

**Mehmet OGUZ**

Southern University, Institute of Management Business and Law

Health Management / Ph.D. Program

Rostov-on-Don, Russia

E-Mail: [mehmetoguz1964@live.com](mailto:mehmetoguz1964@live.com)

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## **Wearable Technology and its Use in Healthcare**

### **Abstract**

This paper addresses wearable technologies which have started to be used increasingly in healthcare. Subjects involving smart wearable systems come across as one of today's most popular research subjects. Involving so many discipline within its scope refer researchers from many different areas to conducting studies on these subjects. Several technological products with different equipment and methods of use play important role in diagnosis and treatment of various disorders. Wearable technological devices are mentioned and quantified self-techniques are emphasized in the paper.

The main purpose of the study is to create awareness of use of wearable technology in healthcare and introduce these systems with different examples.

**Keywords:** Wearable Technology, Quantified Self, Health Informatics

### **1. Introduction**

The technological spectrum extending from desktop computers to tablet PCs and smart phones has started to become a part of every area in our lives along with the wearable technologies recently. Size of sensors has become smaller with wireless technologies and the sensor technology have been taken to a next level with the development of embedded communication systems, making it sure to collect data from different parts of body (Bostancı, 2015). These wearable technologies include several devices that could be worn as jewelry, glasses, and clothes embedded with sensors or other technologies or that could be carried along with the individual in any way (PWC Health Research Institute, 2014). The main objective of such devices is to observe patients' regular health, activity, psychological and mental values via sensors within and ensure the transfer of these data to the central system via communicational modules (Akbulut & Akan, 2015).

Having an important role in increasing the life quality, technology can modify medical practices and healthcare services. Hence, each technology to minimize any possible damage on human's life and/or increase individuals' life quality is accepted to be priceless (Park & Jayaraman, 2003).

Developed countries have gravitated towards treating patients wherever they are rather than in a hospital. Especially low number of personnel to provide care despite the increasing population of elderlies in

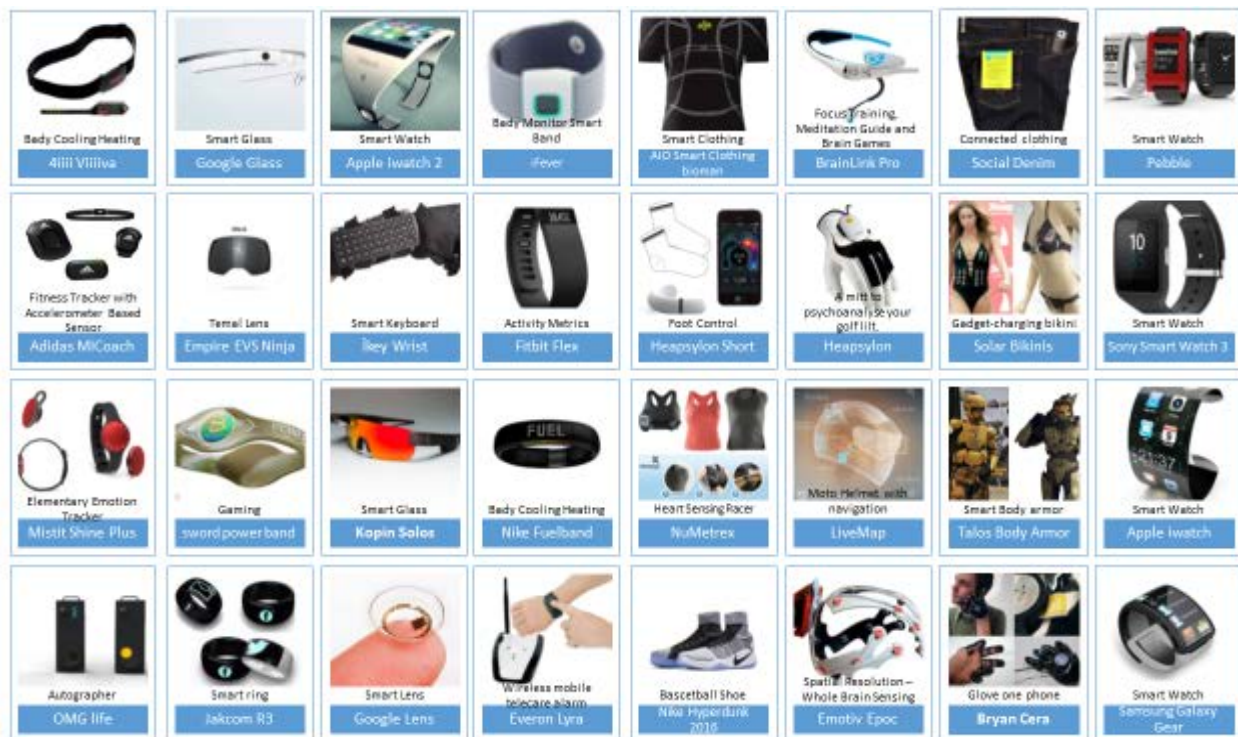
European countries has led to the requirement of doctors monitoring the statuses of patients out of the hospital for longer periods. This has also helped extending healthcare services outwards the hospital.

Addressing health status medically under main themes such as observation, diagnosis, treatment, wearable technology is used for collecting both clinical (heart rate, sugar level) and behavioral (walking, climbing up the stairs) data and follow these up with many different examples (Lewy, 2015). Luckowicz et al. listed wearable technology’s areas of application in health systems as monitoring, helping with daily life, mobile treatment, and administrative tool for healthcare personnel (Lukowicz, Kirstein, & Tröster, 2004). Patel et al. examined its uses as health monitoring, safety monitoring, home rehabilitation (exercise monitoring), control of treatment efficiency and identification of diseases (Patel, Park, Bonato, Chan, & Rodgers, 2012). Bonato associates the interest in the wearable technology in medicine with two main reasons: The first one is the long-term data monitoring, easy diagnosis and treatment and the second one is the idea that insufficiencies of devices in detecting scarce situations will be overcome (Bonato, 2010). Lymberis and Dimitmar da grouped these technologies and gave examples with the definitions of “wearable health systems” and “smart biomedical clothes” (Lymberis & Dittmar, 2007).

## 2. Wearable Technology

This new term is accepted to be the greatest technological innovation subsequent to smart phones. There is almost no limit to what can be done with this technological invention. Wearable technology is the general name given to the technological devices worn by individuals. Yet, there is a clear distinction here: For a product to be called “wearable technology”, it must also connect with smart devices and transfer data coming from smart sensors to those devices.

Figure 1. Some wearable technology products established in the market

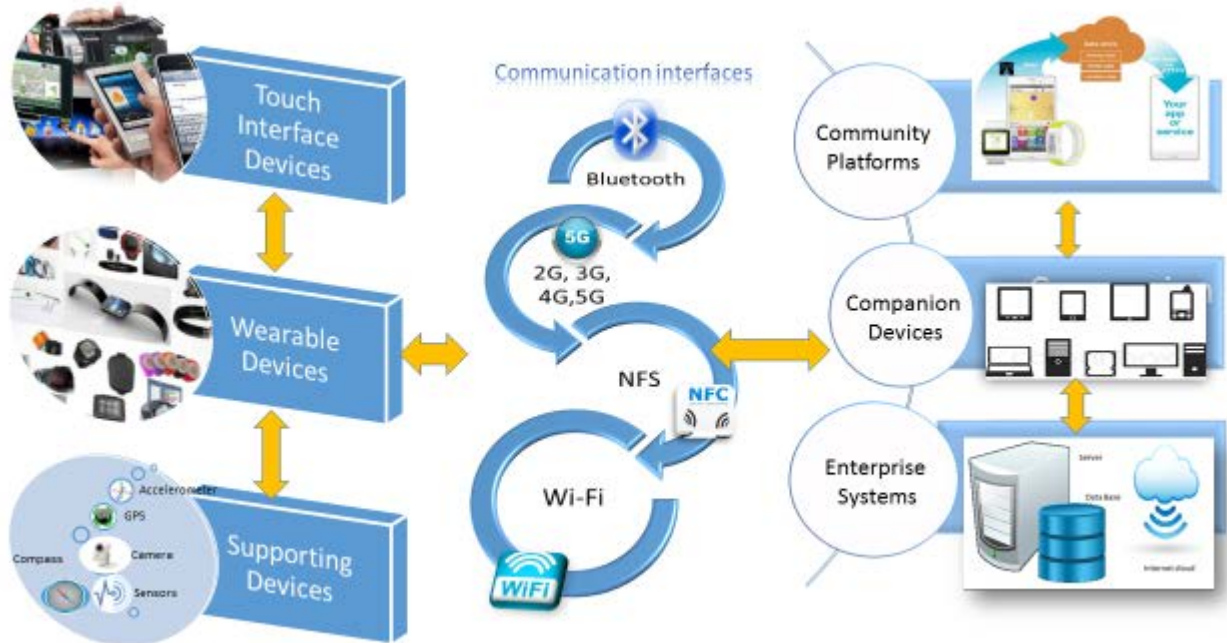


Source: Selected from open sources on the internet between 05-15.01.2017.

These devices have many capabilities in terms of providing and processing data. It is also important for them to be used easily, carried comfortably and be lightweight. They are also featured with their structure that analyze and select efficient data with accurate content. Connecting with other devices, systems, platforms, services and software packages presents a very wide area of work for the devices. The devices are supported with smart systems so they can be used with fast response time and less effort. Multitasking, minimum charging time and usability for longer periods make the devices privileged. Features of user-action recognition such as voice and activity come across as development-providing elements.

All these features like connectivity, comfort, communication, intelligence, multi-function, value, portability, and sensors are the main elements that users expect from wearable technologies.

Figure 2. Relationship between wearable technologies and systems



### 3. Quantified Self

Users can monitor themselves biologically, physically, behaviorally or environmentally by quantified self (Swan, 2013). Quantified self is a new trend which is deemed to enable individuals to measure data on their own health and monitor their health statuses spontaneously, therefore helping themselves preserve their health (Aydan & Aydan, 2016). Quantified self can keep record of healthy life elements such as individual's daily count of step, sleep time, diet, stress level and medical parameters such as blood sugar level, body weight, blood tension and heart function and blood oxygen level (Sözen, 2014). All these are possible due to wearable technology devices.

With weight, diet and exercise schedules of 60% of the USA citizens being monitored and measures of blood sugar, tension, headache and sleep patterns of 33% being recorded, quantified self has become a new trend nowadays. 27% of US internet users are monitoring their health data online and 9% of them are using

the warning messages. There are 40,000 health applications for smart phones available (Swan, 2013). Most researchers rely on these applications in the transfer of collected data and medical information. Leading the way for the open source software programs like itself, it can be said that smart phones facilitate developing solutions in the field and communication and sharing is also possible with devices such as Bluetooth and ZigBee (Bonato, 2010).

In an overall look, smart wearable technology comes across as encouragement of pattern and continuity in bodyweight control, physical and bodily activities and the basic and mutual objectives in the use of this technology in the medical sense.

Ouchi et al. developed a smart wearable health support system in 2002. This product keeps record of user's health status, movements and behaviors and this information is utilized for the user to guide his/her own daily care. The product offers the consumer recommendations such as "save your menu", "take your medicine" and additional suggests menus in regard to calorie levels and refer the user to exercise. This way, the system facilitates user's healthcare by using the data of quantified self.

Selection of sensors, which are the leading component of wearable technology devices, is a very critical decision for the device design. The sensors must be positioned on the most appropriate point of the body to achieve the parameter to be measured. Sensors are the elements providing control modules with inputs so system functions can be performed accurately and the processes can be in place.

All data collected individually are evaluated together and offer social benefit. This brings forward the concept of big data. Big data includes all data compiled from different sources such as network logs, social media publications, blog sites, call logs from GSM operators, statistical databases, pictures and videos.

#### 4. Use of Wearable Technology in Healthcare

Patient monitoring systems utilizing smart wearable devices are systems designed for monitoring the individual for 24 hours a day and warning them when necessary. The objectives of such systems may be monitoring individual's heart activities, measuring diabetic patients' glucose levels and warning against a possible danger, and these smart wearable systems play a key role in solving many problems today. Pictures obtained from open sources on the internet are used as elements to facilitate understanding the systems grouped by their main objectives below.

**Its use for elderlies:** The product can be tracked with RFID systems attached to the clothes due to the loss of sense of direction after a certain age. Besides performing all health measurements, it reminds you of drinking water or the time of medication. This device in the category of "granny trackers" provides great convenience especially for elderlies. SOS button informs healthcare personnel in emergencies. In more traditional solutions, a small switch is worn by elderlies around the neck. When this switch is on, a phone call is automatically made to the ambulance service. Thanks to this technology, the elderly can contact the ambulance service operating for 24 hours a day (Terkeş & Bektaş, 2016).



**Heart disease:** Chronic heart diseases are monitored with regular ECG measurements. There are ECG electrodes and a 3-axis accelerometer detects heartrate, respiration, temperature, step count and even the



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body position in case of falling. It is a wireless monitor that does not require sticky patches or gels. In addition, it possesses the features of activity tracking monitors and the data can be monitored via iOS and Android devices with Bluetooth.



**Asthma:** A warning alarm is sounded in case of an asthma attack and what to be done is shown practically, audibly and visually. There is an application for the device that can obtain real-time data from individuals so asthma can be monitored. Device and application warn you if an asthma attack is imminent and involve information on daily values, treatment plans, images, tracking and treatment of symptoms.

**Postural Disorders and Spinal Diseases:** These are the tracking systems for several physiological exercises to be monitored. They are designed for those who have problem with back health. They give users exercises with video game-like interactions and an interface.



Postural Disorders

**Smart Knee Brace:** This is an extremely functional wearable health and smart technology product. It is not only a knee support but also provides a function beyond what is expected from a knee support. It stores information with embedded sensors and its application ensures access to the information. The device is compatible with

Bluetooth and runs with an accompanying application. It can relieve pain by running for 40 hours without recharging the battery. Thanks to an electrode in the brace, it is activated by tightening the belt and pressing the button on it.

**Diabetes:** One of the main problems encountered by diabetic patients is when and on what dose they must take the insulin medication. Individual's tear is taken and the glucose level in it is

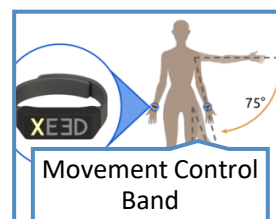


Glucose Level

examined with the developed lens technology. With other technologies, glucose information is read periodically by a sensor placed behind the upper arm. This system renders needing the fingers unnecessary in glucose tests. It has an application and access to smart phone through which doctors can read patient's data. This application also gives information on the food which patients must eat so diabetes can be controlled through exercise and appropriate diet.

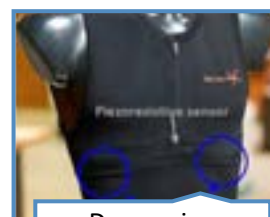


**Parkinson Disease:** Brains of Parkinson patients do not produce enough neurotransmitter dopamine and this hardens the control of their movement. The way to overcome this problem is to challenge your body to move more than ever. Even though it is worn on wrists and ankles, sensors and algorithms of the bands help elbows and shoulders and knees and hips move.



Movement Control Band

**Analyzing and monitoring mental disorders:** It classifies depression, manic-depression, and normal mood and help monitoring patients closely and manage their medications in accordance with the



Depression Monitoring

data collected. Customized Monitoring Systems are rapidly developed in mental healthcare. (Antonio, Gaetano, Mimma, Claudio, & Pasquale, 2012)

With wearable technology changing human's life through devices in the health sector, non-interventive brain simulation devices are being developed for the treatment of neurological and psychiatric disorders such as depression. The patient places one electrode each on his/her temples that sends signals to brain. The positive electrode increase immediate brain activities which are quite useful to overcome depressive symptoms. Research studies show that brain activity and metabolism is reduced or broken in depressive patients. It is possible to fix normal brain activities and mitigate symptoms of depression through the simulation of these areas. It is also increasingly argued that this technology will prove an alternative to depression drugs and therefore side effects of drugs will be removed.

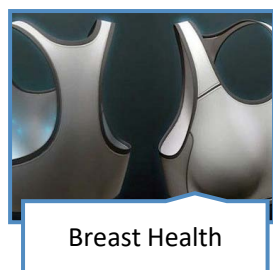


**Drug addiction and smoking:** Carreiro et al. conduct a pilot study to perceive illegal drug use and addiction. To this end, the group that used a wearable bio-sensor technology developed a device for wrists and received data on electrothermal activity, skin temperature and acceleration to test it on 4 emergency service patients. They associated the use of opioid and cocaine with the increasing electrothermal activity and changes in skin temperature. (Carreiro, 2014) This involves sensors which run with



movement algorithms that sense changes in the body and individual's desire for smoking and nicotine. Next, medication is given to reduce that desire. This device is accompanied by an application that coaches users and help them quit. Such devices are smart tools that enable addicts to quit smoking. They constitute sensors that sense bodily changes and person's desire for smoking and nicotine. To eliminate that desire, a program suggests a new approach for quitting smoking with customized medication and behavioral tools. It has also an application that informs user for ending the use of alcohol, drug and similar harmful habits.

**Cancer:** With Smart Bra, embedded sensors monitor the conditions in the breast tissue to warn against possible cancer. The application accompanying this bra keeps record of all data, coaches for breast health and care and provides information.



**Smart pills (cyber pills):** This Nano technological product can communicate with a wearable device after being swallowed and detect cancerous cells that may be available in the body. There are iron-oxide nanoparticles in the smart pill. These magnetic nanoparticles stick to cancerous cells and a wearable device which creates an area of magnetic attraction is worn around patient's wrist and attracts the "marked" cancerous cells to itself with iron-oxide particles. By this means, cancerous cells are gathered in one point and counted, which helps diagnosing a possible cancer disease in early stages.



**Prostheses:** Alternative studies offer individuals with prosthetic joints unique opportunities. New prosthetic designs remarkably open the way for individuals to be better than or different than normal.

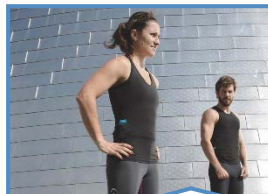
Therefore, some creative designers utilize smart systems to work on prostheses that wraps its limbs around an object to lift it up or handle it in a different approach like the Octopus.



Prosthetic Arm:

**Ulcer:** The three-axis accelerometer locates where the individual is and helps him/her turn around appropriately. It optimizes the tissue pressure when turning and moving and helps ulcer pains eliminated.

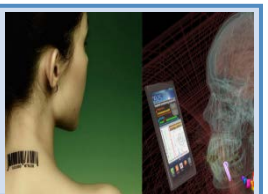
**Multi-functional uses:** When developing the wearable technology devices, multiple sensors that can measure and control are placed in those devices. This way, it is ensured that the devices are developed with several features. For instance, such a t-shirt can do the job and be washed in the washing machine to achieve continuity of use as well as measuring the cardiac rhythm and respiration and amount of sweating. These devices monitor your activities such as walking, running, and sleeping. Also being water-resistant, they can help calculate how



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much calorie has been burned.

**Implants:** These are the products that will come along the individuals whatever they do and wherever they go. They can be implanted into body in an operation due to health problems like insulin problems, birth control, blood tension problems. It is anticipated that such products will be improved further in 20 years.



Multi-Functional Measurement

## 5. Discussion

This study focused on the wearable technologies utilized by patients and addressed the use of the technologies. On the other hand, there are technological devices that can be worn by the healthcare personnel besides patients. This rapidly-developing topic can be included in other researchers' area of interest. Health informatics is being improved with wearable technologies, hospital and surgery room automation, decision support systems and artificial intelligence application as well as the concepts of big data and data mining. Each of these fields is a separate research object.

## 6. Conclusions

Wearable technology products are very successful in monitoring and evaluating individuals in the medical field. They can calculate cardiac rhythms, body fat rate, sweating, health, temperature, and muscular activities by touching our bodies via sensors or through our movements with communication systems and provide a report of them. The troubled part in this technology is the interpretation of the results. Programs using several algorithms are needed to understand what is going on when running, playing football or eating and interpret the results. As soon as such programs that know how to do it are integrated with these devices, the wearable technology should play a much greater role in our lives.

If wearable technologies remain as devices only used by patients, this cannot contribute to the treatment of patients by doctors. Hence, it is also necessary to ensure that doctors' own medical applications are integrated with the data produced by the devices.

In several centers where smart hospitals, wireless systems, big data analysis, and cloud technologies are studies, the most important outputs of this technology include decreasing costs, more advanced treatment methods and efficient results, effective disease management, decreasing number of human-factor errors, more interactive patient-doctor communication experience, improved drug production and management with big integration of big data and internet of things (IoT) with medicine.

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