire 3	2022	0.7 inch	10 days	99,99	+8,99€/mes (Premium)
Huawei Band 6	2021	1.47"	14 days	49,9	49,9
Xiaomi Mi Smart Band 6	2021	1.56"	14 days	49,99	49,99
Huawei Band 7	2022	1.47"	14 days	59,9	59,9
Fitbit Inspire 2	2020	0.7 inch	10 days	69,95	+8,99€/mes (Premium)
Amazfit Band 5	2020	1.1"	15 days	21,9	21,9
OPPO Band Style	2021	1.1"	12 days	From 39,99	Until 69,99
Band GPS SecuLife System	–	Don´t have screen	Depends tracking interval 8-24h	Basic Plan 19 $/mes	Elite Plan 39$/mes
MGMove	Company in 2006	1.25"	Up to 24 hours	439$ year 39,9$/mes	MG Protection Plan +6,99$/mes

TABLE 6.5. TABLE 1 SMARTBAND

Name	GPS	Cardiac monitor	Blood oxygen level	Step Counter	Calories burned	Temperature Sensor of your Body	Transpiration
Seremy	Yes	Yes	No	Yes	Yes	No	No
Honor Band 6	No	Yes	Yes	Yes	Yes	No	No
FitBit Charge 5	Yes	Yes	Yes	Yes	Yes	Yes	No
Xiaomi Smart Band 7 Pro	Yes	Yes	Yes	Yes	Yes	No	No
Durcal Watch	Yes	Yes	Yes	Yes	No	No	No
Garmin VivoSmart4	No	Yes	Yes	Yes	Yes	No	No
Garmin VivoFit 4	No	No	No	Yes	Yes	No	No
Muvit I/O Health Tensio Lite	No	Yes	No	Yes	No	No	No
Samsung Galaxy Fit 2	No	Yes	No	Yes	Yes	No	No
FitBit Inspire 3	No	Yes	Yes	Yes	Yes	Yes	No
Huawei Band 6	No	Yes	Yes	Yes	Yes	No	No
Xiaomi Mi Smart Band 6	No	Yes	Yes	Yes	Yes	No	No
Huawei Band 7	No	Yes	Yes	Yes	Yes	No	No
Fitbit Inspire 2	No	Yes	No	Yes	Yes	No	No
Amazfit Band 5	No	Yes	Yes	Yes	Yes	No	No
OPPO Band Style	No	Yes	Yes	Yes	Yes	No	No
Band GPS SecuLife System	Yes	No	No	No	No	No	No
MGMove	Yes	No	No	Yes	No	No	No

TABLE 6.6. TABLE 2 SMARTBAND

Name	Barometer	Sleep hours counter	App	Emergency Botton	Fall Detector
Seremy	No	Yes	Seremy App	Yes	No
Honor Band 6	No	Yes	Honor Health	No	No
FitBit Charge 5	No	Yes	Fitbit App	No	No
Xiaomi Smart Band 7 Pro	Yes	Yes	Strava y Apple Health.	No	No
Durcal Watch	No	No	Durcal App	Yes	Yes
Garmin VivoSmart4	Yes	Yes	Garmin Connect ™ Mobile	No	No
Garmin VivoFit 4	No	No	Garmin Connect ™ Mobile	No	No
Muvit I/O Health Tensio Lite	No	Yes	Yoho Sports	No	No
Samsung Galaxy Fit 2	No	Yes	Samsung Health	No	No
FitBit Inspire 3	Yes	Yes	Fitbit App	No	No
Huawei Band 6	No	Yes	Huawei Health App	No	No
Xiaomi Mi Smart Band 6	No	Yes	Mi Fit	No	No
Huawei Band 7	No	Yes	Huawei Health App	No	No
Fitbit Inspire 2	No	Yes	Mi Fit	No	No
Amazfit Band 5	No	Yes	Huami Pai ™ /Somnus Care ™	No	No
OPPO Band Style	No	Yes	HeyTap Health	No	No
Band GPS SecuLife System	No	No	Don´t need App	Yes	No
MGMove	No	No	MyGuardian web portal and mobile app	Yes	No

TABLE 6.7. TABLE 3 SMARTBAND

Name	Year	Type of device	Price	Waterproof	Bluetooth
Garmin HRM-Dual™	2019	Heart rate sensor	69,99 €	Yes	Yes
Gx Sweat Patch	2021	Sweat Patch	24,99 €	No	No
Cube Tracker	2016	Tracking sensor	$16.50/mo	Yes	Yes
Google Glass Explorer Edition	2012	Smart Glass	Now they are not for sale	No	Yes
Bosch Sensortec BMA456	2017	Accelerometer	About 12690 €	No	No
Polar H10	2017	Heart rate sensor	90 €	Yes	Yes
Wahoo Tickr	2020	Heart rate sensor	49,99 €	Yes	Yes
Suunto Smart Sensor	2015	Heart rate sensor	66 €	Yes	Yes
Garmin HRM-Pro	2020	Heart rate sensor	129,99 €	Yes	Yes
Freestyle Libre Sensor	2014	Glucose sensor	65,90 €	Yes	No
Medtronic Guardian Connect	2018	Glucose sensor	1000-2000 € transmitter/ + sensor 50-70 €	Yes	Yes
Xiaomi Ultra Smart Sportswear	2017	Smart Shoes	50 €	Yes	No
Dexcom G6	2018	Glucose sensor	393,12 €	Yes	Yes
Vue Lite 2	2021	Smart Glass	199 €	Yes	Yes
Oura Ring 3 Silver/Black	2021	Smart Ring	Horizon 484 € / Heritage 431 € || –> + 5.99 €/month (Premium)	Yes	Yes
Oura Ring 3 Steal	2021	Smart Ring	Horizon 484 € / Heritage 431 € || –> + 5.99 €/month (Premium)	Yes	Yes
Oura Ring 3 Gold	2021	Smart Ring	Horizon 484 € / Heritage 431 € || –> + 5.99 €/month (Premium)	Yes	Yes
Motiv Ring	2017	Smart Ring	199,99 $ —> +9,99$/month for certain advanced features	Yes	Yes
Nimb Ring	2016	Smart Ring	23,95 $/month (annually) || $26.95 / month(half-a year) ||$29.95 / month (monthly)	Yes	Yes
Bellabeat Leaf Urban	2016	Smart Pendant	63,90 $	No	Yes
Mclear Ring Pay	2016	Smart Ring	89,99 $	Yes	No
Moov Now	2015	Smart Brazalet	40-60 $	Yes	Yes
HEXOSKIN PROSHIRT - MEN'S	2017	Smart T-Shirt	249 $	Yes	Yes
HEXOSKIN PROSHIRT - WOMEN'S	2017	Smart T-Shirt	249 $	Yes	Yes
HEXOSKIN SMART DEVICE	—	Smart Device for the torso	399 $	Yes	Yes
AliveCor KardiaMobile	2015	EGC Device	119 €	No	Yes
AliveCor KardiaMobile 6L	2019	EGC Device	169 €	No	Yes
GE Healthcare MAC 800	2008	EGC Device	2000-5000	No	No
Sensoria Smart Socks	2015	Smart Socks	69 $ || With Sensoria Core –199$	No	Yes
Sensoria Smart Band	–	Smart Band	69 $	Yes	Yes
Active(+) Smart Mask	2021	Smart Mask	$59.99 USD	No	Yes
Atmoblue Smart Mask	—	Smart Mask	69,69 €	—	Yes
LG PuriCare Wearable Air Purifier:	2020	Smart Mask	100-200$	No	Yes
Embrace 2	2020	Smart Brazalet	249 $ + 9,90$/month (Subscription Plan)	Yes	Yes
Aktiia Monitoraggio Pressione Arteriosa 24 h	2019	Smart Brazalet	229,99 €	No	Yes

TABLE 6.8. TABLE 1 OTHER DEVICES

Name	Battery Life	Weight	Size
Garmin HRM-Dual™	3,5 years	54,4 gr	63,5-132 cm
Gx Sweat Patch	Don't have battery(Single-use patch)	1.25 ounces	2.5x1.5 inches
Cube Tracker	10-60 days depending the use	63gr	2.75" x 1.57" x 0.64"
Google Glass Explorer Edition	1 day of use	50 gr	50 mm x 150 mm x 16 mm
Bosch Sensortec BMA456	From several weeks to several months	0,22 g	2mm x 2mm x 0,65mm
Polar H10	400 hours	99 g	65-95 cm
Wahoo Tickr	500 hours	49 gr	66-132 cm
Suunto Smart Sensor	400 hours	40 gr	70-120 cm
Garmin HRM-Pro	1 year	52 gr	60-106 cm with exntensor until 142 cm
Freestyle Libre Sensor	14 days	5 gr	5 mm height, 35 mm diameter
Medtronic Guardian Connect	7 days sensor / 6 days transmitter	19 gr	0,5 cm sensor diameter / 4,1 cm x 3,1 cm x 1,0 cm transmitter
Xiaomi Ultra Smart Sportswear	60 days	230 gr	Depends on each person's foot size
Dexcom G6	10 days	6 gr	3.5 cm long, 2.4 cm wide and 1.0 cm deep
Vue Lite 2	20 housr on hold / 4 hours continue use	25 gr- 30gr depends the model	Depends the model of the glasses
Oura Ring 3 Silver/Black	7 days	6 gr	26 mm diameter
Oura Ring 3 Steal	7 days	6 gr	26 mm diameter
Oura Ring 3 Gold	7 days	6 gr	26 mm diameter
Motiv Ring	3 days	3,5 gr - 8 gr	20,6 cm diameter
Nimb Ring	14 days	10 gr	20-24 cm diameter
Bellabeat Leaf Urban	Up to 6 months	16 gr	48mm in length, 24mm in width and 12mm in depth
Mclear Ring Pay	7 days	6 gr	20 Sizes available depends the user
Moov Now	Up to 6 months	15,1 gr	27.9 x 7.6 x 226 mm
HEXOSKIN PROSHIRT - MEN'S	90 hours	130-150 gr	XS-XXL
HEXOSKIN PROSHIRT - WOMEN'S	90 hours	130-150 gr	XS-XXL
HEXOSKIN SMART DEVICE	Up 36 hours	40 gr	13 x 42 x 72 mm
AliveCor KardiaMobile	12 months typical use /200 hours operational time	18 gr	8,2 cm x 3,2 cm x 0,35 cm
AliveCor KardiaMobile 6L	12 months typical use /200 hours operational time	24 gr	9.0 cm x 3.0 cm x 0.72 cm
GE Healthcare MAC 800	Don't have battery(Conect to electric network)	3 kg	320mm wide, 170mm high and 240mm deep.
Sensoria Smart Socks	6 hours	80 gr	36-49 in shoes size
Sensoria Smart Band	5-7 days of use	–	39 x 17 x 9 mm (length, width, height)
Active(+) Smart Mask	Don't have battery	20 gr	195mm x 105mm x 95mm
Atmoblue Smart Mask	150 hours	6,7 ounces	7.75 x 7.75 x 3.5 inches
LG PuriCare Wearable Air Purifier:	8 hours low power || 2 hours high power	126 g	156 x 110 x 63 mm
Embrace 2	48 hours	13 gr	Length: 37.6mm ,Width: 29.7mm ,Height: 10.3mm
Aktiia Monitoraggio	9 days	20 gr	0.75mm thick x 14mm wide x 231.5mm long

TABLE 6.9. TABLE 2 OTHER DEVICES

Model	In which App can we can view the data
Garmin Tactix Delta Solar Edition	App Garmin Connect
Garmin Fenix 7X Sapphire Solar	App Garmin Connect
Garmin Fenix 7X Solar	App Garmin Connect
Garmin Epix Gen 2	App Garmin Connect
Samsung Galaxy Watch 4 Classic LTE	App Galaxy Health
Samsung Galaxy Watch5 Pro LTE	App Galaxy Health
Samsung Galaxy Watch Active2 LTE Stainless Steel	App Galaxy Health
Huawei Watch 3 Pro	HUAWEI Salud
Apple Watch Nike+	Health app
Apple Watch Series 8	Health app
Apple Watch SE (2022)	Health app
Apple Watch Ultra	Health app
Google Pixel Watch	Google Pixel Watch app
Amazfit GTR 4	Zepp app
Mobvoi TicWatch Pro 3 Ultra GPS	Mobvoi, TicTacSleep,TicExercise
Fitbit Versa 4	Fitbit
Xiaomi Mi Watch Revolve Active	Xiaomi Wear/Xiaomi Wear Lite App
Fossil Gen 6	Fossil Smartwatches
Xiomi Watch S1	Xiaomi Wear/Xiaomi Wear Lite App
Honor Watch GS Pro	HONOR Health
Amazfit GTR 3	Zepp app
Garmin Vivoactive 4	App Garmin Connect
Mobvoi TicWatch E3	Mobvoi, TicTacSleep,TicExercise
Amazfit GTS 2e	Zepp app
Realme Watch S Pro	Realme Link
Honor Watch Gs 3	HONOR Health

TABLE 6.10. DATA STORAGE OF SMARTWATCHS

Name	App
Seremy	Seremy App
Honor Band 6	Honor Health
FitBit Charge 5	Fitbit App
Xiaomi Smart Band 7 Pro	Strava y Apple Health.
Durcal Watch	Durcal App
Garmin VivoSmart4	Garmin Connect ™ Mobile
Garmin VivoFit 4	Garmin Connect ™ Mobile
Muvit I/O Health Tensio Lite	Yoho Sports
Samsung Galaxy Fit 2	Samsung Health
FitBit Inspire 3	Fitbit App
Huawei Band 6	Huawei Health App
Xiaomi Mi Smart Band 6	Mi Fit
Huawei Band 7	Huawei Health App
Fitbit Inspire 2	Mi Fit
Amazfit Band 5	Huami Pai ™ /Somnus Care ™
OPPO Band Style	HeyTap Health
Band GPS SecuLife System	Don´t need App
MGMove	MyGuardian web portal and mobile app

TABLE 6.11. DATA STORAGE OF SMARTBANDS

Brand	Where store the data in the cloud
Apple	iCloud
Xiaomi	Mi Cloud
Samsung	Samsung Cloud
Garmin	Garmin Connect
Huawei	Huawei Cloud
Google	Google Drive
Amazfit	Amazfit Cloud
Mobvoi	Mobvoi Cloud
Fitbit	Fitbit Cloud
Honor	Honor Cloud
Fossil	Google Drive or Fossil's own cloud
Realme	Realme Cloud

TABLE 6.12. CLOUD OF EACH BRAND