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Article

Survey on Cycling Mobile Applications for Workout Performance

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Abstract: This article analyzes some available bike mobile applications for smartphones as an alternative to bike computers (Cycle Computers or speedometer or speed sensors). We have records of a large number of MTB (Mountain Bike) datasets, 219 datasets were recorded on 4 different routes. These applications create maps and profiles from geographic data. Inputs can be in GPS data (tracks and waypoints), driving routes, street addresses, or simple coordinates. Most applications estimate fields such as speed, heading, slope, distance, VMG (velocity made good) and pace (cadence). However, it is necessary to calculate the relationship between cadence and power in pedaling so that cyclists know the appropriate moment to apply power to their legs to improve the torque. This paper shows tables, comparative graphs, and performance evaluation of biking routes in four different cycling mobile applications.

Keywords: cycling computer; fitness and health statistics; bike computer; mobile sensing; social fitness network; bike mobile applications; wheeled vehicles; MTB datasets

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1. Introduction

As we have seen in sports TV channels, cycling is a hard sport, it requires maximum effort, it rides many kilometers a day. Pressure, a minimum error, physical fatigue and specially mental weariness can give us a bad run.

A cyclist must know all details of cycling and characteristics of sports equipment used in different racing formats: route, road, track, and mountain bike, every racing format has particular data. A professional or amateur cyclist should know times, durations, types of tests, as much information and knowledge as possible so that he can get better performance from each workout.

For this reason, it is necessary to have a speedometer that provides real-time information to cyclists (device that measures speed). For a long time, there have been different types of cycle computers (speed sensor) enabled with speedometer, odometer, and other basic functions. At present exists cycle computers that provide an overview of metrics related to cycling. Particularly, it depends on the type of bicycle, computers can offer us data as simple as distance, current speed and travel time; however, some cycle computers can give us more detailed information such as heart rate, power, and cadence. Therefore, cyclists, whether beginners or professionals have to look at technology to know their fitness and progress.

An experienced cyclist thinks about in cycle computer with advanced features and accurate physiological data to aid in his improvement and progress. In addition to all the metrics mentioned above, this category is complemented by heart rate component, which includes calories burned, maximum heart rate and training in target areas. An experienced cyclist chooses cycle computers that provide application services, such as data to be shared, data transfer and training regimes. These advanced versions of cycle computers become too expensive.

Recently, hundreds of mobile applications have been released for road, mountain, and urban cycling. Apps with different features, ranging from applications that serve to trace the safest or least

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contaminated route, apps that calculate the best ratio for our speed, apps that guide us about how to give first aid, to apps that recommend us wear the kind of clothes to go pedaling according to the weather. Most of these cycling apps are free, a few apps we must pay for installing.

These apps provide GPS-enabled real-time maps, these apps track the route and long-term storage, interval tracking, calorie burn estimation and a fully customizable reading screen with maps, hours or graphics. Other features for cyclists who like music, there are also available functions that sync it with music to access the playlists, and so on.

In general, this kind of mobile applications for bikes are preferred by cyclists, they also have the benefit of analyzing workouts, facilitate statistical data sharing and help to improve their performance.

Comparing the high costs of buying a cycle computer or installing a mobile application for cyclists, always the best decision of a cyclist will be to install a free bike application. Now, having so many mobile applications, the question arises about which application to install to measure bike rides.

Therefore, in this paper, we try to analyze statistics on mountain bike (MTB) training on different scenarios or routes using 4 different mobile applications for bicycles.

Although it should not be forgotten that a cycle computer in principle measures with greater precision and accuracy the basic metrics such as distance, time and speed. Since mobile applications for bicycles, these measurements are done based on calculations provided by GPS.

In our analysis is considered in each training to measure in parallel also with a cycle computer (speed sensor) while measuring with 4 cycling mobile apps. That is, having a measurement made by a physical device since this cycle computer measures with a sensor and a magnet mounted on the front wheel of the bicycle that sends a signal in real time each time the wheel makes a spin.

2. Related Works

Cycling has been published in several papers, mainly works about health and mobility related to routes and maps of cycling routes; experiments about tests applied to cyclists in laboratories and indoor controlled scenarios; studies about pedaling movement in order to maximize the performance and minimize risks of injuries; also about mobile sensing system for mapping cyclist experiences, and so on. Below we will briefly describe some related works to cycling.

Several works deal with the subject of pedaling and power, as well as the theme of the cranks. In this classic study [1], the authors intend to determine the effect that different pedaling techniques have on mechanical effectiveness and gross efficiency during cycling in a steady-state. They propose that in order to determine the mechanical effectiveness of cycling, cranks with power meters and pedals with force sensors should be used to determine if a mechanically effective pedaling technique can achieve greater efficiency.

Another related work to pedaling and cranks is [2], a dynamometer pedal is used to record changes in the pedaling technique of 14 cyclists (40 km), who rode at a constant rate. One half of the group of cyclists showed no change in the pedal orientation, and they increased the vertical component of the force applied during the descent as the workload increased. In addition to increasing the vertical component during the ascent. Other seven cyclists also increased the pedal rotation throughout the descent and increased the horizontal component between 0^o and 90^o. Another result is that the negative torque on the pedal during the ascent usually becomes a positive torque at the high workload. However, although the torque during the ascent decreased the total positive work required during the slope, it did not contribute significantly to the external work performed, since 98.6% and 96.3% of the total work done in the low and high workload, respectively, It was done during the descent.

BikeNet is a mobile sensing system built leveraging the MetroSense architecture to provide people-centric sensing into the real-world and mapping the cyclist's experience. BikeNet uses several sensors embedded into a cyclist's bicycle to gather quantitative data about the cyclist's rides. This proposal uses a dual-mode operation for data collection, using opportunistically encountered wireless access points in a delay-tolerant fashion by default, and leveraging the cellular data channel of the cyclist's mobile phone for real-time communication as required. It is also provided a Web-based portal where each cyclist can access his/her data, and let to share data among cycling groups, and more general data (environmental data). Authors present a prototype of the system architecture based on small sensors and a mobile phone, it infers cyclist performance and the cyclist environment [3].

Due to mobile devices available on the market that already provide a set of integrated sensors and sensing enabled devices there has been a significant evolution of applications for mobile devices that provide location-based services. In [4], authors present the development and results concerning a mobile sensing system applied to cycling which collects performance data using both smartphone with sensors integrated and several wireless sensor nodes. The data collected is stored in a local database and also uploaded to a remote database, where it can be accessed using the mobile application or a web browser. Mobile application users can share data, create events, consult graphs and access past routes in a map. Therefore, users can obtain detailed feedback for enjoyment of the cycling experience.

Some papers propose novel ideas to control cyclist's physical effort and support to cyclists when they are out of their comfort zone. Afonso et al. [5], developed and evaluated a control system for cycling, which contributes to promote the users' mobility and physical health. System proposed provides an automatic mechanism to control the motor assistance level of an electric bicycle in order to ensure that the cyclist's effort remains inside the desired target zone (which could be for comfort or a health goal). The system has to control the assistance level considering variables that affect the effort, such as the slope of the road. Authors proposal controls the pedaling resistance perceived by the cyclist through the use of a sensor device placed inside of the bicycle crankset, which provides the required torque signal. Effort control algorithm is implemented in a smartphone application, while a micro controller on the bicycle acquire data, exchange data wirelessly with the smartphone, and control the motor assistance level in real time. Experimental results offered by authors validate the effectiveness of the implemented effort control system [6].

Bicycle sharing systems are becoming increasingly popular in the world's major cities. These systems operate with online maps that reveal situations such as the number of bicycles available and the number of free parking spaces at stations. Online maps are very useful both for cyclists and for those who want to do a granular analysis of a city's cyclist trends; in addition, some work indicates that many cities have unique spatial-temporal characteristics and therefore require customized solutions. The authors in [7] analyze during four and half months online data on bicycle sharing in ten cities. They applied unsupervised learning to time data and the results showed that only larger systems have heterogeneous behavior with intrinsic similarities. The similarities can be used to forecast the number of bicycles a station will have in the near future. The discovery of the similarities makes it possible to design, build and manage future bicycle sharing systems.

A study by [8] analyzed more than 10 million journeys made by members of the Cycle Hire Scheme in London and found that women's use characteristics are clearly different from those of men. Women used bicycles on weekends and in London's parks, while men made much longer trips and often occupied roads outside the city.

It is essential that any highly trained cyclist optimize his or her pedaling movement to maximize performance and minimize the risk of injury. Current techniques are based on the assembly of bicycles and measurements with laboratory tests. These techniques do not allow to evaluate the cyclist's kinematics in real scenarios during training and competition when fatigue can alter the cyclist's ability to apply forces to the pedals and thus induce a poorly adapted load on the joint. [9] proposes a solution based on wireless motion sensor nodes for the body area that can collaboratively process sensory information and provide cyclists with immediate, real-time information on pedaling motion to determine the actual condition of the lower extremity segments of the cyclist in real-life conditions. Knee and ankle angles, which influence performance, and the risk of injury from overuse during pedaling are measured. The system offers to estimate the energy consumption and determines the possible improvements and the aspects of usability found.

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3. Cycling performance

In all sports exist different ways to measure training performance. In other sports perceiving this improvement can be subjective, in cycling, there are objective methods that can give reliable data about the performance of cyclists.

There are cycle computers and mobile applications that record interesting data about bicycle rides such as distance traveled, average speed, maximum speed, pedaling power, total time, cadence, heart rate, and so on.

3.1. Cycle Computer (speed sensor)

In addition to data collected from the cycling mobile applications, we decided to have a different reference about distance, time and speed, for this reason, a traditional speed sensor was used. A cycle computer can help us to accurately measure the right distance and speed of the route where we made the tests. Figure 1 shows the cycle computer ((Specialized Speed Zone Sport Wireless) used to validate some measurements such as speed, distance and time.

Figure 1. Cycle computer (Specialized Speed Zone Sport Wireless) receives data from a sensor mounted on the suspension fork.

A magnet placed on a cycle wheel spoke and a sensor mounted on the suspension fork, then the sensor sends data to a cycle computer. Figure 2 illustrates each time the magnet passes a sensor placed on the suspension fork a signal is generated. The cycle computer measures the time between those signals and works out how fast the cyclist is pedaling, based on the wheel dimension we gave it on initial set up.

Figure 2. Magnet on a cycle wheel spoke and sensor mounted on the right suspension fork measure when the wheel makes a spin.

From this measurement the cycle computer can also works out a whole range of information including distance, average speed, ride time and maximum speed. Depending on the designer's choices it may also have features like auto on/off, pausing the stopwatch, and different types of timing and average speed.

As we mentioned, in particular, this cycle computer measures values such us: speed, average speed, maximum speed, cadence, ride time, and ride/trip distance.

It is very important the sensor accurately measures the right distance, so we must configure the cycle computer by entering the wheel circumference size into the setting. Calculating wheel circumference by means of two ways:

1. If it is known wheel diameter, multiply it by π (pi) to find the circumference. For example, a wheel with a 27.5 inches diameter will have a circumference of 27.5 x 3.14159 = 86.3937979737 inches = 2,194.41 mm (millimeters).
2. Mark the tire and the ground where they meet. Roll bicycle forward full revolution and mark the point on the floor, then measure the distance in millimeters.

This measure introduced into the speed sensor gives us the certainty that the odometer counts with accuracy every spin given by the wheel, so distance and speed calculation made by the cycle computer is reliable.

3.2. Mobile Applications for bicycles (Bike Mobile Applications)

Popularizing smartphones appeared several cycling mobile applications, from highly analytical information tools to social networks applications. We analyze the most popular. Immediately when thinking about applications for cyclists, we come up with: Urban Biker, BikeComputer, Strava, Bike Computer, Runtastic, MapMyRide, Garmin Connect, Endomondo, and so on. These applications analyze training, facilitate sharing statistics and help improve performance, there are a large number of applications for cycling.

In this analysis, as previously mentioned, there are dozens of cycling mobile applications available for this purpose. Although we know a current list of the most useful cycling apps, four mobile applications were used in these workouts: Endomondo [10], MapMyRide [11], BikeComputer [12], and Runtastic [13]. All of them offer users almost the same functions and features, register practices more or less accurately and allow sharing data through social networks. However, in this paper, we try to analyze some differences in performance. In Figure 3 is shown four mobile track applications.

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Figure 3. Four Cycling Mobile Track Applications analyzed.

3.2.1. Endomondo

Endomondo is a cycling mobile application with GPS, it can be used on Android, IOS and Windows platforms. Endomondo is a social fitness network. Endomondo allows real-time track workouts, it measures distance, speed, altitude, and location, because it uses GPS and Google maps. Endomondo has functions such as:

- Follow workout with GPS while riding a bicycle.
- Check duration, speed, distance or caloric expenditure.
- Get audio information about the distance and the rhythm every km.
- Manually register workouts that we have not followed with GPS.
- Record of all workouts.
- View daily physical activity volume.
- Analyze performance in partial times.
- When sessions are finished, data is exported to GPX files

Endomondo has a web site where we can see workout's history, progress and much more. Endomondo is a free application that can be very useful for monitoring training or find extra motivation for activities. Figure 4 shows the endomondo's main screen.

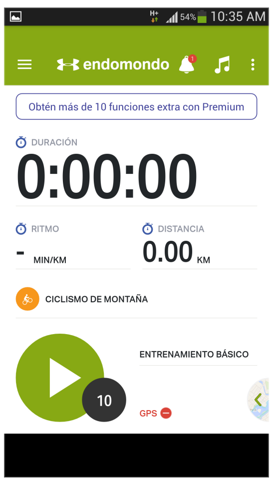

Figure 4. Endomondo's main screen.

Endomondo has its own website where we can see total kilometers traveled, workout duration, calories burned, average speed, and other data; Endomondo allows us to visualize on google map the route traveled and a graph with time, speed, and distance (Figure 5).

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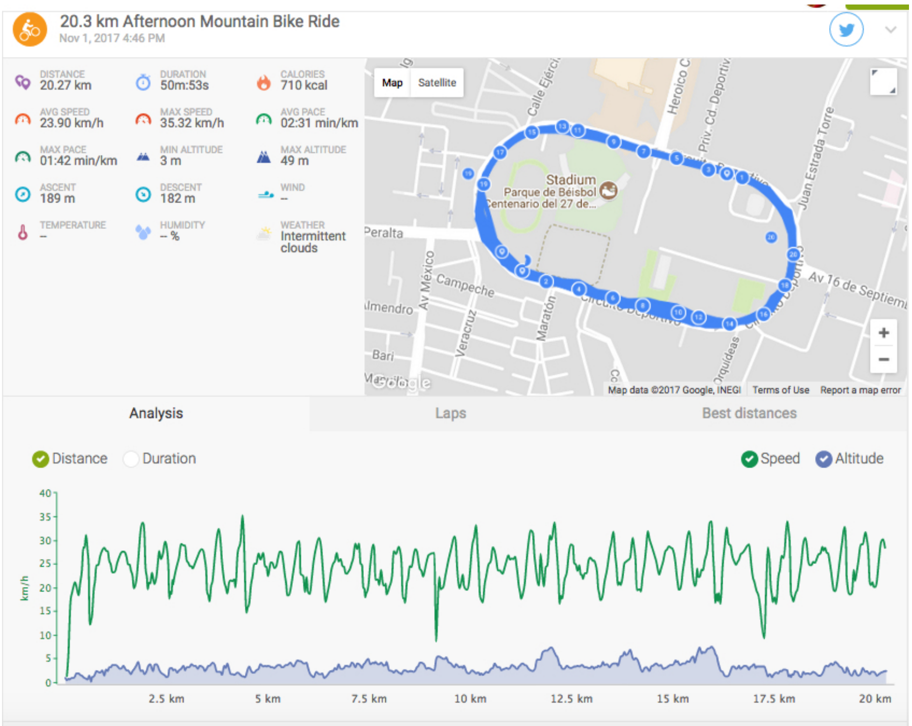

Figure 5. Endomondo's website.

3.2.2. MapMyRide

MapMyRide allows to see, search or create maps of favorite routes and destinations, print them or take them on our mobile device. Record the workouts, follow up on them and analyze the results in order to improve your training habits and motivate ourselves. Get in touch with other people, become part of a group or invite all your friends to train with us. This and much more is what we find in this application. (See Figure 6).

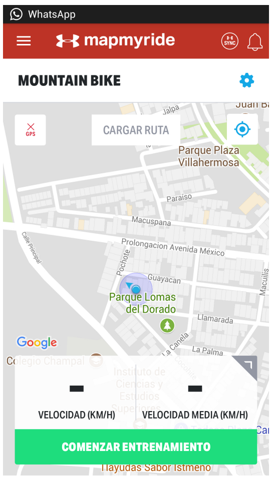

Figure 6. MapMyRide's main screen.

MapMyRide GPS Cycling also allows sharing data through social networks (Facebook and Twitter). MapMyRide is free. When starting to create routes with MapMyRide it is possible to do it by means of two ways. The first one is through its web interface, where we can select a location on a map and start plotting points, in a similar way what we would do in Google Maps. The second option to

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create routes is directly using the mobile applications for Android or iPhone. In this way, the map is drawn as we go along the route.

There is also the possibility of creating a training plan, for more advanced users or an interesting option is to create the route and then publish journey times.

Other options of MapMyRide is to record calories burned, pace, depending on the weight, size or bicycle used including duration, elevation and route traveled. Figure 7 depicts the MapMyRide website. All of this can be uploaded to the MapMyRide site for detailed analysis. Data generated by these app are stored in GPX file format.

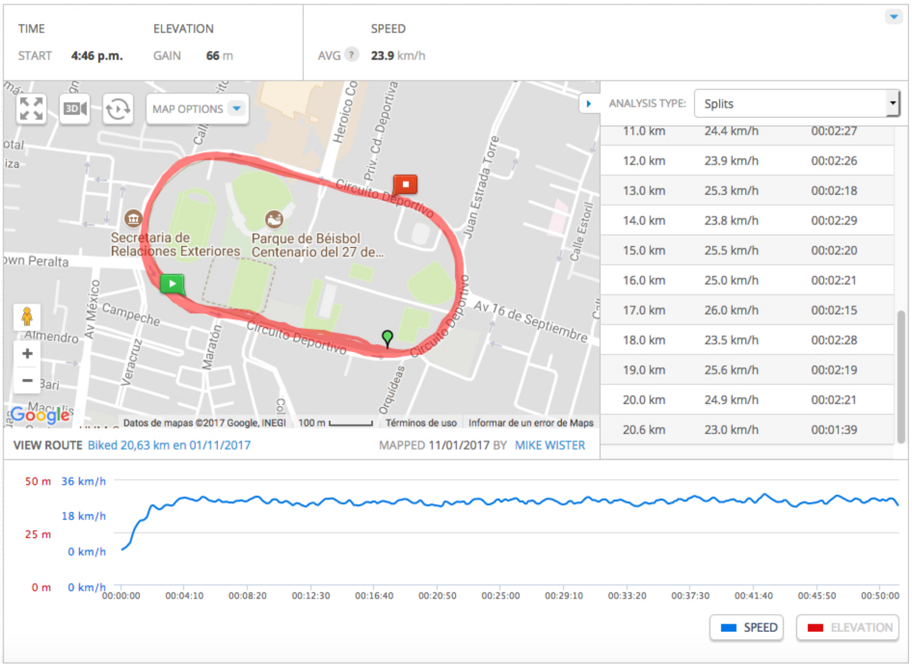

Figure 7. MapMyRide's website.

3.2.3. BikeComputer

BikeComputer is one of the most popular platforms used for tracking cycling performance. BikeComputer follow trips on the map, distance, speed and all other relevant data. It also plans a route by setting points on the map, BikeComputer calculates track and distance. BikeComputer moves waypoints of the route using drag and drop functions and it discovers new trails or unknown paths we have always wanted to try. BikeComputer shows an elevation profile for the planned route. When finishing a trip, it is possible to review this session and post data on social networks (Facebook, Twitter) and it also exports data as GPX.

BikeComputer can be used across smartphone and computer platforms, and all data is displayed on screen. All data is synced and available on site. In Figure 8 is shown the BikeComputer main screen.

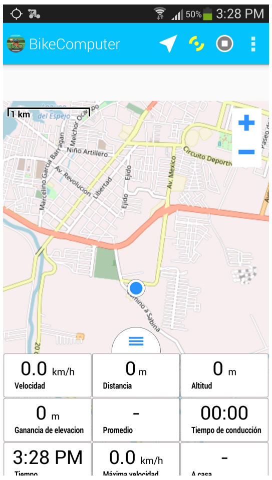

Figure 8. BikeComputer's main screen.

BikeComputer is focused exclusively on the world of cycling, any improvement or update that comes is designed for cyclists. BikeComputer is designed to monitor routes every time a cyclist goes with the bicycle, being able to know thanks to GPS, kilometers traveled, speed in different segments, pedaling rhythm (pace or cadence), etc. Figure 8 shows the BikeComputer's main display.

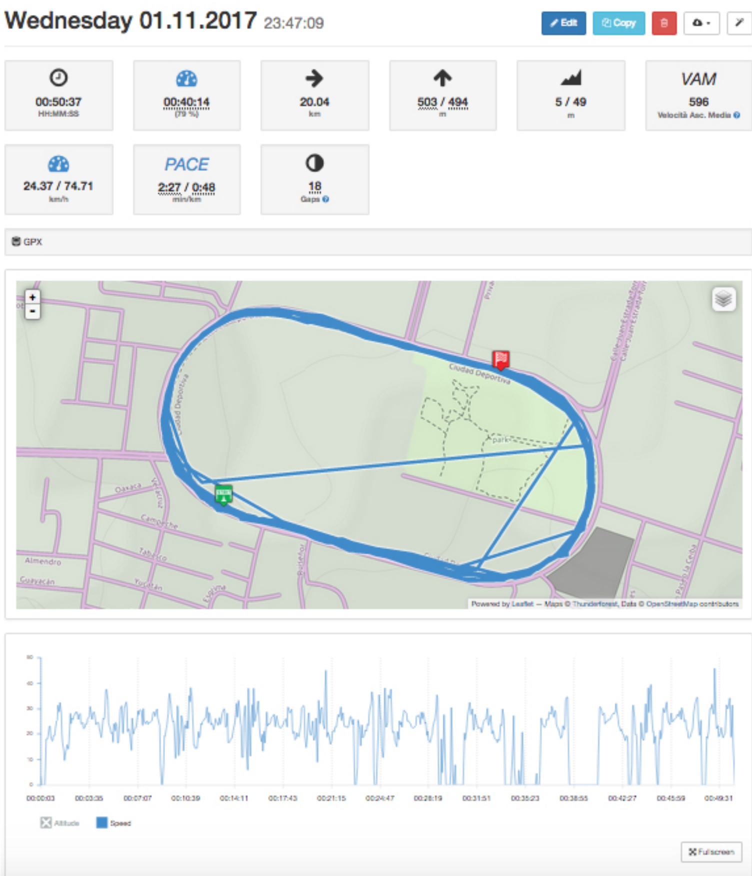

Figure 9. bikecomputer's website.

3.2.4. Runtastic

Runtastic is a cycling application, that records fitness and cycling activities using GPS technology. It also plans cycle route, records rides, monitors workouts. Runtastic offers some features as follows:

- Track GPS
- Measure distance, duration, speed, rhythm, calories burned
- View map
- Create tables (speed, elevation, heart rate)
- Generates training history
- Create table for lapses
- Share on social networks

Runtastic excels among other similar applications for simplicity when using it. Runtastic has a free application version. Once a workout is finished, data is exported to GPX file to be visualized and analyzed the collected data. In Figure 10 is shown the Runtastic main display.

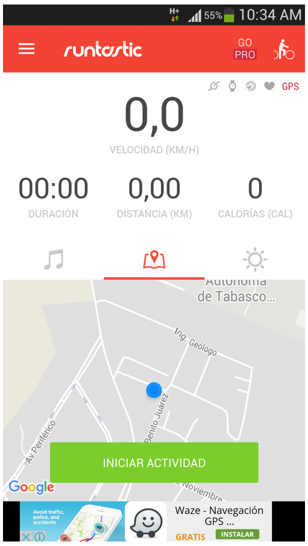

Figure 10. Runtastic's main screen.

Runtastic also offers a web interface to view the collected data (See Figure 11). Runtastic allows us to see history showing a list of all sessions, with a view to a month or a week. There is also option of a website where users appear who at the same time are using Runtastic in the world and around us. If we have added friends, it is possible to see routines about my friends.

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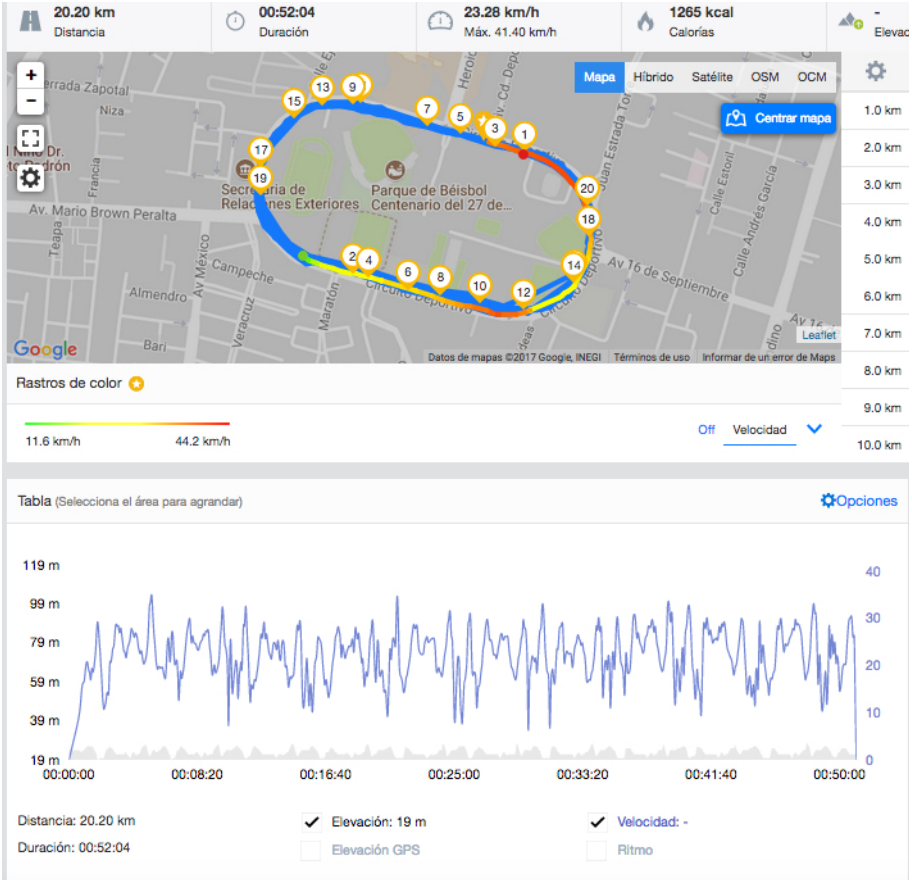

Figure 11. Runtastic's website.

4. Experimental setting

To carry out our experiments we chose some routes to ride a bike, it was also necessary to have a smartphone for installing the applications, and finally, a cyclist also needed.

One smartphone Samsung Galaxy S4 was used to make this bike ride, operating system Android, Samsung Galaxy S4 has several sensors such as accelerometer, geomagnetic compass, proximity, gyroscope, barometer, infrared, humidity, and temperature. Four cycling mobile applications mentioned above were installed on this Samsung Galaxy S4.

One mountain bike (MTB) was used to carry out our experiments, Specialized brand, model Hardrock Disc 650b, wheel size 27.5 inches, frame constructed from A1 Premium Aluminum, 7 rear sprockets and 3 chain rings.

One cyclist participated in our experiments, male, 48 years old, 170 cm, and 82 Kg. All tests performed riding the same bicycle. Our experiments consisted of two hundred and nineteen rides or workouts; Table 1 summarizes the total number of workouts, corresponding to four different routes. Our cyclist performed each ride in approximately 50 minutes, 20 km, average speed 23.9 km/h, and 800 Kcal.

Table 1. Total number of training

Application	Workouts
Endomondo	119
MapMyRide	36
BikeComputer	33
Runtastic	31
– Total –	219

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Every bike mobile application analyzed has a particular way to log a workout, Table 2 shows the average rows by datasets, this number of rows depends on the sample that the application records in the GPX file.

Table 2. Average rows per datasets

Application	Average Rows
Endomondo	493
MapMyRide	673
BikeComputer	1400
Runtastic	965

Our datasets were collected from four different routes (Table 3). We collected data from 219 workouts (rides from mobile applications) corresponding to two different routes. For our analysis, fist of all, we are going to study the 1.94 km route, since it is a controlled scenario where the trip is labeled every 100 m.

Table 3. Bike routes where our workouts were ridden. Villahermosa, Tabasco, Mexico

Route	Location	Distance (Km)
A	Lomas del dorado - Sabina - Ixtacomitan	20.00
B	Lomas del dorado Ixtacomitan	22.55
C	Sabina	20.00
D	CD Deportiva VHSA	1.94

In order to analyze in particular our workouts, two routes were chosen, the first one, a route with fixed measures, a circuit 1.94 km length; the second one, a route 20.00 km length.

From 219 training and 4 routes, we analyzed two routes only. The first one consists of 20 laps on the circuit of 1.94 km. (Route D. CD Deportiva VHSA. Figure 12 (Left)), this route could be said it is a controlled scenario, where the exact distance is previously known, it is an oval form with two slight slopes at the ends. The second one is a trip of 20.00 km. (Route A. Lomas del dorado - Sabina - Ixtacomitan. Figure 12 (Right)), this route contains a descent of 52 m and a length of 150 m; on the other hand, there is also an ascent of 400 m (approximately) and a length of 66 m, both descent and ascent certainly influence the cyclist's performance.

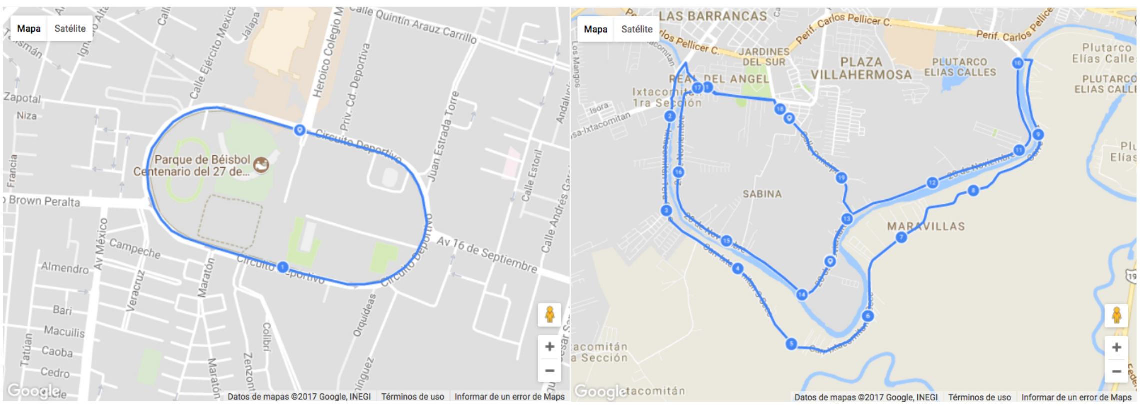

Figure 12. (Left) Route D. CD Deportiva VHSA. (Right) Route A. Lomas del dorado - Sabina - Ixtacomitan. As we can notice, each map has points to signal 1 kilometer.

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5. Cycle Computer vs. Bike Mobile Applications Comparison

Two measures (distance and average speed) were used for establishing the accuracy between the speedometer and the bike mobile applications.

5.1. Distance Analysis

To verify the accuracy of the cycle computer was tested on the route D since it has exactly calculated 1.94 km and it is printed on the traffic sign of route D; it can be said that it adjusts 1,940 m. And this measure was checked with the cycle computer, that also recorded 1,940 m.

After checking the distance on route D, a workout was ridden on this route. Talking only about distance traveled. In the ride of 20 laps on route D, the cycle computer recorded 20.63 Km, while the other applications recorded 20.27 km (Endomondo), 20.63 km (MapMyRide), 20.18 km (BikeComputer), and 20.20 km (Runtastic). In Table 4 it is noticed slight differences of some meters in the same applications. There are also some differences between data collected by the mobile applications with respect to data collected by the cycle computer. The summary results are shown in Table 4.

Table 4. Workout Summary. Route D - CD Deportiva VHSA, circuit distance = 1.94 km, laps = 10, total distance = 20.63 km. and date = Nov/01/2017.

Application	Devices	Max Speed Km/h	Avg Speed Km/h	Time Minutes	Distance Km	Cadence Min/Km	Calories Kcal
SpeedZone Sport Wireless	Sensor	34.30	23.80	51.57	20.63	–	–
Endomondo	App	35.32	23.90	50.53	20.27	2.31	710
MapMyRide	App	41.60	23.90	51.45	20.63	–	866
BikeComputer	App	41.40	23.90	51.24	20.18	–	–
Runtastic	App	41.40	23.28	52.04	20.20	2.34	1265
Mean		38.80	23.76	51.37	20.38	2.33	
Standard Deviation		3.6647	0.2696	0.5518	0.2288	0.0212	
Variance		13.43.01	0.0727	0.3044	0.0524	0.0004	
Median		41.40	23.90	51.45	20.27	2.33	

Another workout to analyze is a trip of 20.00 Km (route A. Lomas del dorado - Sabina - Ixtacomitan). In this workout, our cyclist stopped his bike just when the cycle computer recorded 20.00 km. Considering these measurements, we see that three out of four applications failed to adjust 20.00 km, instead Endomondo recorded 19.80 Km, Bikecomputer recorded 19.94 Km, and Runtastic recorded 19.72 Km, while MapMyRide recorded exactly 20.00 km. Considering the results, there are small differences between data recorded by the cycle computer and data recorded by the mobile applications. Other measures recorded in the bike ride are displayed in Table 5. It is noticed slight differences of some meters in the same applications. According to data in Table 5 here there are also differences in meters, but these are smaller than the difference in distance shown in Table 4.

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Table 5. Training Summary. Route A. Lomas del dorado - Sabina - Ixtacomitan. 20.00 km, final distance traveled 20.00 km, on November 08 2017.

Application	Devices	Max Speed Km/h	Avg Speed Km/h	Time Minutes	Distance Km	Cadence Min/Km	Calories Kcal
SpeedZone Sport Wireless	Sensor	45.50	24.10	49.42	20.00	–	–
Endomondo	App	38.75	23.72	50.05	19.80	2.32	699
MapMyRide	App	46.00	23.50	51.03	20.00	2.28	832
BikeComputer	App	45.00	24.10	49.34	19.94	2.29	–
Runtastic	App	43.95	23.47	50.24	19.72	2.33	1240
Mean		43.86	23.78	50.02	19.89	2.31	
Standard Deviation		2.9592	0.3094	0.6877	0.1262	0.0238	
Variance		8.7568	0.0957	0.4729	0.0159	0.0006	
Median		45.00	23.72	50.05	19.94	2.31	

However, in another workout when our cyclist stopped his bike until all applications had crossed 20.00 km, it can be seen that three out of four applications had passed several extra meters after 20.00 km, while the cycle computer recorded 20.53 km. Table 6 summarizes this workout. Understanding these measurements, the mobile applications analyzed registered more than 20.00 Km to reach the threshold of 20.00 Km, the distance recorded by the applications are not very accurate.

Table 6. Training Summary. Route A. Lomas del dorado - Sabina - Ixtacomitan. Distance 20.00 km, final distance traveled a little more than 20.00 km, on Nov 06 2017.

Application	Devices	Max Speed Km/h	Avg Speed Km/h	Time Minutes	Distance Km	Cadence Min/Km	Calories Kcal
SpeedZone Sport Wireless	Sensor	41.60	23.70	51.50	20.53	–	–
Endomondo	App	37.28	23.86	50.29	20.07	2.31	704
MapMyRide	App	39.15	23.84	51.33	20.48	2.31	858
BikeComputer	App	41.40	24.38	49.57	20.15	2.27	–
Runtastic	App	40.05	23.64	50.49	20.02	2.34	1263
Mean		39.90	23.88	50.64	20.25	2.31	
Standard Deviation		1.7741	0.2924	0.7914	0.2380	0.0287	
Variance		3.1473	0.0855	0.6264	0.0567	0.0008	
Median		40.05	23.84	50.49	20.15	2.31	

5.2. Speed Analysis

The following figures were plotted and analyzed by VELO HERO [14] to standardize all collected data, these graphs use speed and time values only.

20 laps on route D, the average speed on the cycle computer recorded 23.80 Km/h, Endomondo recorded 23.90 km/h, MapMyRide recorded 23.90 km/h, BikeComputer recorded 23.90 km/h, and Runtastic recorded an average speed of 23.28 km/h. There are slight differences between data collected by the cycle computer and data collected by the mobile applications. Figure 13 plots the behavior in time and speed values. The horizontal axis represents time in seconds and the vertical axes depict speed. The plots compare speed and time values.

We notice a repetitive pattern in speed since the 20 laps were done on the same circuit, as we mentioned above, the curves of the elliptical shape of route D (Figure 12 Left) has descents, while in the straight parts, the track has terrain flat. Therefore, our mobile applications have a very similar pattern. The graph that shows significant differences is Runtastic because the number of events recorded is 965 rows in its dataset (See Table 2). In this ride the arithmetic mean is 23.76 Km/h.

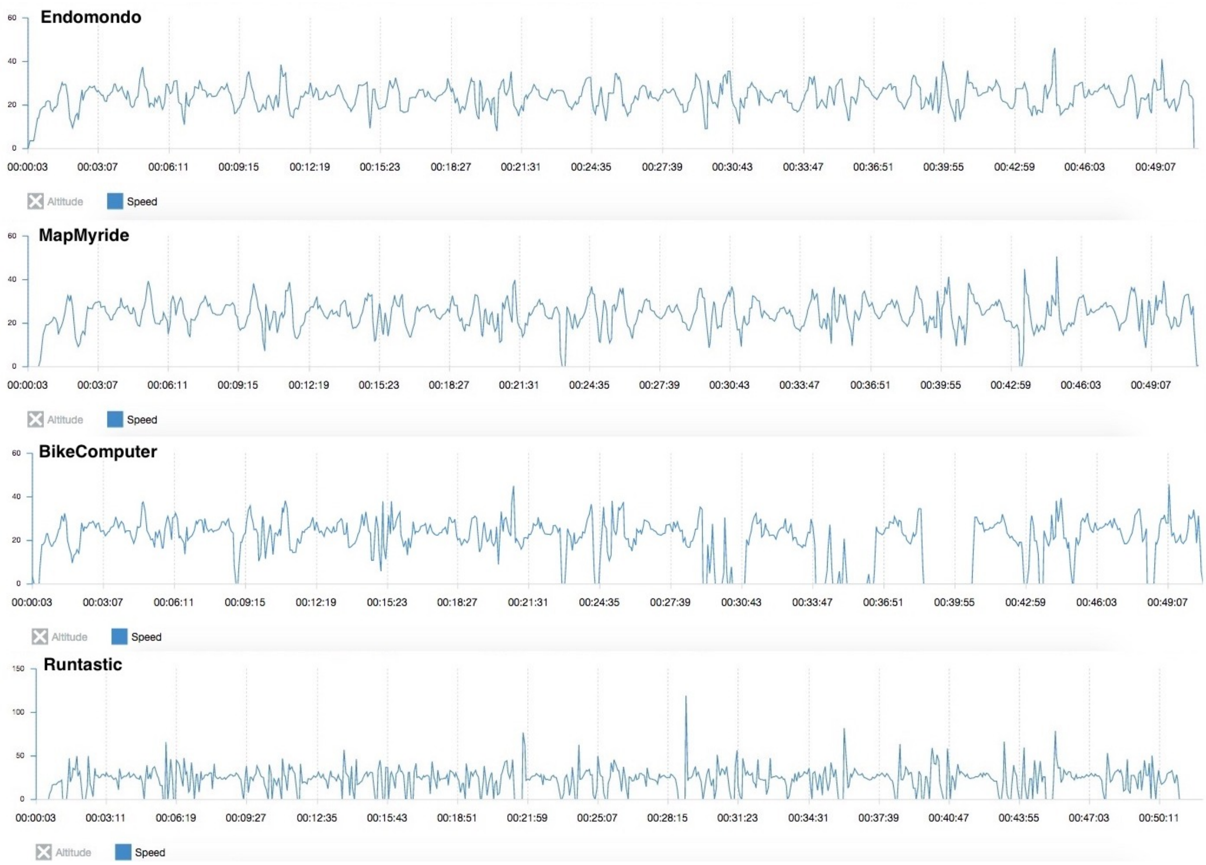

Figure 13. Endomondo, MapMyRide, BikeComputer, and Runtastic workout route and graphic (analized and graphed by Velo Hero). Sample experiment at 20.00 km. The plots shows speed and time values of route D - CD Deportiva VHSA. November 1 2017.

In the trip of 20.00 Km (route A. Lomas del dorado - Sabina - Ixtacomitan) our cyclist recorded an average speed using the cycle computer about 24.10 Km/h, while Endomondo recorded an average speed of 23.72 km/h, MapMyRide obtained 23.50 km/h, BikeComputer recorded an average speed of 24.10 km/h, and Runtastic recorded an average speed of 23.47 km/h. In summary, the arithmetic mean value was 23.78 km/h. We also observe small differences between data collected by the mobile applications with respect to data collected by the cycle computer. Figure 14 plots the behavior in time and speed values.

Graphs in Figure 14 show a clear pattern, since route A (Figure 12 Right) is usually flat, except for a significant descent (From Km 18 to Km 19), route A has some curves and several straight segments. Similarly to the previous graph (Figure 13) Runtastic graph differ slightly with respect to Endomondo, MapMyRide, and BikeComputer, these last graphs are almost equal each other.

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Figure 14. Endomondo, MapMyRide, BikeComputer, and Runtastic workout route and graphic (analized and graphed by Velo Hero). Sample experiment at 20.00 km. The plots shows speed and time values of route A - Lomas del dorado - Sabina - Ixtacomitan. November 6 2017.

When riding route A (Lomas del dorado - Sabina - Ixtacomitan) our cyclist during the ride recorded an average speed about 23.70 Km/h using the cycle computer, while in the other applications our cyclist recorded an average speed of 23.86 km/h (Endomondo), an average speed of 23.84 km/h (MapMyRide), an average speed of 24.38 km/h (BikeComputer), Finally, Runtastic recorded an average speed of 23.64 km/h. The arithmetic mean was 23.88 Km/h. We can see very slight differences between data collected by the mobile applications and data collected by the cycle computer. Figure 15 plots the behavior in time and speed values.

Similar to the graphs in Figure 14, the graphs in Figure 15 have a pattern. As we mentioned before, route A (Figure 12 Right) is almost flat. Route A has a descent only, it has curves and straight segments. Similarly to the previous graph (Figure 14) Endomondo and Runtastic graphs are different slightly with respect to MapMyRide and BikeComputer, MapMyRide and BikeComputer present almost the same behavior in terms of lines.

 doi:10.20944/preprints201711.0170.v1

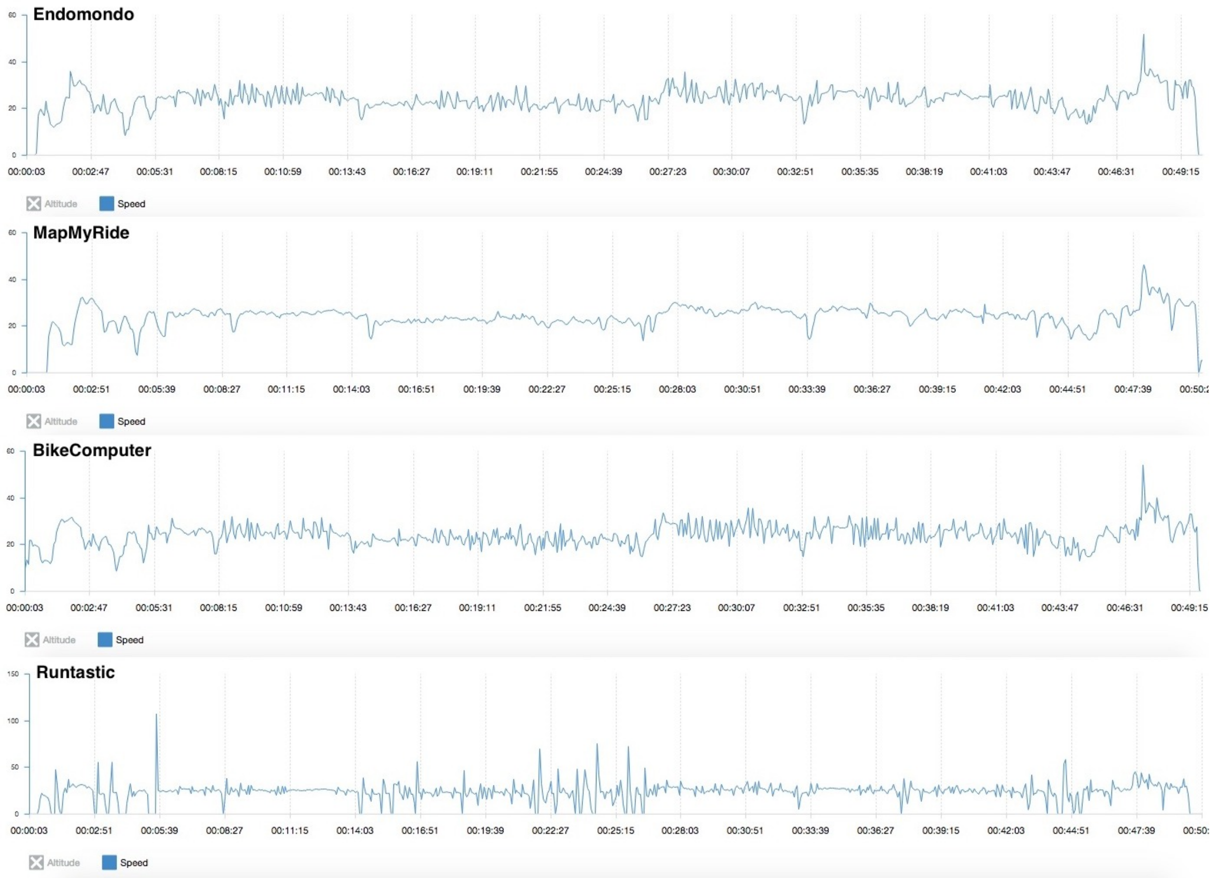

Figure 15. Endomondo, MapMyRide, BikeComputer, and Runtastic workout route and graphic (analized and graphed by Velo Hero). Sample experiment at 20.00 km. The plots shows speed and time values of Route A - Lomas del dorado - Sabina - Ixtacomitan. November 8 2017.

6. Discussion

All training registered in the datasets keep knowledge, at least it is possible to exploit them with data analysis tools.

As we have seen, the analyzed applications are not very accurate, theses present very slight differences. In routes analyzed (about 20 km) in most cases the differences in distances become 100 m or more; however, their measurements are not so distant in terms of average speed, these measurements keep an approximation of the values recorded.

Sometimes appear subjective aspects that can not be registered in workout log files. Some workouts have records that travel the same distance in less time since it is the same route, it is the same cyclist, it is the same bicycle, and in general, it is the same scenario. We know the wind at our back plays an important role to get good records, however, subjectively and hypothetically, sometimes a dog persecutes to a cyclist motivate him to apply more force into the pedal and therefore, the final time record decreases.

This paper contributes to the decision-making process when cyclist must select an application for installing to have and share data such as speed, distance, cadence and burned calories along their routes. Our research objective was achieved by comparing the values obtained with four different applications compared to a conventional cycle computer.

One of the findings obtained is that although each application offers efficient measurements, it was proved that the distance traveled parameter (obtained using GPS from smartphone), it had inconsistencies between one application and another in a range of 100 to 200 meters. On the contrary, speed values recorded by these applications are very close to those obtained by the speedometer.

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Another aspect that can be improved, it is to have a reference application that is widely validated by its quality and accuracy in results obtained from measurements, so that it is useful to know the differences in the applications evaluated, with respect to the reference application.

7. Conclusions

The main contribution of this work has been to develop the measurements of four mobile applications for cycling. In this paper a comparison among mobile applications for cycling was made, differences in accuracy of distance, speed, and time; similarly, those measurements were compared against the measurements provided by a speedometer.

These four mobile applications for cycling use Google Maps to visualize and calculate travel, something that is important to emphasize since it influences when taking into account that the GPS of the phone works on the same basis in the distances and terrain.

The applications analyzed measured similar distance, the measurement was calculated by GPS installed on the smartphone, finally, it is the same for all applications. Taking into account that all applications were activated stopped and at the same time, it turns out that some applications measure a few meters less than others in sometimes and sometimes measure a few meters more than others.

The results obtained from a series of experiments demonstrate that bike mobile applications based on GPS present differences in distance, p.e. when the speedometer shows 20.00 km, a bike mobile application only registers 19.72 km.

It is necessary to calculate the relationship between cadence and power in pedaling so that cyclists know the appropriate moment to apply more power in their legs to improve torque. This paper shows tables and comparative graphs of monitoring and performance evaluation of cyclist's routes in four different mobile bike track applications

Author Contributions: Miguel Wister was in charge of the entire project including idea generation, he also conceived, designed and performed the experiments; Pablo Pancardo is the corresponding author, he sought similar or related works to this study. Miguel Wister and Pablo Pancardo wrote the paper. Pablo Payro was responsible for the statistical analysis model, contributed with analysis tools and conducted the data analysis.

Conflicts of Interest: The authors declare no conflict of interest.

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Sample Availability: Dataset samples are available from the authors.