# Reviewing Mobile Apps to Control Heart Rate in Literature and Virtual Stores

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## Abstract

**Background** Information and communications technologies are transforming our social interactions and life-styles. One of the most promising applications of information technology is healthcare and wellness management that characterized by early detection of conditions, prevention, and long-term healthcare management.

**Objective** The main purpose of this document is to do a study, first about the actual literature about mobile phone applications to measure and control heart-rate and second a study about these applications themselves, analyzing the different app stores more popular nowadays, Google Play Store and iTunes (for Android and iOS devices respectively).

**Methods** The Web portals and databases that were used to perform the searches are IEEE Xplore, National Center for Biotechnology Information, Springer, ResearchGate, Science Direct and Scopus, taking into account the date of publication from 2010 to 2018, publications in English and Spanish.

**Results** 40 relevant papers have been found related to mobile phone apps to measure and control heart rate. The results show that of a total of 400 applications found 61.25% of them are in the Play Store (Android systems) and the remaining 38.75% were found in the iTunes Store (iOS systems).

**Conclusions** From the review of the research articles analyzed, it can be said that the most applications found are for Android devices. They occupy 76.53% of the world mobile phone market, while iOS only owns 18.97%.

**Keywords** Android · Heart-rate · iOS · Mobile apps · Photoplethysmogram

## Introduction

In a globalized and industrialized society as we all live nowadays, mobile devices have become since some years in an indispensable gadget in our day to day. This is possible

because the reduction in the prices of the technology that makes that the sales of tablets and mobile phones have been increased significantly in the last years.

The fast implementations of this device in our actual society enable the use of this device for many fields, such as a

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medical and health field. In this field, these tools offer support to many different users.

On the one hand, the uses of mobile devices by health professionals have made an important change in the usual procedures. Many medical applications have arisen that provides the specialist of useful tools for his day to day works [1]. Some examples of this application are medical calculators, diagnostic checklists, medicaments registry, adverse reactions searches, formative resources data bases, medical data bases, etc. These devices are totally integrated in this works and it's expected that its use becomes more and more usual in the near future [2, 3].

On the other hand, we can find the common users. Is in this field where health mobile applications have become more and more popular in the last years. This provides an easy access to training apps; constants control apps (like weight, arterial tension, heart-rate, etc.) or remote medical attention apps. All this apps are known as "e-Health" applications, which provide universality and ubiquity. These apps have become such important that the "Food and Drug Administration (FDA)" and the Europe Union elaborated a guide in 2013 where all the most reliable applications were collected [3].

During the elaboration of the present study I will perform a literature revision of the principal publications about heart-rate control apps and everything related to this. Also, a field study will be made about these mobile applications available in the two most important markets (Android and iOS). Then, all the recollected information will be use to extract some statistics about the actual state, how are them categorized, how them works and the relation with the real medical environment.

Definitely, mobile apps market in the health sector can be considered as one of the most important recent revolutions. It's expected that this revolution will transform the actual health professional sector by offering access to information in a fast and easy way, throwing out any geographical wall and giving the common user tools and resources to know every time the state of his health [4–8].

The remainder of this paper is as follows: firstly, the methodology that have been followed to identify the mobile apps in literature and virtual stores; secondly, the results of the different found mobile apps after they were categorised; lastly, the discussion and conclusions drawn from the work will be presented.

## Methods

In this paper, two kinds of studies have been made. First, we will focus ourselves in the literature available about heart-rate control mobile applications and second, we will continue with the mobile applications available in the app stores. To archive theses purposes, we will define the methodology followed:
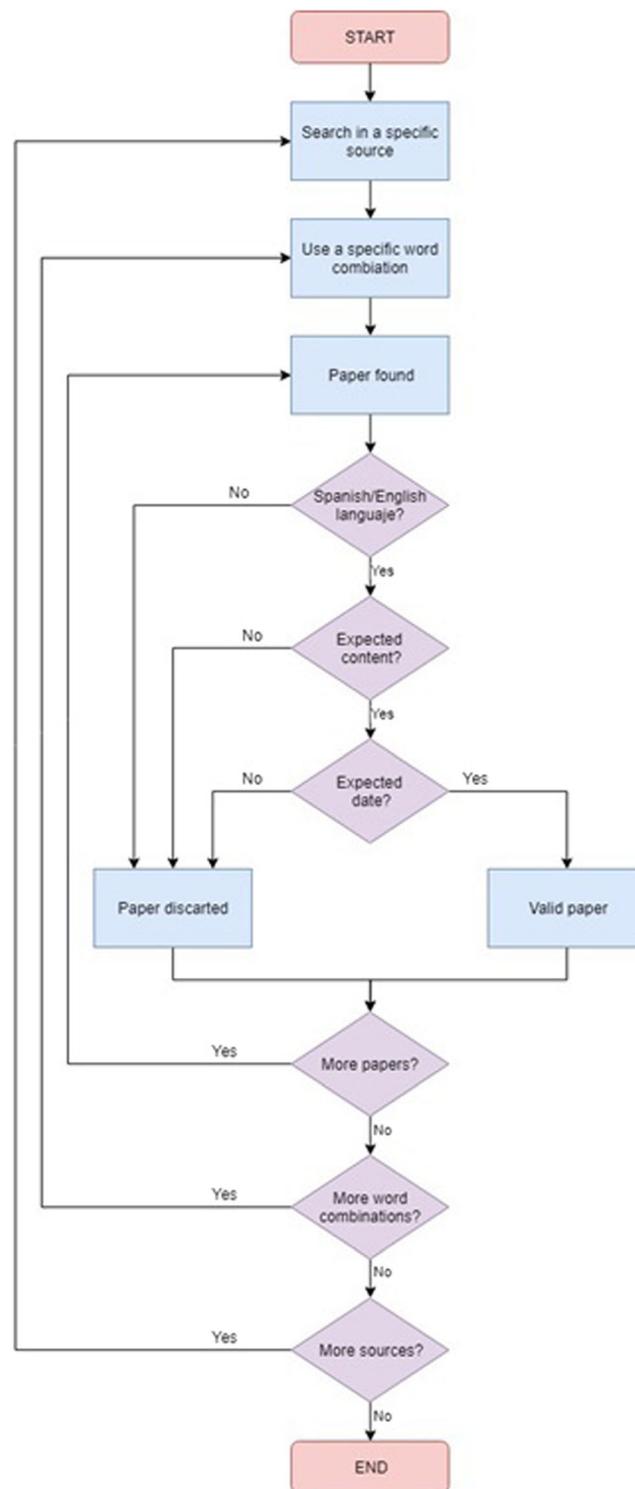


Fig. 1  Flow chart of the steps taken in the publications selection process
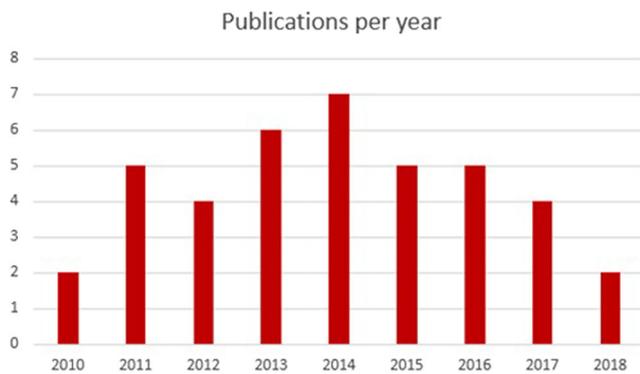
Fig. 2 Histogram of publications per year


Fig. 3 Percentage of publications for each category

## Literature review

We used the next sources to find all the available literature: IEEE Explorer, National Center for Biotechnology Information, Springer, ResearchGate, Science Direct and Scopus. In order to find all the available literatures, some search strings were defined and used in all the mentioned sources: "rhythm" OR "heart" AND "cardiac" AND "app"; "heart" AND "rate" AND ("app" OR "beat" OR "android" OR "iphone" OR "smartphone"; "heartbeat" AND "rate" AND "android"; "heartbeat" AND "measurement" AND "iphone"; "heart" AND "measurement" AND ("app" OR "android" OR "iphone"), "smartphone" AND "heart" AND ("app" OR "beat"); "cardiac" AND "rhythm" AND ("app" OR "android" OR "iphone"), taking into account Abstract and Keywords.

After that, we filtered all the publications found. The publications taken into account should meet the following requirements: 1) The language should be English or Spanish. 2) Any publication taken into account should be about the measurement of heart-rate though mobile applications (or at least mobile devices). Also, publications about techniques and algorithms of heart-rate measurements were accepted. 3) In order to limit documentation and make an actual study all articles with date of publication prior to 2010 was also discarded. Therefore, there were only taken into account the publications made between 2010 and 2018.

The process of obtaining and validation of the analyzed literature is reflected through the flowchart (See Fig. 1).

## Applications review in virtual stores

After the collection and review of the available literature on mobile heart-rate control applications we continued with a review of the all the applications available for this purpose.

To reach this purpose, we took as sources of applications the two currently most popular in mobile systems, The Android app store (Google Play Store) [4] and the iOS app store (iTunes) [5]. Windows phone mobile operating system (as well as its store) was discarded of this study because of its current disuse and little relevance.

Table 1    Categorization of publications

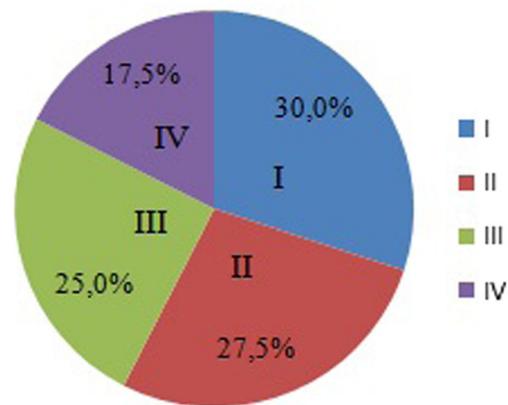| Group | Number of publications |
| --- | --- |
| I - Extraction techniques of heart rate through the mobile device (typically camera or accelerometer) sensors | 12 |
| II - Description of systems of monitoring based on mobile devices | 11 |
| III - Comparison and validation of the results obtained with mobile applications for the control of heart rate | 10 |
| IV - Health anomalies detection by the heart-rate measurements obtained through a mobile device. | 7 |

Table 2 Categorization of Android applications [5]

| Category | Number of applications |
| --- | --- |
| Health & Fitness | 152 |
| Entertainment | 57 |
| Tools | 10 |
| Medical | 7 |
| Personalization | 5 |
| Sports | 5 |
| Lifestyle | 2 |
| Video Players & Editors | 2 |
| Arcade | 1 |
| Casual | 1 |
| Simulation | 1 |
| Social | 1 |
| Libraries & Demo | 1 |

**Table 3** Categorization of application on iOS [6]

| Category | Number of applications |
|---|---|
| Health & Fitness | 140 |
| Medical | 52 |
| Utilities | 30 |
| Lifestyle | 25 |
| Sports | 25 |
| Education | 8 |
| Entertainment | 8 |
| Social Networking | 7 |
| Games | 4 |
| Simulation | 1 |

To collect all the available heart-rate control applications a data source was used: 42 Matters [7]. The methodology used for this second part was similar to the previous one. Search strings were defined to try to cover and collect the largest number of applications in the above-mentioned database. The chains used were these: Heart Rate, Heart Rate Measurement, Heart Pulse, Pulso cardíaco, Medición Pulso, mHealth Heart, Cardiac Pulse, Cardiac Rhythm and Pulse. Once collected all found apps, we discarded all that not fulfil the language, content and proposed requirements in a similar way to the anterior section.

It is important to know that the iOS store divides the tablet (iPad) and mobile (iPhone) applications, whereas Google plays don't. So, in the case of iOS both types of applications were included in this study without considering the device for which they were created as Google Play does. In the next section we show the results achieved in the review.

## Results

Now let's look at the results of our research work. Once again, we will first talk about the results obtained in terms of literature and, later, those obtained in the corresponding to mobile devices applications:

### Literature about heart-rate control apps

After the collection of papers and documentation process a total of 40 papers that fulfilled the conditions of content, language and dates proposed initially were obtained. We can see the amount of obtained papers per year in the Fig. 2. We can categorize all the literature obtained in four main groups according to the content they treat (See Table 1 and Fig. 3). As we can see in Table 1, category I related to extraction techniques of heart rate through the mobile device sensors is the most used. The second more used is category II about description of systems of monitoring based on mobile devices. The main justification of this is because of the users prefer this type of services with camera, etc. to control and monitor heart rate.

### Heart-rate control apps in virtual stores

After the process of collection all the available mobile applications, following the previously exposed methodology, we obtained a total of 400 applications which met our requirements, 245 of them were found in the Play Store (Android systems) and the 155 remaining were found on the iTunes Store (iOS systems).

The available applications found for Android systems depending on the category in which they are included are shown
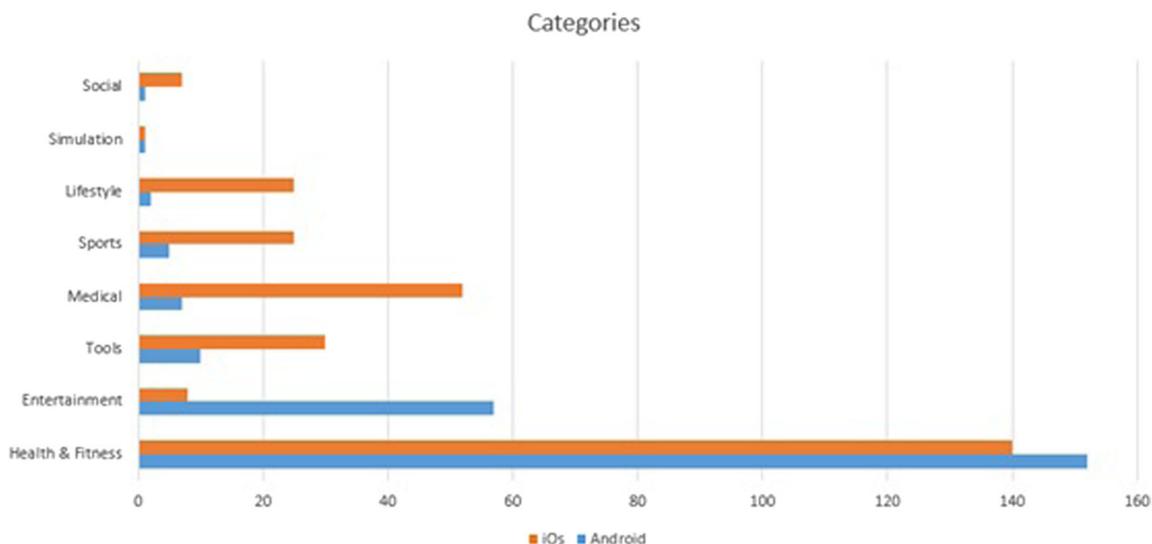


**Fig. 4** Comparison of the applications number depending on the category
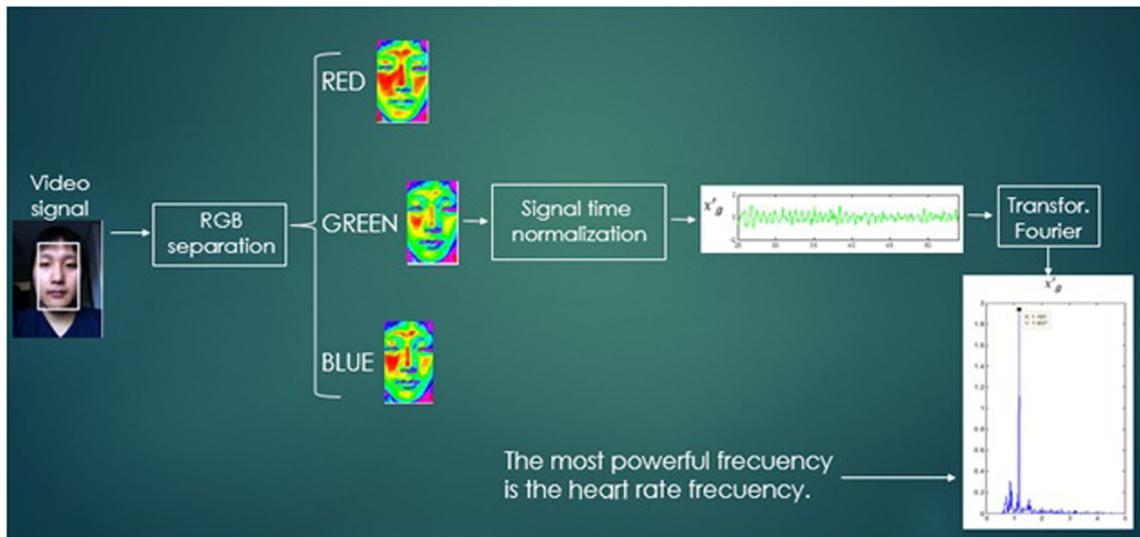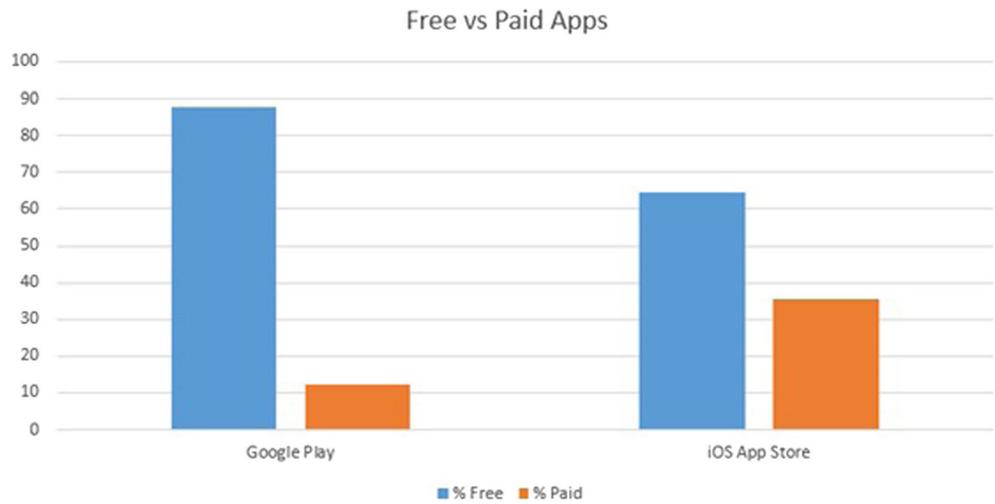
**Fig. 5** Comparison of paid vs. free applications



**Fig. 6** Calculation of the heart-rate process

**Table 4** Comparison of measures PPG vs ECG [14]

| Subject | PPG Mean | ECG Mean | % Error |
|---|---|---|---|
| 1 | 64.57 | 66.10 | 2.31 |
| 2 | 70.89 | 70.88 | 0.01 |
| 3 | 79.85 | 76.49 | 4.39 |
| 4 | 86.73 | 86.10 | 0.74 |
| 5 | 87.58 | 86.24 | 1.55 |
| 6 | 76.20 | 75.06 | 1.52 |
| 7 | 68.03 | 67.55 | 0.70 |
| 8 | 79.91 | 78.59 | 1.69 |
| 9 | 86.44 | 86.06 | 0.45 |
| 10 | 72.18 | 70.71 | 2.08 |
| Total | | | 1.08 |

in Table 2 while those found for iOS systems are shown in Table 3.

It is worth mentioning that in iOS systems an application can be found in several categories, not only in one as in Google Play occurs, this is why the total number of applications is less than the sum of the applications that are within each category shown in the above table.

If we compare the number of applications for each system in the main categories we obtain the results shown in Fig. 4.

Also, in terms of price, let's see how many are paid and how many are free. First, we analyze again Google Play, where 215 applications are free of charge while the remaining 30 are paid, the price of this paid apps is between $ 0.99 and $ 9.99.

**Fig. 7** Screen capture of What's My Heart Rate

In the case of iOS, we find that 100 apps are free; being the 55 remaining paid applications, with prices between $ 0.99 and $ 7.99. We can see a percentage of paid vs free applications in the Fig. 5 for each app stores.

As you can see in the Fig. 5, in Google Play store approximately 88% of the available apps are free, while approximately 65% of the available applications are free IOS App Store.

## Discussion

Focusing on the section of literature we can see how a large majority of the total publications recollected treat about techniques and algorithms of how to take measurements of heart rate by using available sensors on the mobile phone (typically the camera), but only a small percentage of them actually covers the topic of commercial mobile applications designed for that purpose. In all of these publications the main technique to which reference is made is known as "Photoplethysmogram" (PPG), which consists of determining the volume of blood flowing through the veins (or capillaries) capturing images of them while illuminating them with the integrated led mobile light [9].

A diagram of the technique more widely used for heart-rate measurement through the video signal captured by the camera of a mobile device is presents by Sungjun Kwon et al. 2012 [10] and can be seen in the Fig. 6.

The reliability of this method of calculation of the heart-rate is shown in the Table 4 in a comparison of the results obtained by this technique (PPG) versus those obtained by a traditional electrocardiogram (ECG).

The average error made with this technique is only a 1.08%. We have two main techniques available to obtain

**Fig. 8** Screenshots of Accurate Heart Rate and GoPhoton! Hearth Rate

measures of heart-rate based on PPG both of them: With contact. This technique is both the most widespread in applications available in stores, and in the bibliography. It works by putting the camera on your mobile device on the skin (usually the index finger) to do the PPG. Most of the available pulse measurement applications make use of this modality. However, also in certain publications [11–14] is in consideration an alternative technique of making the PPG without direct contact to the skin. It usually works by focusing the mobile phone front camera to the face. The reliability of this technique will be smaller and therefore less extended, as it is highly dependent on the light conditions in the environment where the PPG is made. A representative application of this category is "What's My Heart Rate" (See Fig. 7) [15].

Also, alternative ways of heart-rate measurement can be found, proposed by Sungjun Kwon et al. 2011 [16]. They use the mobile phone accelerometer of the iPhone to make the heart-rate measurement by placing it in the chest of the users.

Taking in consideration all the publications obtained [10–14], [16–50] we can only find a few publications (specifically six) where commercial applications available in the stores are mentioned: 1) "HeartDroid: Cardiac monitoring system using Android devices" [13]. 2) "Smartphone Applications (Apps) for Heart Rate Measurement in Children: Comparison with Electrocardiography Monitor" [27]. 3) "iPhysioMeter: A new approach for measuring heart rate and normalized pulse volume using only a smartphone" [30]. 4) "Monitoring Heart Rate with Common Market Smart-phones for Identifying Potential Signs that may Lead to Sudden Death"

[42]. 5) "Applications of smartphones for ubiquitous health monitoring and wellbeing management" [44]. 6) "Heart Rate Estimation based on Camera Image" [14].

You can see how from the year 2010 the number of mobile devices heart-rate control related papers published per year followed an upward trend until the year 2014. Year from which the trend became decreasing until the current year 2018.

Regarding the heart-rate control applications available in the Google Play and iTunes stores, the Tables 3 and 4 in the previous section show that there is a considerable high difference between the first (Health and fitness) and the rest of categories. This category has 152 and 140 apps in Android and iTunes respectively. It is noteworthy the second position in number of available applications on iOS systems which have 52 applications in the Medical category (See Table 4) while Android devices only have 7 applications in this category (See Table 3).

Analyzing the most popular applications, taking in consideration its consumer ratings, in the application stores of both systems (iOS and Android) we can find the following ones: In systems Android the two most valued applications are (See Fig. 8): GoPhoton! Heart Rate 4.6/5 and Accurate Heart Rate Monitor 4.5/5. On iOS systems we find (See Fig. 9): Instant Heart Rate: HR Monitor 4.8/5 and Cardiio: Heart Rate Monitor 4.7/5.

## Conclusion

The conclusions that can be extract are, firstly, in terms of literature, the study, comparison and testing of heart-rate control mobile applications is very low, however, we have found a large number of papers and publications that are about new algorithms and methods for measurement of the pulse through the signal processing of a video signal obtained with our smartphone. Secondly, due to the actual large increase of the use (and ownership) of mobile devices, we can find a large number of available applications in the main stores for this purpose [51].

Note that there is a greater number of applications available for Android devices, this makes sense, since Android is a more extended than iOS system, exactly Android occupies a 76.53% of the world mobile phone market while iOS only own a 18.97% currently (May 2018) [52]. Also, in comparison in terms of free apps, once again Android outperforms iOS (in percentage) with an 88% of free applications versus a 65% of the iOS systems. That is consistent with the general people's thinking that Android have a greater number of free apps than iOS [7].

However, the application with the highest price it is found on the Google Play store, with a price 20% higher than the highest price found on iOS for this application. This contrasts



**Fig. 9** Screenshots of Instant Heart Rate: HR and Cardiio: Hearth Rate Monitor

with the widespread thought that Android is cheaper than iOS [53].

In general, both Android and iOS applications have become the point of attention for society and the business world; due to the various functions and incredible opportunities they offer us. The progress of mobile technology, the availability and access to high-speed Internet and the remarkable communication interface in these devices result in a complete level of experience and innovation in mobile computing.

## Compliance with Ethical Standards

**Conflict of Interest**    The authors declare that they have no conflict of interest.

**Ethical Approval**    This article does not contain any studies with human participants or animals performed by any of the authors.

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