

**THE PHYSICAL AND PSYCHOLOGICAL IMPACTS OF WEARABLE
TECHNOLOGIES ON PERSONAL HEALTH**

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Bachelor of Science in Systems Engineering

By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Due to the onset of the coronavirus disease 2019 (COVID-19) pandemic, sports teams have been challenged to come up with easy-to-implement solutions to provide a safe training environment for their players and staff (Fowler, 2020, para. 4). In hopes of finding a solution for the UVA Men's Basketball Team, the technical project focused on investigating novel proximity detection techniques by researching and testing various sensor technologies and determining if these devices would be feasible to use for athletic activities. Specifically, the technical project has involved testing and comparing the accuracy and performance of Bluetooth, ultra-wideband (UWB) and ultrasound technologies. The STS scholarly article will examine the positive and negative effects that wearable fitness tracking technologies have on the physical and psychological health of users. The technical project and tightly coupled STS research analyzed both the current usages and potential capabilities of wearable technologies as well as their effects on the stakeholders in their network.

Because individuals and athletes need devices to monitor their physical activities and their health, sports teams need ways to track social distancing, and healthcare professionals need to monitor the health of their patients, the STS portion of this thesis addresses how fitness wearables could be used to improve overall health while also accounting for the negative impacts that these devices entail. Additionally, some potential consumers are not made aware of how impactful fitness trackers can be since they are either scared to use them, such as older adults, or they are not aware of how to use them correctly in regards to personalized fitness programs, which can trigger mental health issues. An analysis of the various ways in which different stakeholders view wearables and how each group manipulates the technology to act in a way that best benefits them will be shown using the Social Construction of Technology (SCOT; Bijker et al., 1987) framework. The STS research will aim to answer how the negative impacts of using

fitness trackers can be minimized, how the technology can become more accessible and attractive to all social groups, and how various social groups can be motivated to use fitness trackers correctly.

ASSESSING THE IMPACTS OF FITNESS WEARABLES

The evolution of wearable and user-friendly personal fitness tracking technologies has allowed such devices to become affordable tools for people to monitor their physical well-being. According to a study conducted in Australia, “activity trackers mainly motivated users to monitor activity patterns (35.9%, $n = 85$), improve fitness (27.4%, $n = 65$) and improve health (18.1%, $n = 43$)” (Maher et al., 2017, p. 4). Additionally, the vast majority of users appreciated the real-time monitoring capabilities of these devices as well as the increase in physical activity that resulted from them wearing the fitness trackers (Maher et al., 2017, p. 7). Along with the potential for improvements in physical activity that these devices provide, another motivating factor stems from peer encouragement, especially among older users. Although younger consumers are being discouraged to use fitness trackers since they feel like they will be judged for needing to refine their fitness, older consumers are not as concerned about social media stereotypes and are more likely to use a product if they hear positive feedback from peers who have tried it (Kim & Choudhury, 2020, p. 5).

Another benefit of using fitness wearables is that they provide a potential for more accurate monitoring by healthcare professionals (Brinson, 2020, p. 1356). Wang et al. (2020) points out that wearables can be used to assist individuals in weight loss programs and, eventually, help combat the obesity epidemic. As these technologies continue to evolve and as more sensors are added to wearables, the potential to use smart devices “to facilitate prevention,

early diagnosis, and management of chronic diseases outside of conventional healthcare settings” (Wang et al., 2019, p. 748) is promising. Pakhomov et al. (2020) presents an example of how fitness trackers could be used to help monitor health conditions of patients, stating that wearables could be used to monitor people’s mental and physical health by detecting their physiological reactions to stressful environments. Since “widely available and accessible consumer wearable fitness trackers such as Fitbit1 with HR [heart rate] sensor capabilities are able to capture changes in continuous heart rate in response to naturally occurring psychosocial stressors” (Pakhomov et al., 2020, p. 10), there is an opportunity for wearables to assist in the early detection or prevention of potential diseases or other health concerns that are induced by stress. However, potential issues involved with conducting studies that involve detecting stress levels of individuals include obtaining data that is not generalizable and that takes a long time to collect. In hopes of avoiding those concerns, Can et al. discusses a study that clustered baseline stress reports from several individuals into low, medium, and high stress classes and used data from smartwatches and smart bands to conduct “a stress detection system which uses heart activity, skin conductance, accelerometer and skin temperature for recognizing multiple stress levels” (Can et al., 2020, p. 38510). The strengths and weaknesses of a variety of smart devices used to obtain these measurements are outlined as well since none of the devices contain all four sensors that were needed.

The increasing technological developments and capabilities of sensor technology provides a promising outlook on the many ways in which wearable devices can improve people’s lifestyles. However, in order for older consumers to take advantage of these potentially life-saving technologies, technology developers need to recognize ways in which to make these devices more attractive to consumers of various ages (Kim & Choudhury, 2020, p. 5).

NEGATIVE PHYSICAL AND PSYCHOLOGICAL EFFECTS

An underlying complication related to this subject is the relationship between fitness trackers, exercise dependence, and eating disorders. The negative effects of the increasing pressure on individuals to look and eat a certain way can potentially be amplified by the use of fitness trackers as “results show that wearable use can cross a line in which the device goes from a motivational tool to meet a particular activity goal, to a deleterious device eliciting compensatory behaviors if the goal is not met” (Blackstone, 2020, p. 229). If users become obsessed with achieving unrealistic fitness standards that they see others accomplishing online, the use of these devices can cause individuals to develop eating disorders or to partake in other harmful behaviors. Although wearable technologies began as a way for users to keep track of their physical activities for personal health reasons, the rise of social media has encouraged increasing amounts of people to feel obligated to share their personal fitness data with others online. In a study conducted by Hardey (2019) on avid runners in the UK who heavily use fitness trackers and their associated apps, results showed that:

A major destabilising factor was the risk of appearing unhealthy. For some, the experience of ‘bad performance’ – and, thus, record of bad data – was ‘too stressful’ and it was ‘worthwhile risking injury’ so that apps and wearables would track an appropriate level of fitness activity (p. 997).

This study shows how vital it is for users to understand the consequences for publicly sharing their health data online and to realize the effects that it can have on body image perceptions.

A common problem with the advancement of new technological devices is that their promising capabilities sometimes prevent society from fully understanding the unanticipated consequences that the devices could cause. Specifically, in regard to fitness tracking devices, “Issues such as user acceptance, security, ethics and big data concerns in wearable technology

still need to be addressed to enhance the usability and functions of these devices for practical use” (Wu & Luo, 2019, “Abstract”). For these products to be successful, it is crucial that users feel that they are receiving accurate and helpful data and that their personal information is protected when that data is shared. When looking at how wearable devices are used by professional athletes, professional sports leagues, such as the NFL, have made sure the rights and data of their players is protected; however, “The youth and amateur level are where there is potential for abuse from a legal perspective . . . People are not fully informed as to what data is being gathered and how it’s being used” (Busca, 2021, para. 24). While a few states have been successful in passing legislation surrounding the collection and use of biometric data, Busca (2021) states that the U.S. has done little to attempt to implement federal regulations regarding the privacy of biometric data in comparison to the European Union. Although the European Union’s General Data Protection Regulation has made some headway, for example, by requiring training data of German professional cyclists to be given back when they leave the team, there is still a long way to go to ensure mass protection of data from a global standpoint (Busca, 2021, para. 17). It is crucial that athletes have the right to protect their own data because if they cannot, “teams or leagues that own the information will be free to do what they want with it, including using it against players in contract negotiations or selling it to third parties such as betting or marketing companies” (Busca, 2021, para. 18).

ETHICAL CONSIDERATIONS

The problems concerning data privacy and protection can be viewed through the lens of the rights ethics ethical theory, described in the third chapter of an *Introduction to Engineering*

Ethics. Engineering codes incorporate rights ethics by “holding paramount the safety, health, and welfare of the public, a requirement that can be interpreted as having respect for the public’s rights to life, rights not to be injured by dangerous products, rights to privacy” (Martin & Schinzinger, 2010, p. 50). Therefore, the human rights that athletes have to the privacy of their data cannot be disregarded and it is important that regulations are set in place so that companies and leagues do not exploit athletes for monetary gains (Busca, 2021, para. 18).

Additionally, it is crucial that these technology companies realize the immense health impacts these devices can have on people who are less likely to purchase them and that they implement alternative options to ease the adoption and learning processes (Kim & Choudhury, 2020, p. 7). A significant distinction between younger and older users of fitness trackers is the way in which they interact with novel wearables. Since the younger generation grew up with more current forms of technology, they are more apt to disregard reading directions and will use their intuition to learn how to use new devices. One of the definitions of engineering as described in the first chapter of an *Introduction to Engineering Ethics* as “a trial-and error process with backtracking based on decisions made after examining results obtained along the way” (Martin & Schinzinger, 2010, p. 7), can be applicable to the increasing need for the people involved in new technological developments to re-evaluate the perspectives of all potential users so that one group is not excluded for another.

Duty ethics, as described by Martin & Schinzinger, states that “right actions are those required by duties to respect the liberty or autonomy (self-determination) of individuals” (Martin & Schinzinger, 2010, p. 52) and it is important to note that the technology companies who manufacture wearables have the duty to provide equal opportunities for various user groups. The duties ethics test can also be applied to healthcare professionals who recommend that their

patients use wearables since they have the duty to make sure their patients understand how to correctly use the devices and are aware of the negative consequences involved.

STAKEHOLDER ANALYSIS AND POTENTIAL SOLUTIONS

The problems involving the acceptability and accessibility of wearable devices can be solved by ensuring that users of wearables are encouraged, supported, and taught how to use the devices correctly. While the recent advancements in sensor technology and real-time data collection have revolutionized the sports analytics and healthcare industries (Li et al., 2016), it is critical that healthcare professionals make users aware of the healthy fitness standards for their particular lifestyle as well as the proper way to use these devices if they are prescribed to monitor patterns of stress. Users will not be able to appreciate or realize the full benefits of using a fitness tracker if they are unclear on how the device can be adopted into their lifestyle and how it can be tailored to meet their specific health needs.

THE SOCIAL CONSTRUCTION OF TECHNOLOGY APPLIED TO WEARABLES

The goal of the Social Construction of Technology (SCOT, Bijker et al., 1987) approach is to identify the various ways in which different stakeholders view a certain artifact and to analyze how each group manipulates the technology to act in a way that best benefits them. The multidirectional view that the SCOT framework provides allows for a more in-depth analysis of the developmental processes of an artifact and helps to improve the understanding of what aspects of the technology do and do not work for the relevant social groups. Bijker et al. (1987) emphasize the importance of conducting a comprehensive stakeholder analysis by stating that “We need to have a detailed description of the relevant

social groups in order to define better the function of the artifact with respect to each group” (Bijker et al., 1987, p. 34).

RELEVANT SOCIAL GROUPS

The use of wearable sensors as a way to conduct more accurate measurements to improve physical fitness and to monitor for health concerns is a prime example of how cultural values shape the design and development of technology. Figure 1 below depicts wearables in the center interacting with the relevant social groups which include users, healthcare professionals, regulatory agencies, the technology companies who manufacture the devices, and the people or companies who attempt to steal personal information online.

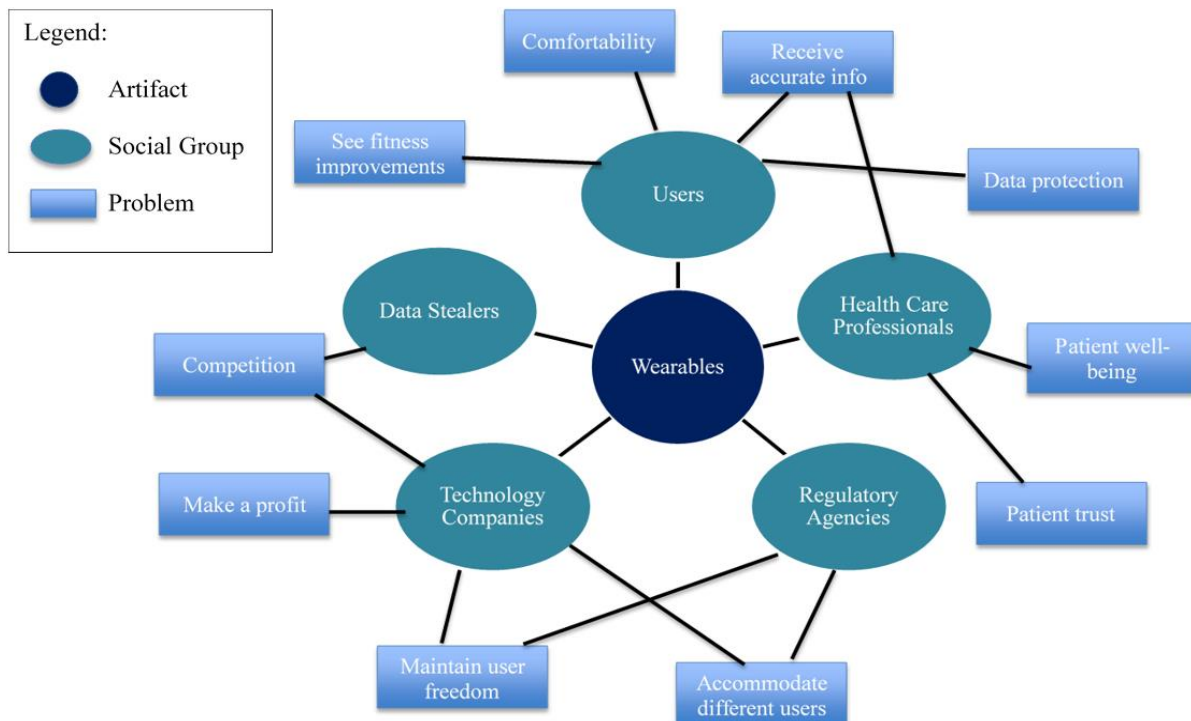


Figure 1: Relevant Social Groups and their Potential Problems with Wearable Devices. A depiction of the five social groups and the associated problems each group faces with the adoption of wearable technologies. (Adapted by Seanna Adam (2020) from Bijker et al., 1984).

The Users social group can be further broken down to include older users and younger users of the general public, who primarily use wearables to track their health and physical activity, as well as athletes and teams who primarily use data from these devices to optimize athletic performance (Kim & Choudhury, 2020). Additionally, Figure 1 on page 8 showcases the major problems that each social group faces with the adoption of wearable fitness trackers.

One of the primary needs for the Users group is they have to be able see personal fitness improvements in order to justify continuing to use the device. It is vital that users understand how to use wearables correctly and that they feel comfortable doing so (Hardey, 2019, p. 1002). Comfortability is also important in regards to users feeling like their personal data collected and stored on these devices is safe and protected. Similarly, healthcare professionals also need to receive accurate data from devices that they prescribe to their patients for health monitoring purposes. Two crucial aspects of a new technology that healthcare professionals require are that the technology prioritizes patient well-being and that it allows for a trusting relationship between the healthcare professional and their patient (Brinson, 2020, p. 1359). Regulatory agencies are mainly concerned about maintaining and protecting user freedom and their privacy rights as well as accommodating various users. It is crucial that regulatory agencies get more involved since the unregulated flow of biometric data can have several negative consequences for athletes and teams, especially, if the data falls into the hands of a competitor or a data stealing entity (Busca, 2021, para. 4). While the technology companies who produce wearable devices are also focused on making sure that they appeal to a variety of consumers and that they maintain user freedom, they are mainly concerned with earning profits and it is imperative that they abide by guidelines and accurately inform the public so they do not gain too much market power (Brinson, 2020, p.

1361).

Solutions for Healthcare Professionals Group

Narrowing in on the Healthcare Professionals social group, identifying potential solutions to the problems healthcare professionals face when adopting a new technology will help to understand how the technology can be updated to be more acceptable and successful. Figure 2 below displays some of these potential solutions. Making sure that healthcare professionals address mental health concerns in addition to physical health concerns and that they suggest limiting social media use when conferring with their patients about using a fitness wearable could help to reduce some of the negative consequences that can result from users having unrealistic expectations of fitness improvements.

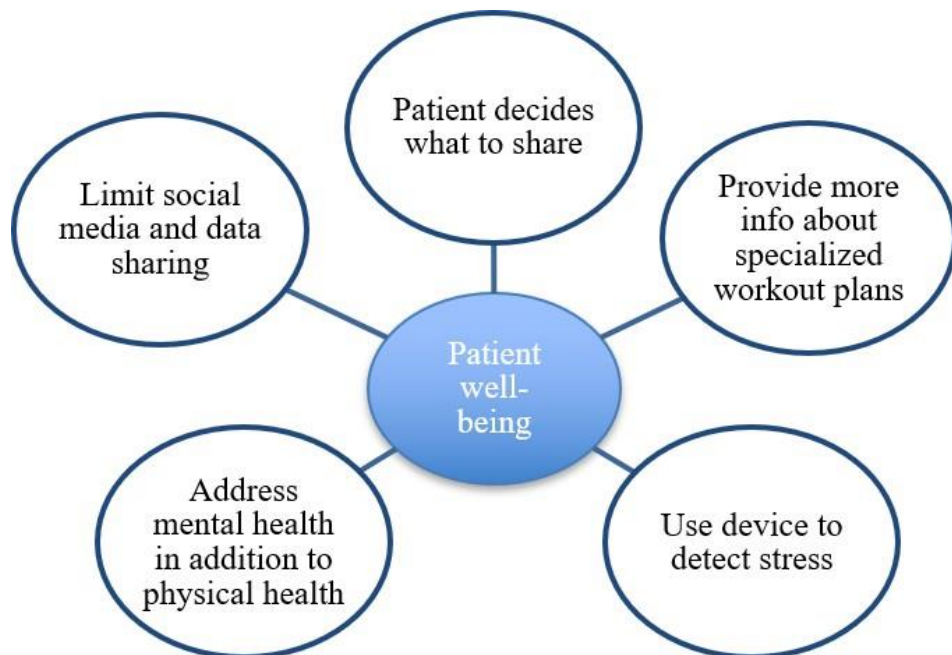


Figure 2: Solutions to the Problem of Patient Well-Being. A depiction of five potential solutions for healthcare professionals to ensure patient well-being when using wearables. (Adapted by Seanna Adam (2020) from Bijker et al., 1984).

Similarly, healthcare professionals have a duty to provide necessary resources and more information about specialized workout plans to ensure that patients use the device correctly and that they set realistic goals for themselves based on their health condition and abilities. Furthermore, Kim & Choudhury (2020) provide a solution to the issue of making fitness tracking technology more accessible to older adults by stating that “it is crucial to provide older adults with easy access to facilitating conditions to lessen their tension and concern about learning a new technology” (p. 7). Younger users most likely will not have an issue learning to use a new technological device; however, older users can be discouraged from attempting to learn how to use one if they believe they do not have access to the resources necessary to be successful (Kim & Choudhury, 2020, p. 7). If healthcare professionals were to work in tandem with technology companies to ensure that users receive adequate information and equal opportunities to use wearables, all three of the social groups listed would benefit by improving relationships, expanding a customer base, and enhancing physical health, respectively.

Allowing patients to decide what data they want to share will foster a better relationship between patients and healthcare professionals monitoring their data by providing patients with a heightened sense of privacy and security knowing that everything they do throughout the day does not have to be observed. Lastly, using fitness trackers to monitor patterns of stress in patients can help identify potential stressors in everyday life and can assist in catching potential health issues before it is too late (Pakhomov et al., 2020, p. 2).

RECOMMENDATIONS FOR FUTURE WORK

As technological solutions continue to evolve, the significant impact that wearable sensors have in the sports and healthcare industries continues to grow. Wearables have shown to be very beneficial as a means of tracking physical fitness, motivating users to be more active, and the potential for them to be used to assist in monitoring for health conditions such as COVID-19 is promising. However, as with the implementation of any new technology, there are still ethical concerns about fitness trackers. In order for these devices to be successful, they need to be able to pass the rights ethics test, which indicates users have the right to the privacy of their data, and the duty ethics tests, which indicates that the healthcare professionals recommending wearables to their patients have the duty to provide them with the resources necessary to use the devices successfully. The duty ethics test also showed that technology companies need to develop alternative options and resources to ensure that all social groups involved are able to easily learn how to use the devices.

When analyzing how each social group views wearable technology, the SCOT framework was used to focus on the needs of the Healthcare Professionals user group and provided potential solutions for improving the implementation of these devices. In order to further enhance user acceptance of wearable technologies, future work should be done to understand how to make new devices more user-friendly for different social groups and to see which data metrics are favorable. For example, future studies could look at consumer reviews of fitness trackers if healthcare professionals explain how to use the devices correctly, if certain wearables are preferred over others in terms of accuracy and usability, and if fitness trackers are successful at being used to detect heart disease, strokes, and anxiety attacks.

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