Chapter 5

Technological Development in the Cycling

Duran Akbaş[1]

Nuray Satılmış[2]

Abstract

There is a linear relationship between the cycling branch and technological developments. The development of technology over time and its combination with the sports industry has enabled the data obtained in training and competitions to be obtained instantaneously. Cyclists have started to use lighter and higher quality bicycles in training and competitions with developing technology. With the introduction of pulse and power measurement devices and the development of tests suitable for the cycling branch, the possibility of determining the performance status of athletes and preparing more efficient training programs has been developed. When the competition results and technological developments from the past to the present are analysed, technological developments in the cycling branch positively affect the performance of cyclists.

CONCEPT OF TECHNOLOGY AND INTRODUCTION

When people hear the words technology or technique, they think of a form of machine or hardware. However, the word technology alone does not include mechanical hardware. Technology also encompasses the enterprise dimension. The concept of technology is called a technical language, an applied science, a concept related to techniques, a method in which it is used for the realization of an applied purpose, and the general name given to all the developments made so that people can live more comfortably (İşman, 2001). According to a different definition, it is to express the knowledge and experience necessary for the production of a good or service as a whole (Camkıran, Sersan, & Yıldız, 2021).

1 Alanya Alaaddin Keykubat Üniversitesi, Spor Bilimleri Fakültesi, Antalya, Türkiye, duranakbas7@gmail.com 0000-0002-4030-0935

2 Alanya Alaaddin Keykubat Üniversitesi/Spor Bilimleri Fakültesi/Alanya/Antalya/Türkiye nuray.satilmis@alanya.edu.tr, 0000-0002-2086-1436

https://doi.org/10.58830/ozgur.pub315.c1480

Technology and Sports Industry

With the developing technology, the sports industry has also been positively affected. Many products have been developed through service industry technology and made available to users (Tekin & Karakuş, 2018). With technological advances, technology has an important effect on sporting equipment and sports fields to be more ergometric. Sporting materials influenced by developing technology have been effective in breaking new records for athletes (Atasoy & Kuter, 2005).

Developments in innovation, communication, the internet and technology form the cornerstones of the industry. As in all industries, there have been technical, scientific and technological developments. In this way, the integration of sports and technology has been realized. Through technological developments, data is processed instantaneously in training and competitions (Tekin & Karakuş, 2018). We can transfer our data from training and competitions to cycling monitors or apps using sensors or cloud services via a wired or wireless internet connection. For these devices to communicate with each other, the connection is established via Wi-Fi, NFC, RFID, Bluetooth and Zigbee, while technologies such as GPRS, GSM, LTE, 4G, and 5G are used for local wireless network connections (Banger, 2017). For example, cyclists use heart rate bands and power measuring devices in training and competitions. These devices allow the data obtained in training and competitions to be transferred to bicycle monitors or applications developed for the device via Bluetooth connections.

DEFINITION AND HISTORICAL DEVELOPMENT OF THE BIKE

A bicycle is defined as a non-motorized vehicle in which people transfer their power to the rims via pedals (Aydilek & Sarıçiçek, 2019; Morpa, 1997). The word bicycle comes from the Latin bis [twice] and the Ancient Greek κύκλος [circle] (Wilson & Schmidt, 2020).

The history of the bicycle goes back as far as human history. Although quite different from its present form, the first bicycle was seen in China in the 12th century. But in 1817, German Baron Karl Von Draise invented a two-wheeled bicycle that could move with the thrust of its rider. In 1839, the effective use of pedals was provided by Kirkpatrick Macmillan of Scotland (Aydilek & Sarıçiçek, 2019; Wilson & Schmidt, 2020). In 1868, the bicycle spread from Paris to Belgium, the Netherlands, Germany and the United States (Wilson & Schmidt, 2020). In 1874, H. J. Lawson developed the first chain-driven bicycle. In 1888, J. B. Dunlop saved the bicycle from being jerky by using hollow tyres and made it comfortable and useful (Aydilek & Sarıçiçek, 2019; Wilson & Schmidt, 2020). The first bicycles in our country were seen in the Ottoman Period in the 1880s (Aydilek & Sarıçiçek, 2019).

The introduction of the bicycle to Turks began in 1885 when an American named Monsieur Tomas Istefanis travelled around Istanbul, Izmit, Ankara, Yozgat and Sivas provinces with his bicycle. In the 19th century, Izmir and Thessaloniki were the most common places in the Ottoman Empire outside the capital Istanbul. During the Ottoman Period, the first bicycle competition was held in Izmir on May 15, 1895 and in Istanbul on August 18, 1895. The first major road race in Turkey in 1924 was held between Fethiye and Antalya. The bicycle has provided mobility in both daily life and sports in the 120 years from the 1890s to the present day (Süme & Özsoy, 2010).

Modern bicycles began to be widely used in the United States in the 1970s. Bicycle sales have increased to exceed automobile sales. Initially, three-speed models were fashionable, but later they were replaced by ten-speed models. With the decline in interest in road cycling in the United States, interest in lighter road bikes has increased. In California, downhill bikes have been introduced. With the sea change event in 1982, there was a transition from road bikes to mountain bikes and from thin tires to thick tires. The interest in mountain bikes was not as short-lived as in road bikes, and cyclists used road bikes for commuting to work, shopping and travelling over rough roads. These bikes have front and rear suspension, carbon, and aluminum frames, hydraulic disc brakes and 27 gears as a gear system (Wilson & Schmidt, 2020). With the developing technology, 12-gear systems have started to be used over time. There has been a shift from mechanical gears to gear systems with electronic and wireless connectivity (Shimano, 2023).

Purposes of Use of the Bicycle

The way the bicycle is used and its role has changed over time. These can be listed as use within the city, use on rough roads and terrains, use for sightseeing purposes between cities and long-distance roads, use in short and long-distance races, for acrobatics and demonstration purposes, for tourism purposes, as a means of fitness and exercise (Aydın, 2015).

While individuals use bicycles in daily life, there is no limitation on the design of their bicycles and the components on them. However, there are restrictions on the type of bicycles of cyclists participating in cycling competitions. These limitations are set by the International Cycling Union

(UCI). The UCI gives details of what the components will be like in a standard bike used to participate in competitions (UCI, 2023).

Development of Technology in Bicycle Components

Various components on the bicycle can affect the performance of cyclists. These components can mainly be explained as rims, cranksets, gear systems, shifters, and tyres.

There are different types of cranksets among bicycle components. Elliptical cranksets, normal cranksets, and single, double and triple cranksets can be given as examples. Elliptical cranksets can be attached to normal cranksets. In this case, the pedal movements of the athletes remain circular, but the speed and gear ratio varies. The purpose of elliptical cranksets is to reduce the time spent in the upper and lower dead spots of the pedal. The ovality degrees of the elliptical crankset is determined by using the ratio of the large diameter of the underlying ellipse to its small diameter. In the 1890s, the prevalence of these cranksets decreased when cyclists using elliptical cranksets, which had an ovality of approximately 1.3, could not achieve the performance they wanted in the races. In 1930, the ovality ratio of 1.1 Thetic cranksets began to become popular. Compared to circular cranksets, there is no deterioration in the performance of cyclists and it has even been shown to improve the performance of some athletes. In the 1980s, Shimano produced the non-elliptical Biopace (Wilson & Schmidt, 2020). Today, different brands offer various crankset preferences for cyclists to use most efficiently (Campagnolo, 2023; Shimano, 2023; Sram, 2023). However, over time, cyclists have started to prefer single-leaf cranksets to make their bikes lighter.

One of the factors affecting the speed of cycling athletes is the hubs of the wheels. Wheel hubs are ball and bearing according to the companies. There are various levels of aluminium and carbon wheels according to the quality of the wheels and the hub condition. (Shimano, 2023; Sram, 2023).

Wheels are one of humanity's greatest inventions. Their ability to carry a load of low resistance depends on their size, the ground condition of the surface being travelled, its hardness, and the characteristics of tires and suspensions. When riders are travelling on unstable ground, the uneven ground shakes the cyclists and delays their acceleration. Thomson in 1845 and Dunlop in 1888 invented pneumatic tires to reduce the effect of the force generated during a collision on their cyclists, to reduce energy losses and to make them more comfortable when moving from one place to another (Wilson & Schmidt, 2020). With the advancement of technology day by day, different types of tyres have started to be produced with the use of bicycles both in daily life and in competitions. These tyre types range from tubeless tyres to tubular tyres (Vittoria, 2023). Likewise, there has been a transition from aluminium wheels to carbon wheels, and from unprofiled wheels to profiled wheels. In this way, it allows athletes to be less affected by the wind and to go faster (Shimano, 2023).

Another piece of bicycle equipment is the brake. Brake systems vary according to the type of bicycle and the purpose of use. Piston brakes are used in some children's bicycles and tricycles. The disadvantage of this type of brake is poor performance in rainy weather since the tires constantly get wet. The internal expanding drum brake system is a hub brake system similar to the old automotive brake system. It began to be widely used in the 1930s but lost its popularity over time because it was heavy with rim brakes. These braking systems are becoming popular to eliminate the problem of rim and tire overheating. The reverse pedalling system brings multiple discs together when the cranks are turned backwards. This braking system works on oil and is not affected by weather conditions. Coaster brakes break off and don't have a lot of surface area to dissipate heat. During prolonged driving and intensive use situations, the braking systems can reach high temperatures, which adversely affects braking performance (Wilson & Schmidt, 2020. A different type of brake used by cyclists is the disc brake system. This brake system is a preferred form of brake in motorcycles, automobiles, racing cars and aeroplanes. Various types of disc brakes can be used in bicycles according to the budget situation. Brake systems are in the form of a disc partition connected to the hub, brake pads and calliper. These brake systems can work with mechanical wire cables or hydraulics. Compared to other braking systems, and in wet weather conditions, the braking performance is better. There are holes in the discs to reduce their weight and cool them (Shimano, 2023; Sram, 2023; Wilson & Schmidt, 2020). The rim brake system is the most popular type of brake worldwide. This braking system consists of a gear lever, a pad made of rubber material, a calliper and gear wires. The brake pads are very sensitive to water. Electric brakes are only used on some types of e-bikes. In addition to mechanical brakes, they are usually installed on the hubs of the bike. There are different braking options for downhills. When the mechanical brake lever is pressed, medium braking is automatically activated. Magnetic and aerodynamic brakes are used in a variety of stationary exercise brakes. Not suitable for road bikes (Wilson & Schmidt, 2020).

Another factor that affects the performance of cyclists is the helmet. Athletes prefer lighter and aerodynamic helmets in competitions (Wilson & Schmidt, 2020).

The Development of Speed in the Cycling Branch with Developing Technology

Cyclists have started to reach longer distances and speeds with the developing technology. The wheel was invented thousands of years ago and people do not exceed 15 km/h on the bicycle invented by Draisine 200 years ago. This speed is slower than the speed that people reach when running or skating. But soon the bicycle showed a great improvement (Wilson & Schmidt, 2020). With the development of technology, the UCI track cycling records for a fast start over 200 m have reached 77.0 km/h for men and 69.3 km/h for women. A study of the outdoor altitude velodrome achieved speeds of 63.16 km/h in the unique men's category (in 2008) and 54.04 km/h in women (in 2009) (Wilson & Schmidt, 2020).

In the first Olympic Games held in 1896, the road bicycle branch also took part. The first men's athlete in the Olympic Games completed the 87-kilometre course at 3:22:31 at a speed of 25.80 km/h (InternationalOlympicCommittee, 2023; Wikipedia, 2021). The men's branch of road cycling at the Tokyo 2020 Olympic Games was held on a 234-kilometer course. The winning male athlete completed the race in 6:05:26 hours with a speed of 38.43 km/h. In the women's category, she completed the 137.0 km course with an average speed of 3:52:42 hours and 35.32 km/h (Vikipedi, 2023).

In a study conducted by Haake (2009) to determine the effect of technology on four sports branches, it was found that athletes improved their performance by 24% in 108 years in the 100-metre sprint, 86% in 94 years in pole vault, 95% in 76 years in javelin throw, 221% in 111 years in one-hour cycling record and 35% in 32 years in four-kilometre individual pursuit.

Advancement of Technology in Bicycle Measuring Devices

With the development of bicycle ergometers, it has become easier to follow variables such as the mechanical efficiency of cyclists, heart rate, respiratory rate, etc. during measurements (von Döbeln, 1954). Bicycle ergometers have a frame structure, seat, handlebars and cranksets that reflect the normal bicycle appearance. Some ergometers can measure hand power output as well as foot rotation (Lanooy & Bonjer, 1956; von Döbeln, 1954).

Pedalling performance is related to the force exerted by the cyclist and the resulting fatigue. These different power levels range from a few seconds to a few hours for cyclists. To test the pedalling performance, tests performed on the bicycle ergometer in the laboratory environment are advantageous in terms of keeping the resistance constant. However, these tests can be applied outdoors on a flat road, on slightly hilly ground, against the wind or as sprint studies. Athletes with different levels of power produce power with different characteristics. Sprinter athletes have better short-term power output, while long-distance athletes have better long-term performance values (Wilson & Schmidt, 2020).

Pulse in the Cycling Branch

Monitoring the performance of athletes, and determining and controlling their training intensity is important for competition athletes. That's why heart rate has long been the gold standard in practising and tracking cyclists' workouts (Theobald, 2023).

Depending on the devices used by the cyclists, the pulse rate of the cyclists can be measured using a pulse band worn on the wrist, arm and chest area. While the data from the first heart rate meters are uploaded to the internet via an infrared connection, the data can be easily uploaded to the internet with Bluetooth or ANT+ sensor in the latest developed devices.

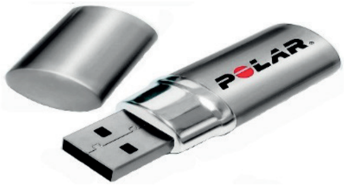


Figure 1. Example of USB made for transferring pulse data

Bi-directional infrared data communication is provided via USB (Polar, 2023).

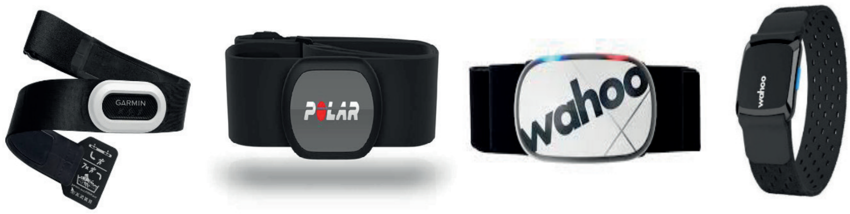


Figure 2. Arm and chest heart rate bands with Bluetooth capability that provide ANT+ data transfer. (Garmin, 2023; Polar, 2023; Wahoo, 2023)

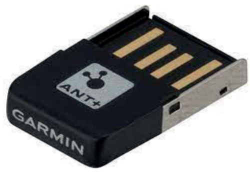
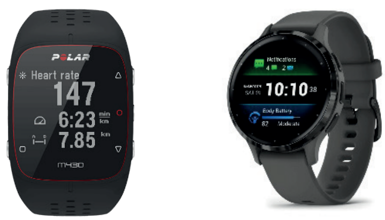


Figure 3. ANT+ sensor that transmits data from smart power meters to the computer (Garmin, 2023).

ANT+ sensors are used to prevent data loss during Bluetooth data transfer.



Polar M340 Garmin Venu 3S

Figure 4. Devices that measure from the wrist (Garmin, 2023; Polar, 2023).

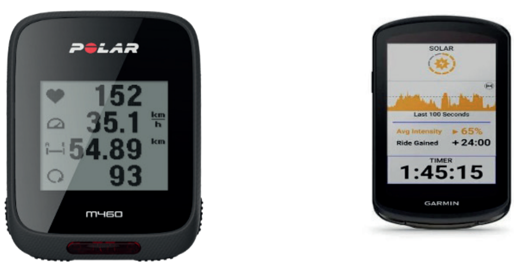


Figure 5. Devices for monitoring heart rate and other data via bicycle monitors

The Use of Power Meters with the Advancement of Technology

Power outputs are one of the best tools for cyclists to control external loads (Gandia Soriano, Carpes, Rodríguez Fernández, & Priego-Quesada, 2020).

Indoor power meters and ergometers first appeared in the late 1880s. Andrew Coggan, an exercise physiologist, began working on ergometers in the physiology laboratory in the early 1980s. Through the use of specific protocols, he learned how the body responds and what changes in bloodlactate levels occur. With the introduction of suitable mobile meters in the late 1990s, more information began to be obtained during training and competition (Allen & Coggan, 2010).

Power output data can be obtained on the track, on the road, in off-road conditions and various environments including indoor space. Power measuring devices were first introduced to commercial production of the SRM in the 1980s. The SRM power meter was first used by riders such as the East German cycling national team and Greg Lemod, who competed in European competitions. In recent years, power measuring devices have become widespread and the market network has expanded greatly (Yeh vd., 2022). Mobile power meters can be easily used when cycling outdoors or indoors (Passfield, Hopker, Jobson, Friel, & Zabala, 2016; Schneeweiss, Haerlen, Ahrend, Niess, & Krauss, 2018). It is a valid tool for determining the power output of cyclists. The measurements made give information very accurately and reliably. The devices are attached to the bicycle and used to monitor and evaluate the performance of the athletes in training and races through the data obtained.

Mobile power meter devices are produced by different companies. Examples of these companies are Garmin Vectors, Stages Cycling Powermeter, and Cycleops Powertap. These devices can measure in different ways from different zones. For example, it is possible to measure the power output of cyclists from the shoe (Zone DPMX), pedal (Garmin Vector), Hub (Cyclops Powertap), middle hub (Rotor INpower), crankset (Stages Powermeter) (Passfield vd., 2016). For cyclists and professional athletes, it can be used a variety of power-measuring devices on almost every type of bike (Schneeweiss vd., 2018). Modern power measuring devices such as the Schoberer Rad Messtechnik (SRM) and PowerTap, which can be mounted on the bike, give more efficient results (Wilson & Schmidt, 2020). Pedal-based power meters have several advantages. In a study comparing the validity of the pedal-based Favero Assioma Duo (FAD) power meter and the SRM power meter, which is considered the gold standard, the FAD was found to be valid for measuring maximum efforts (Yeh vd., 2022). CyclingPeaks software was developed by Andrew Coggan and Kevin Williams in 2003. In this software, cyclists can load their workouts on the power meter and analyze the workouts they have done. Thus, they were able to follow the data of the cyclists in training and competitions. For this reason, it is the best way to control the intensity of training and competitions (Allen & Coggan, 2010).

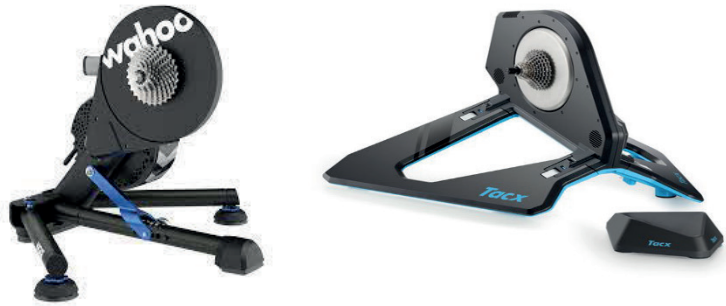


Figure 6. Examples of stationary power measuring devices

Constant power measuring devices can be given the feeling of training outdoors by applying inclination or different protocols.

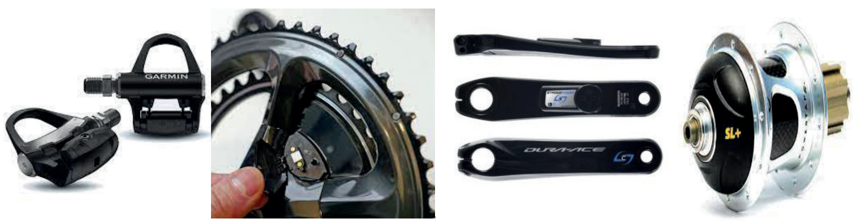


Figure 7. They measure power from the pedal, crankset, and rear hub measure in different ways (Garmin, 2023; PowerTap, 2023; Shimano, 2023; StagesCycling, 2023).

Tests Used in the Bicycle Branch

With the use of power meters, various tests can be carried out to monitor the performance of cyclists:

Critical Power: It is defined as a power output that cyclists can sustain forever. This power output is obtained as a result of the mathematical formula curve adaptation of the test results obtained by short-term tests (Wilson & Schmidt, 2020). Hugh Morton and Hogson (1996) note that tests performed at intervals of 2-15 min to determine the critical power always fit well.

A similar definition is defined as the level of power that the cyclist can sustain for one hour (Wilson & Schmidt, 2020). Allen and Cogan (2010) define the FTP test as the power output that cyclists can sustain in a semi-stable state for one hour. However, the long duration of this period is difficult and stressful for athletes. Therefore, over time, the 20-minute FTP test was introduced. A 45-minute warm-up protocol is recommended for athletes before starting the test. After 20 minutes of time trial after warming up to obtain the FTP value, the average power output obtained by the athletes is 0.95 (Allen & Coggan, 2010; Mcgrath, Mahony, Fleming, & Donne, 2019; Valenzuela, Morales, Foster, Lucia, & Villa, 2018). In addition, the FTP value of the athlete can be found by calculating 0.90 of the average power output of the cyclists for eight minutes with a different protocol (Allen & Coggan, 2010). According to the FTP value, the training zones of the athlete are determined. In addition, when the FTP value of the cyclist is divided by the body weight, the relative power value is calculated. This value allows us to estimate the number of training hours and training stress score (TSS) that the athlete should do weekly and monthly.

An important test for cycling athletes is the anaerobic power wingate test. The test was first introduced by Ayalon, Inbar and Bar-Or (1974). The test starts with 60 cadence and the athlete is asked to perform the best performance he/she can perform without getting up from the saddle for 30 seconds. During the test, the data are recorded at intervals of five seconds. As a result of the test, average power, maximum power, minimum power, and fatigue index are calculated (Castañeda-Babarro, 2021; Wilson & Schmidt, 2020).

Table 1. Training zones by functional threshold pulse (FTHR) and FTP value

Training Zones	FTHR	FTP
Zone 1	≤81%	≤55%
Zone 2	82%-89%	56%-74%
Zone 3	90%-93%	75%-89%
Zone 4	94%-99%	90%-104%
Zone 5	100%-102%	105%-120%
Zone 6	103%-106%	121%-150%
Zone 7	≥107%	≥150%

Table 2. Volume values that cyclists should make according to their performance status (Friel, 2018)

Category	Annual Recommended Hours	Weekly Average Hours	Annual Recommended TSS	Weekly Average TSS
1 or 2	700-1.000	14-20	35.000-50.000	700-1000
3	500-700	10-14	25.000-35.000	500-700
4	350-500	7-10	17.500-25.000	350-500
5 or Youths	220-350	4-7	11,000-,17,500	200-350
Masters	350-650	7-13	17.500-32.500	350-650

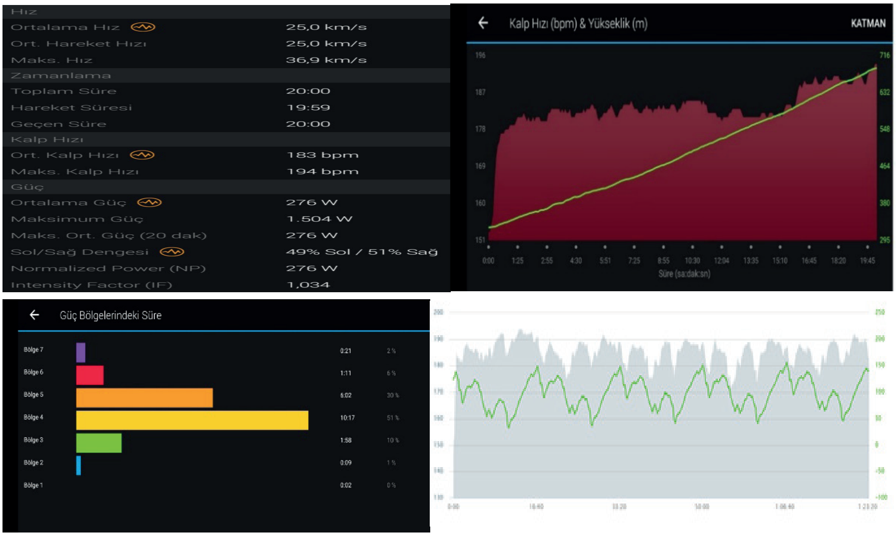


Figure 8. Athletes can follow their training data through various software.

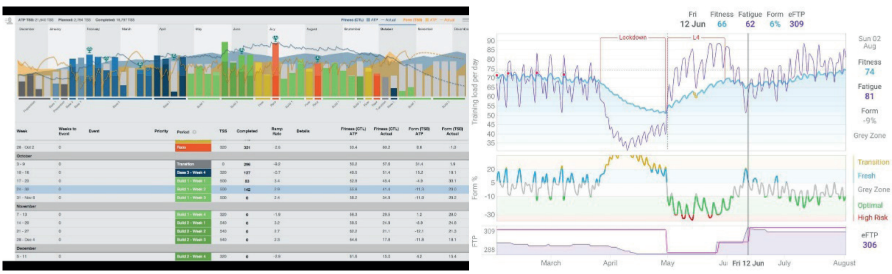


Figure 9. It is ensured that athletes' training and performance status can be followed with various applications.

Athletes can be analyzed by uploading their workouts to various applications such as TrainingPeaks or Interval.uci. In addition, fatigue and fitness can be examined together with the analysis of the trainings (Intervals.icu, 2023; TrainingPeaks, 2023).

CONCLUSION

With the development of technology, bicycle athletes have been provided with more aerodynamic and lightweight bicycle usage opportunities. In addition, with the development and increase in the number of components that cyclists can use every day, more options have been offered. With the production of pulse and power measuring devices and the use of various tests, the performance status of athletes could be determined. In addition, it has been possible to implement more efficient training programs. When the competition results of the athletes are examined with the technological development to the past and present, it can be said that technological developments have positively affected the performance of the athletes in the cycling branch.

REFERENCES

Allen, H., & Coggan, A. (2010). *Training and racing with a power meter* (2.). Boulder: Velopress.

Atasoy, B., & Kuter, F. Ö. (2005). Küreselleşme ve Spor. *Eğitim Fakültesi Dergisi*, *18*(1), 11–22. Tarihinde adresinden erişildi https://dergipark.org.tr/tr/download/article-file/153255

Ayalon, A., Inbar, O., & Bar-Or, O. (1974). Relationships Among measurements of explosive strength and anaerobic power. Içinde *In Biomechanics IV* (ss. 572–577). London: Palgrave. https://doi.org/10.1007/978-1-349-02612-8_85

Aydilek, B., & Sarıçiçek, C. (2019). *Ortaöğretim Spor Lisesi Bireysel Sporlar* (3.). T.C. Milli Eğitim Bakanlığı. Tarihinde adresinden erişildi https://drive.google.com/file/d/1XmS6u7hcXIqX8b5yKpR2mXX63W5Z97uB/view

Aydın, M. (2015). Bisiklet Kullanımının Ortaya çıkardığı pozitif Dışsallıklar. *Dokuz Eylül Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *17*(3), 273–290.

Banger, G. (2017). *Endüstri 40. Ekstra* (2.). Ankara: Dorlion Yayınları.

Camkıran, N., Sersan, V., & Yıldız, K. (2021). Spor Ortamında Teknoloji Kullanımına Yönelik Bir Derleme Çalışma. *Gaziantep Üniversitesi Spor Bilimleri Dergisi*, *6*(2), 162–177. https://doi.org/10.31680/gaunjss.913352

Campagnolo. (2023). Campagnolo. Tarihinde 07 Eylül 2023, adresinden erişildi https://www.campagnolo.com/gb-en/

Castañeda-Babarro, A. (2021). The wingate anaerobic test, a narrative review of the protocol variables that affect the results obtained. *Applied Sciences (Switzerland)*, *11*(16). https://doi.org/10.3390/app11167417

Friel, J. (2018). *The Cyclist's Training Bible* (5.). Boulder, Colorado: VeloPress.

Gandia Soriano, A., Carpes, F. P., Rodríguez Fernández, A., & Priego-Quesada, J. I. (2020). Effect of cycling specialization on effort and physiological responses to uphill and flat cycling at similar intensity. *European Journal of Sport Science*, *21*(6), 1–7. https://doi.org/10.1080/17461391.2020.1785016

Garmin. (2023). Garmin. Tarihinde 09 Eylül 2023, adresinden erişildi https://www.garmin.com.tr/

Haake, S. J. (2009). The impact of technology on sporting performance in olympic sports. *Journal of Sports Sciences*, *27*(13), 1421–1431. https://doi.org/10.1080/02640410903062019

Hugh Morton, R., & Hodgson, D. J. (1996). The relationship between power output and endurance: A brief review. *European Journal of Applied Physiology and Occupational Physiology*, *73*, 491–502. https://doi.org/10.1007/bf00357670

InternationalOlympicCommittee. (2023). Olympic Results. Tarihinde 09 Eylül 2023, adresinden erişildi https://olympics.com/en/olympic-games/olympic-results

Intervals.icu. (2023). Intervals.icu. Tarihinde 11 Eylül 2023, adresinden erişildi https://intervals.icu/

İşman, A. (2001). Teknolojinin felsefi temelleri. *Sakarya Üniversitesi Eğitim Fakültesi Dergisi*, *1*, 1–19.

Lanooy, C., & Bonjer, F. H. (1956). A Hyperbolic Ergometer. *Journal of Applied Physiology*, *9*, 499–500. Tarihinde adresinden erişildi http://citeseerx.ist.psu.edu/viewdoc/%0Adownload?doi=10.1.1.919.7808&rep=rep1&type=pdf.

Mcgrath, E., Mahony, N., Fleming, N., & Donne, B. (2019). Is the FTP Test a Reliable, Reproducible and Functional Assessment Tool in Highly-Trained Athletes? *International journal of exercise science*, *12*(4), 1334–1345. Tarihinde adresinden erişildi http://www.ncbi.nlm.nih.gov/pubmed/31839854%0Ahttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC6886609

Morpa. (1997). *Spor Ansiklopedisi* (5. baskı; M. Yakın, İ. Bodur, & A. Yalman, Ed.). Ankara: Morpa Kültür Yayınlar Ltd. Şti.

Passfield, L., Hopker, J. G., Jobson, S., Friel, D., & Zabala, M. (2016). Knowledge is power: Issues of measuring training and performance in cycling. *Journal of Sports Sciences*, *35*(14), 1426–1434. https://doi.org/10.1080/02640414.2016.1215504

Polar. (2023). Polar. Tarihinde 09 Eylül 2023, adresinden erişildi https://www.polar.com/tr/

PowerTap. (2023). PowerTap. Tarihinde 23 Ağustos 2023, adresinden erişildi https://pezcyclingnews.com/technspec/pez-tech-zipppowertapgarmin-satisfaction/

Schneeweiss, P., Haerlen, S., Ahrend, M.-D., Niess, A. M., & Krauss, I. (2018). Agreement between the Stages Cycling and PowerTap Powermeter. *Journal of Science and Cycling*, *7*(1), 3–8. https://doi.org/10.28985/180130.jsc.02

Shimano. (2023). Shimano. Tarihinde 07 Eylül 2023, adresinden erişildi https://bike.shimano.com/en-EU/home.html

Sram. (2023). Sram. Tarihinde 07 Eylül 2023, adresinden erişildi https://www.sram.com/en/sram

StagesCycling. (2023). StagesCycling. Tarihinde 25 Ağustos 2023, adresinden erişildi https://stagescycling.com/en_us/product/power-meters

Süme, M., & Özsoy, S. (2010). Osmanlı'dan Günümüze Türkiye'de Bisiklet Sporu. *Selçuk Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *24*, 345–360.

Tekin, Z., & Karakuş, K. (2018). Gelenekselden Akıllı Üretime Spor Endüstrisi 4.0. *İnsan ve Toplum Bilimleri Araştırmaları Dergisi*, *7*(3), 2103–2117. https://doi.org/10.15869/itobiad.428815

Theobald, U. (2023). Leistungsanforderungen und Trainingsmittel in der Radsportdisziplin Mountainbike Cross-Country.

TrainingPeaks. (2023). TrainingPeaks. Tarihinde 11 Eylül 2023, adresinden erişildi https://www.trainingpeaks.com/

UCI. (2023). Disciplines. Tarihinde 01 Mart 2023, adresinden erişildi https://www.uci.org/disciplines/all/2tLnZMo6WrUBplRXDxyEi7

Valenzuela, P. L., Morales, J. S., Foster, C., Lucia, A., & Villa, P. de la. (2018). Is the Functional Threshold Power (FTP) a Valid Surrogate of the Lactate Threshold? *International Journal of Sports Physiology and Performance*, *13*(10), 1293–1298. Tarihinde adresinden erişildi https://research.rug.nl/files/30892751/Den_Hartigh_et_al._Short_and_long_term_PM_JSEP_accepted_version_Pure.pdf

Vikipedi. (2021). Vikipedi. Tarihinde 09 Eylül 2023, adresinden erişildi https://tr.wikipedia.org/wiki/1896_Yaz_Olimpiyatları%27nda_bisiklet_-_Erkekler_yol_yarışı

Vikipedi. (2023). Cumhurbaşkanlığı Türkiye Bisiklet Turu. Tarihinde 14 Mart 2023, adresinden erişildi https://tr.wikipedia.org/wiki/Cumhurbaşkanlığı_Türkiye_Bisiklet_Turu

Vittoria. (2023). Vittoria. Tarihinde 01 Eylül 2023, adresinden erişildi https://www.vittoria.com/ww/en/tyres/road-tires/zaffiro

von Döbeln, W. (1954). A Simple Bicycle Ergometer . *Journal of Applied Physiology*, *7*(2), 222–224. https://doi.org/10.1152/jappl.1954.7.2.222

Wahoo. (2023). Wahoo. Tarihinde 02 Eylül 2023, adresinden erişildi https://eu.wahoofitness.com/

Wilson, D. G., & Schmidt, T. (2020). Bicycling Science. Içinde D. G. Wilson & T. Schmidt (Ed.), *Jurnal Penelitian Pendidikan Guru Sekolah Dasar* (4th baskı). MIT press.

Yeh, M. C., Chen, W. H., Lu, S. T., Chen, C. H., Liu, Y. C., & Liu, C. (2022). Validity of the Favero Assioma Duo Power Pedal System in Maximal-Effort Cycling Tests. *International Journal of Sports Physiology and Performance*, *17*(5), 800–805. https://doi.org/10.1123/ijspp.2021-0384