Think Biosolution

Smart Apparel vs. Wristband Based Trackers: A Study

August 2018

1 Introduction

Buying a fitness tracking device is no ordinary decision. Depending on an individual's ideals and preferences, there is a wide array of devices available in the marketplace today. Whether it is to track your heart rate, number of calories burned, or your sleeping habits, these gadgets promise to collect massive amounts of data that would otherwise be left unmonitored. Tracking sensors can be conveniently embedded into many everyday items such as clothing, shoes, wristbands and even socks.

Technologically speaking, there are many leaps and boundaries yet to be surpassed in the nascent industry of wearables. Throughout the years, this field has been making massive strides and has taken over the lives of many people around the world. According to IDC, 125.5 million wearables have been shipped worldwide in 2017 (Swaney, 2017). The numbers are expected to be double at 240.1 million devices by 2021 (Swaney, 2017). While some pose the question of whether these devices are accurate enough to serve as more than an everyday tracking device, others see great possibility in turning these personal devices into digital medical tools. The earliest encounter of wearable technology can be dated all the way back to the 13thth century when the first pair of eye spectacles were invented to help with visual impairment (Glasseshistory.com, 2018). Today, eye glasses are so ubiquitous that they are not only used for impaired vision, but they also hold a significant place in the fashion world. In addition, many other devices have emerged over time, especially in the health and fitness market. The most notable of these devices are smart-watches, hearables, smart jewelry, smart glasses and smart clothing. In a forecast study conducted by Jupiter Research, it has been found that within the wearable market, there is a growing shift away from wristband based trackers and towards smart clothing. "Connected clothing" is ranked first in the fastest growing wearable sectors, while smartwatches and hearables are ranked the lowest (Larkin, 2018). This indicates that smart apparel has great potential in surpassing the wristband tracking industry.

The purpose of this article is to present cases of comparing wristband based trackers with smart apparel. The two main topics of discussion are accuracy of the monitoring device and the comfortability of the device usage.

2 Accuracy

Assessing the accuracy of the many wearable tracking devices currently available in the market is a complicated matter. The accuracy of each the wearable devices can vary significantly, with each user's body type. This is not necessarily because the sensors embedded in the wearable device is inaccurate, but due to the fact that each wearable device was built for a particular sub-set of user and use-cases.

The wearable device's location plays a significant role in determining the accuracy of the device. Depending on where the wearable device is worn on the body, the sensors will detect and generate a different multitude of signals. For example, sensors embedded in the wearable devices worn on the chest are more likely to pick

up respiratory rate, compared to the same sensors when embedded in a different set of wearable devices worn on the arm or the foot.

As the name suggests, wristband-based trackers are expected to track fitness parameters solely from the wrist. This is a huge limitation to wristband trackers, when compared to smart apparel based wearable devices that are able to cover a greater body surface area and hence more collect data. For example, when physicians perform an electrocardiogram (ECG) to measure the electrical activity of the heart on patients, 12 "leads" are placed on various parts of the body, most of them are located near the patient's chest area (Potter, 2018). Compared to the 12 "lead" ECG, smart apparels with a single "lead" ECG offers a more convenient solution for patients who wish to continuously monitor their heart condition. These single "lead" ECG sensors are often embedded in wearable chest straps or can be embedded in a "smart" t-shirt. These chest strap or "smart" t-shirt based trackers are placed in an optimal position to monitor the heart, and are more accurate compared to wristband based trackers.

In 2016, Fitbit™® was confronted with a class-action lawsuit alleging that its heart monitoring technology (known as PurePulse™) is inaccurate. A study conducted by California State Polytechnic University revealed that during moderate to high-intensity workouts, the Fitbit™® device deferred the heart-rate count on average by 19 beats per minute when compared to an ECG (Viola, 2016). This study, which was conducted among 43 test subjects, concluded that "Overall, the results of this investigation demonstrate that the PurePulse™ technology integrated in Fitbit™®'s heart rate monitoring devices is not a valid method for heart rate measurement, and cannot be used to provide a meaningful estimate of a user's heart rate (Viola, 2016)."

During the PurePulse™ lawsuit, Fitbit™ claimed that "PurePulse™ provides better overall heart rate tracking than cardio machines at the gym…But it's also important to note that Fitbit™® trackers are designed to provide meaningful data to our users to help them reach their health and fitness goals and are not intended to be scientific or medical devices (Bolton, 2016)." Unless stated otherwise by the product manufacturer, consumer-grade fitness monitors are not intended to be used for more than casual, lifestyle use. Diagnosed medical conditions should be officially monitored under the guidance and supervision of a medical authority.

Furthermore, in collaboration with the CNET reporter Sharon Profis, Kaiser Permanente cardiologist Dr. Jonathon Zaroff tested heart rate accuracy amongst five healthcare tracking devices in the market: Garmin VivoFit, Withings Pulse O2, Basis Carbon Steel, Samsung Gear Fit, Samsung Galaxy S5.

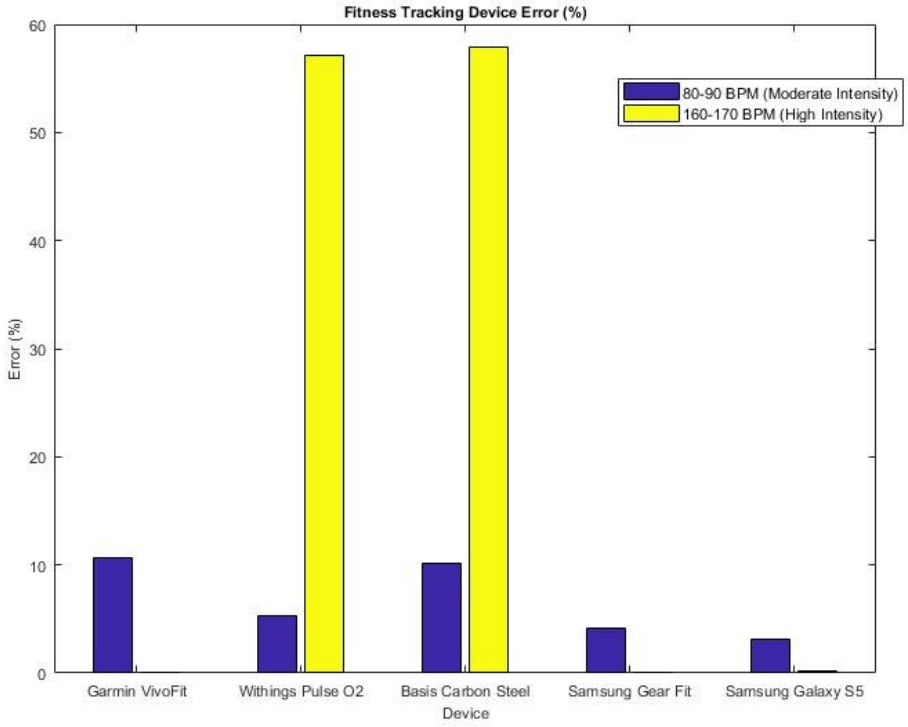


Figure 1: (Profis, 2014)

Of the five devices tested, Garmin VivoFit™ is the only device that employs a chest strap into its design. Samsung Galaxy S5 is a mobile phone device that has a built-in fingertip sensor for pulse readings. Withings Pulse O2, Basis Carbon Steel and Samsung Gear Fit use optical sensors to measure the pulse from the wrist. Both Withings Pulse O2 and Basis Carbon Steel are wristband-based tracking devices that have an error percentage that is five times higher during high-intensity activity. Samsung Gear Fit is the third wristband-based tracking device used in the study and during high-intensity activity, it was shown to be unable to read the pulse rates. In contrast, Garmin VivoFit and Samsung Galaxy S5 has shown 0% and 0.2% error during high-intensity activity, indicating little to none tracking errors. It is apparent that wristband-based trackers offer reasonably accurate readings during low-intensity periods but fail to measure just as accurately during high-intensity periods. This is because the wrist-band based devices utilize optical sensors which use LED light to measure the speed at which the blood flows through the capillaries (Profis, 2014). As stated by Mr. Bharat Vasan, co-founder of Basis, “the light has to penetrate through several layers… and so the higher the person is on the Fitzpatrick scale (a measure of skin tone), the more difficult it is for light to bounce back.” Apart from skin pigmentation, Samsung further suggests that, “To ensure the most accurate reading possible on our devices, we recommend sitting still during measurement or adjusting the device sensor so it is close to your veins” (Profis, 2014)

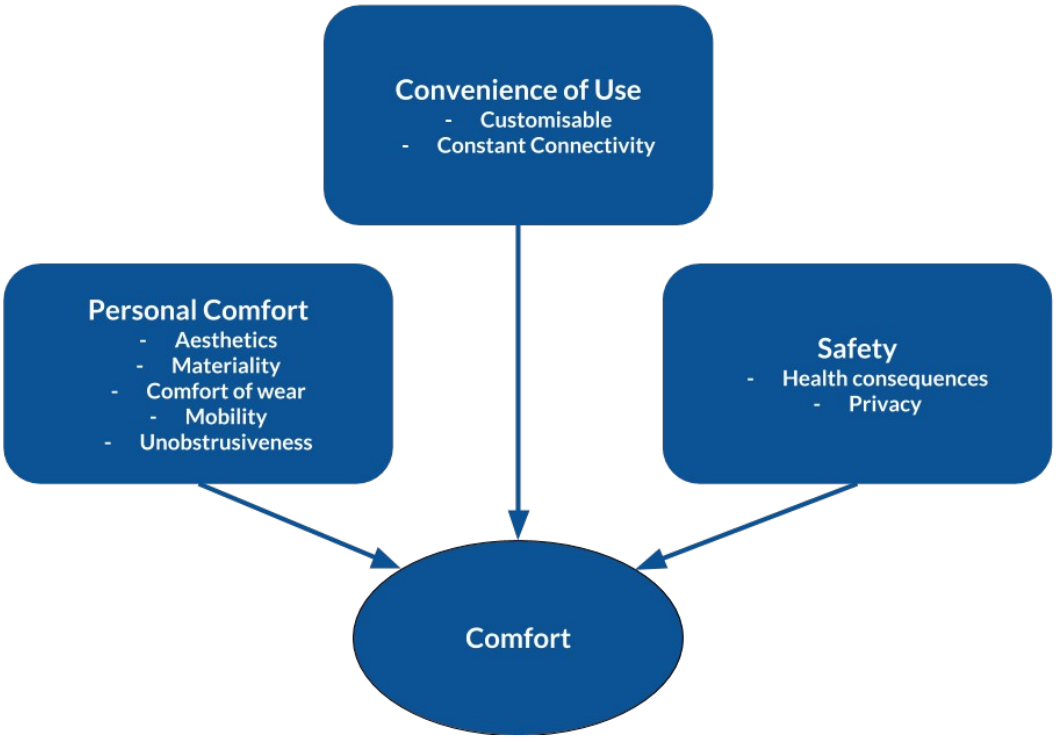
On the other hand, Garmin VivoFit™ utilizes a chest strap that detects the pulse via an electrical signal, rather than through optical signals. Therefore, the mechanism through which Garmin VivoFit™ functions electrically closely emulates that of an ECG, therefore offering a pulse rate reading with higher accuracy. The location of the chest strap right on top of one's heart offers a clear competitive advantage against wrist-band trackers, which "track somewhat-accurate heart rate during rest" but reap their competitive advantage from other features such as sleep tracking (Profis, 2014).

3 Comfort

Comfortability of the end-users is based upon three factors: personal comfort, convenience of use, and safety.

Personal Comfort

Personal comfort is a subjective factor that can have different meanings for each individual. Aesthetics, materiality, comfort of wear, mobility and unobtrusiveness are some of the many aspects that need to be taken into consideration during the design of the wearable device (Knecht, Bryan-Kinns and Shoop, 2016)



Manufacturers are continually faced with the challenge of balancing the design of their product to be equally "smart" and "wearable" (Heater, 2014). A sleek, thin design can be appealing, but when it comes at the

expense of the device's functionality consumers may find themselves disappointed. Similarly, a bulky device with a bunch of packed sensors may negatively intrude the user's personal space. The most successful wearable devices are those whose functionality is maximized without any distractions from the physical attributes of the device. "A well-made wearable is one you don't remember you're wearing most of the time. It ought to be inconspicuous enough so as to forget about its existence until you need to consult it" (Heater, 2014).

Ultimately, it all comes down to the user's personal preferences. Everybody has a different body and it is a challenge for manufacturers to design a product that is able to perform the same functionalities amongst all types of populations. Ethnicity, skin color, body fat percentage, etc. are all differentiating factors that unfortunately defer measurement values for each individual. As stated by Chris Harrison, an assistant professor of human-computer interaction at Carnegie Mellon University, "you can make millions of smart watches that are identical, but you have millions of people who are not identical. It's really hard to find something that's robust across all these people (Metz, 2015)."

Convenience of Use

The ease at which individuals are able to use wearable technology is paramount for retaining clients and end-users. The health and fitness industry have been undergoing periods of transition into a "quantified self" movement, in which ever-growing technology allows everyday users to personally track their health more efficiently (The Economist, 2015).

Wristband based fitness trackers are limited to tracking parameters solely from the wrist. For example, it may not appropriate for professional athletes to be using many of the devices marketed to a typical fitness enthusiast (Silbert, 2018) For higher levels of fitness activity and intensity, it is better to invest in a wearable device that offers more accuracy and additional functionality, including but not limited to, built-in sensors and GPS (Silbert, 2018).

Carrying along a noticeable monitoring device can not only be physically obtrusive for the user, but it also serves as a clear indicator of ageing in the elderly population. Incorporating fitness monitoring technology into everyday items lessens the stigma. The Samsung Gear S3 watch is a prime example. This smart-watch has an appearance of a premium watch but is unique in that it has the "added functionality of instant communication and health monitoring apps that can be configured to the exact needs of the wearer (Swaney, 2017). Constant connectivity further builds a layer of security just in case a healthcare provider or a dear family member needs to be contacted without the hassle of holding a smartphone. Last but not the least, a simple user interface elevates the user experience to be more intuitive and customizable so as the seniors are able to navigate around the technology based on their personal needs. The Gear S3 has a rotating bezel on the watch that immediately gives access to apps without the need to scroll down a screen (Swaney, 2017). For a population that is relatively less mobile and active such as seniors, may find wrist-band trackers more geared towards their personal needs than smart apparel in terms of addressing their physical and mental deterioration. In addition to degenerative symptoms, chronic conditions such as diabetes and heart disease are also quite

prevalent among the elderly population. Siren, a textile company based in San Francisco, launched diabetic socks. These specialized socks have built-in temperature sensors within the fabric, which allows the user to detect foot ulcers. Because inflammation causes body temperature to rise, Siren diabetic socks can detect this rise in temperature and then alert the user or a Siren representative (Muoio, 2018).

Safety

Wrist-band technologies have faced allegations in the past regarding their usage. In 2014, Fitbit™ was forced to recall their Fitbit™ Force device from the market after numerous cases of skin-related complications were reported. Skin rashes became prevalent among users and it was stated that the underlying cause was due to the methacrylate-containing adhesives and the nickel used in the making of the stainless-steel component of the Fitbit™ band. Fitbit™ states that, "Prolonged contact may contribute to skin irritation or allergies in some users. If you notice any signs of skin redness, swelling, itchiness, or other skin irritation, please discontinue use or wear the product clipped over a piece of clothing (Zhang, 2015)."

In reality, depending on the sensitivity of the user's skin, anything in contact with the skin is at risk of causing a reaction. Fitbit™ replaced the adhesives altogether with screws and reduced the amount of stainless steel in contact with skin. The number of skin itching and rashes reduced, but such cases still continue to be reported across other brands as well. Though some people may be allergic to some components of the device, other people may simply be conflicted by irritants that cause disturbance from prolonged use. Substances such as soap are common irritants that can easily become trapped under the fitness band. Such chemicals are harmless for momentary contact but after extended periods, the skin starts formulating an immune response which can manifest itself as discoloration, swelling and itching (Zhang, 2015). Users can also develop Miliaria, a condition that is caused by blocked sweat ducts. Ultimately, proper hygiene needs to be maintained when using wrist-based fitness trackers. Occasionally removing the band off either while taking a shower or periods of inactivity and letting your wrists breath are healthy habits that should be taken into consideration. Regularly washing the wristband with non-irritants and soap-free cleanser can further deteriorate unwanted conditions from developing.

Unlike wrist-band based trackers, smart clothing works very similar to regular clothing, only difference being the extra sensor attached to the clothing article. The sensor can be removed, and the apparel can be thrown into the washing machine. Smart apparel is naturally more breathable for the user's body and does not tightly stick to any particular part of the body, but rather covers up the body as a clothing item. Opting for smart apparel may be a safer option for people known to have sensitive skin types.

4 Conclusion

Both wrist-based trackers and smart apparel offer their advantages and disadvantages. While a t-shirt may be more accurate in tracking high-intensity workouts, a wrist-watch may be better at for casual or low intensity workouts and monitoring sleep activity. The designing of a wearable technology is an art of seamlessly

weaving technology and fashion together in order to encourage the modern society to take better care of themselves while leading healthier lifestyles.

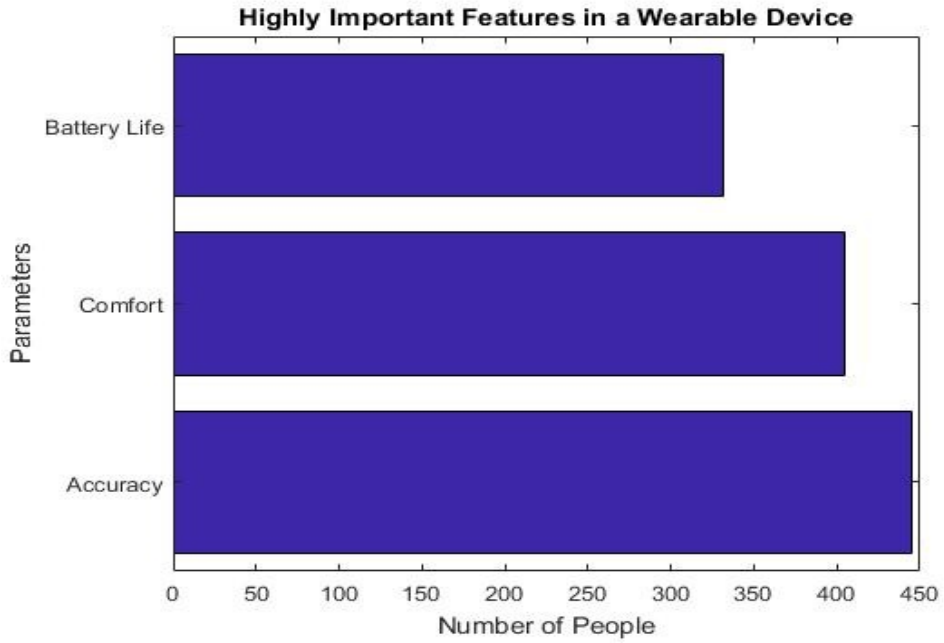


Figure 2: (Sawh, 2016)

The above figure shows results from a polled survey of 706 consumers conducted in the United States by the MEMS & Sensory Industry Group. It was shown that "63% believed accuracy as a highly important feature. That was followed by comfort (57%) and battery life (47%) (Sawh, 2016)". All in all, accuracy and comfort are two components of wearable devices that are highly sought after by manufacturers.

References

Bolton, D. (2016). *Fitbit faces a lawsuit over 'wildly inaccurate' heart rate tracking technology*. [online] The Independent. Available at: https://www.independent.co.uk/life-style/gadgets-and-tech/news/fitbit-class-action-lawsuit-heart-rate-inaccurate-blaze-a6801451.html [Accessed 29 Jun. 2018].

Glasseshistory.com. (2018). *Who Invented Eyeglasses? - Who was Glasses Inventor?*. [online] Available at: http://www.glasseshistory.com/glasses-inventor/who-invented-glasses/ [Accessed 29 Jun. 2018].

Haghi, M., Thurow, K. and Still, R. (2017). *Wearable Devices in Medical Internet of Things: Scientific Research and Commercially Available Devices*. [online] NCBI. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5334130/ [Accessed 29 Jun. 2018].

Heater, B. (2014). *WEARABLES As it turns out, making wearables wearable is harder than it seems*. [online] https://www.digitaltrends.com/wearables/turns-making-wearables-wearable-harder-seems/. Available at: https://www.digitaltrends.com/wearables/turns-making-wearables-wearable-harder-seems/)/ [Accessed 29 Jun. 2018].

Knecht, K., Bryan-Kinns, N. and Shoop, K. (2016). *Usability and Design of Personal Wearable and Portable Devices for Thermal Comfort*. [online] Qmro.qmul.ac.uk. Available at: https://qmro.qmul.ac.uk/xmlui/bitstream/handle/123456789/13753/Knecht%20Usability%20and%20Design%202016%20Accepted.pdf?sequence=1) [Accessed 29 Jun. 2018].

Larkin, M. (2018). *Smart Clothing To Transform Wearables As Tech, Fashion Eye Smart Clothes*. [online] Investor's Business Daily. Available at: https://www.investors.com/news/smart-clothing-technology-wearables-nike-google-smart-clothes/ [Accessed 29 Jun. 2018].

Marcus, M. (2016). *Many seniors are taking their medicines in risky ways*. [online] Cbsnews.com. Available at: https://www.cbsnews.com/news/many-elderly-are-taking-medicines-in-risky-ways/ [Accessed 29 Jun. 2018].

Metz, R. (2015). *For Wearables, Accurate Sensing Is Tricky*. [online] MIT Technology Review. Available at: https://www.technologyreview.com/s/538416/the-struggle-for-accurate-measurements-on-your-wrist/ [Accessed 29 Jun. 2018].

Muoio, D. (2018). *Siren launches smart sock for diabetes patients, announces $3.4M in funding*. [online] MobiHealthNews. Available at: https://www.mobihealthnews.com/content/siren-launches-smart-sock-diabetes-patients-announces-34m-funding [Accessed 29 Jun. 2018].

Potter, L. (2018). *Understanding an ECG | Geeky Medics*. [online] Geeky Medics. Available at: https://geekymedics.com/understanding-an-ecg/ [Accessed 29 Jun. 2018].

Profis, S. (2014). *Do wristband heart trackers actually work? A checkup.*. [online] CNET. Available at: https://www.cnet.com/news/how-accurate-are-wristband-heart-rate-monitors/ [Accessed 29 Jun. 2018].

Sawh, M. (2016). *Accuracy should be a priority for wearable tech according to survey*. [online] Wareable. Available at: https://www.wareable.com/wearable-tech/accuracy-still-the-most-important-wearable-tech-feature-says-survey-2893 [Accessed 13 Jul. 2018].

Silbert, S. (2018). *The Wearables Used by Pro Athletes*. [online] Lifewire. Available at: https://www.lifewire.com/wearables-for-serious-athletes-4068052 [Accessed 29 Jun. 2018].

Swaney, V. (2017). *How Wearable Technology Is Giving Seniors Their Independence Back*. [online] Samsung Business Insights. Available at: https://insights.samsung.com/2017/12/27/how-wearable-technology-is-giving-seniors-their-independence-back/ [Accessed 29 Jun. 2018].

The Economist. (2015). *The wear, why and how*. [online] Available at: https://www.economist.com/business/2015/03/12/the-wear-why-and-how [Accessed 29 Jun. 2018].

Viola, C. (2016). *Fitbit's FalsePulse | The Bottom Line*. [online] Thebottomline.as.ucsb.edu. Available at: https://thebottomline.as.ucsb.edu/2016/06/fitbits-falsepulse [Accessed 29 Jun. 2018].

Zhang, S. (2015). *Are We Doomed to Get Rashes from Our Fitness Trackers?*. [online] Gizmodo.com. Available at: https://gizmodo.com/are-we-doomed-to-get-rashes-from-our-fitness-trackers-1686681542 [Accessed 13 Jul. 2018].

