SYSTEMATIC REVIEW ON WEARABLE GADGETS IN HEALTHCARE MANAGEMENT

Abstract

This chapter reflects upon the impact that wearables have on modern medicine and fitness especially tracking variables of aerobic fitness.

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I. INTRODUCTION

Throughout human history, technology has experienced gradual evolution since the inception of civilization. Innovations in technology have emerged from the work of researchers, manufacturers, and practitioners. This progress has attracted considerable attention, particularly towards wearable technologies, coming from researchers, manufacturers, medical professionals, and patients. These wearable gadgets have the ability to sense and transmit information, falling within the realm of electronic devices. They are categorized as tools that gather data related to users' behaviors, primarily aimed at enhancing health management. These technologies are reshaping the healthcare landscape, encouraging a shift towards a more interconnected approach to well-being. The devices within this category are typically directly attached to a person, or they may be loosely connected, similar to a wrist-worn fitness tracker. Other forms of wearables include those that monitor specific actions, such as a heart rate monitor secured around the chest. Despite their existence for a long time, their widespread utilization has recently surged, a trend that began with the advent of smartphones. [2]

Wearables are closely associated with the concept of the internet, which is fundamentally transforming the future of healthcare. By enabling individuals to track various health-related metrics, these technologies are fostering a culture of proactive self-care. The scope of wearable technology is broad, spanning items like eyeglasses, clothing, wristwatches, wristbands, rings, badges, jewelry, shoes, and more. [3] Although these devices are designed for user convenience, ongoing efforts by various companies and institutions aim to enhance their comfort and reliability further. [4,5] To truly comprehend the intricacies of wearable technologies, a strong awareness is essential, allowing individuals to distinguish these devices from other technological counterparts and discern their unique attributes. Key among these characteristics is their hands-free nature, allowing users to seamlessly access data while carrying out their daily routines. The literature indicates several features that wearable technologies should exhibit, including effective communication through wireless systems like Bluetooth, the capability for data management and storage, energy management facilitated by batteries or charging mechanisms, interfaces that facilitate data transfer, and integrated circuits that process sensor data and transmit it wirelessly.

II. CHARACTERISTICS OF WEARABLE TECHNOLOGIES [6, 7]

The characteristics of wearable technologies must be;

1. Convey information in effective manner
2. Comfortable
3. Hand-free functioning
4. Multi-functional
5. Portable
6. Reliable
7. Stable
8. Socially accepted
9. Useful

III. FUNCTIONS OF WEARABLE TECHNOLOGIES [8, 9]

The main functions of the wearable technologies are;

- Communication
- Data management
- Energy management
- Interface
- Integrated circuits

1. **Communication:** Is the transfer of the data through radio frequencies, wireless systems like, bluetooth technology etc.

2. **Data management:** Is the process of storing the data.

3. **Energy management:** Is the most critical function for wearables to function with the help of batteries/charging etc.
4. **Interface**, is a helpline for transfer of data data the user and wearable.

5. **Integrated circuits:** Help in receiving signals from the sensors with processing units and wireless nodes on printed circuits of the device and provide the data.

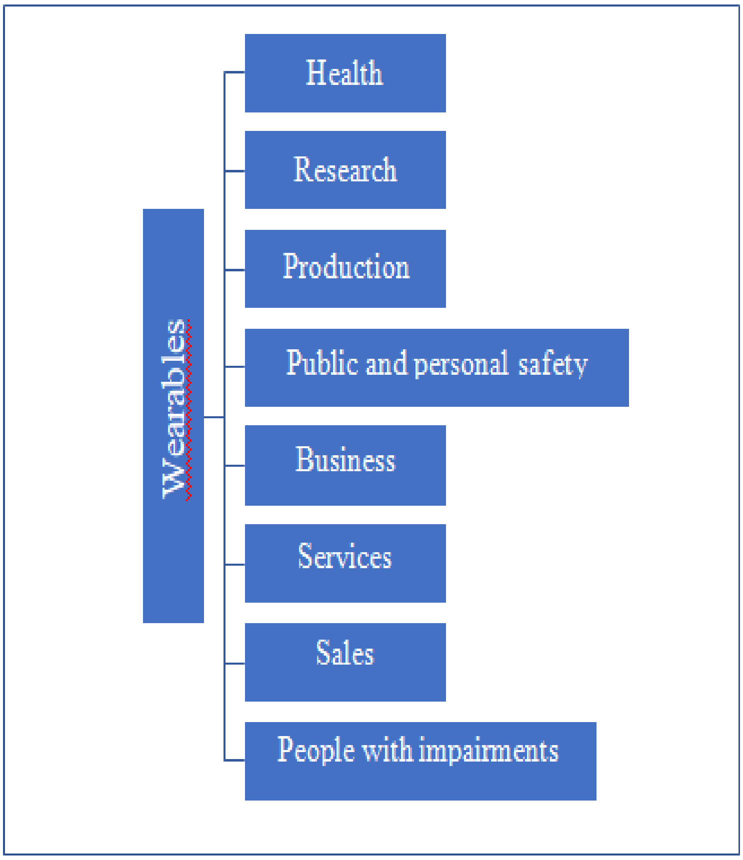

Figure 1: The applications of wearable technologies based on area of utilization

The advancements witnessed in wearable technologies, combined with the widespread acceptance among users and their easy accessibility, are paving the way for a new era of seamless physiological monitoring. These devices are versatile, designed to cater to various needs and purposes. The design and utilization of these devices are highly adaptable, based on specific use cases and requirements. Consequently, the attributes and features of these devices may differ significantly depending on their intended usage. Categorization of these devices is based on factors such as usage patterns, specific attributes, and distinctive features. The available literature offers insights into the diverse range of wearable technologies, each carrying the potential for numerous benefits and applications in the times to come.

IV. CHALLENGES FOR WEARABLES [10-13]

Nonetheless, wearable technologies are not without their challenges. Before these devices can be effectively used, there are assumptions that need to be addressed, particularly concerning their operational mechanisms, accuracy, reproducibility, efficiency in monitoring, and ease of maintenance. These concerns encompass aspects such as data quality, battery life, privacy, security, proprietary algorithms, and the means of annotating data streams. Notably, most wearable systems are primarily targeted towards the fitness market, with less emphasis on catering to the needs of the senior and rehabilitation segments. To overcome these challenges, there is a need to focus on validation, standardization, and interoperability, seeking to enhance the overall efficiency and effectiveness of wearable technologies.

Among the major challenges faced by wearable technologies is power consumption. Without a reliable power source, portable devices cannot function as intended. To mitigate this challenge, energy harvesting techniques are being employed, aiming to improve the functional capacity of wearable sensors while minimizing the drawbacks associated with battery size, weight, and cost. Measurement and validation also emerge as pivotal aspects, as obtaining accurate data from wearable devices is contingent upon these factors. Currently, efforts are underway to develop a common language for measuring and evaluating device performance, safety, and durability.

Privacy and Ethics: Privacy and ethical concerns play a pivotal role in the utilization of wearable technologies. The data collected from sensors—such as accelerometers, gyroscopes, pedometers, respiration sensors, heart rate monitors, and calorie trackers—holds immense potential for commercial use. However, these applications also raise questions about data ownership, ethical interpretations, security, and the extent to which non-health data is safeguarded, beyond health-related information.

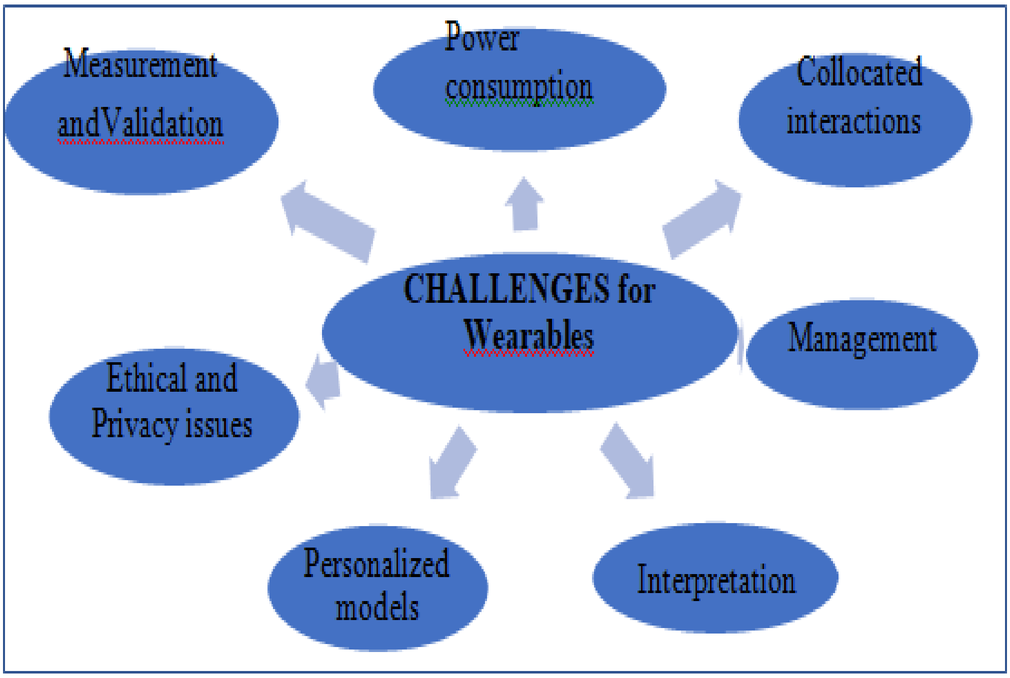

Figure 2: Challenges for Wearables

V. TYPES OF WEARABLE TECHNOLOGIES [14]

- Wearable health technologies
- Wearable consumer electronics
- Wearable textile technologies

1. **Wearable health technologies:** Wearable health technologies are health-related devices manufactured within the healthcare sector and utilized for medical purposes. The ongoing efforts involve designing and developing wearable systems to monitor patients' health, gathe real-world data, and track indicators such as heart rate, blood pressure, and fever. These devices function reliably and independently while patients continue with their daily routines. These wearables hold potential for diagnosing and treating various diseases. Research indicates their applicability in e-health, m-health, tele-healthcare, including the prevention of chronic diseases like diabetes and the treatment of neurodegenerative conditions such as Parkinson's. Notably, they prove beneficial in scenarios like monitoring cardiac health during arrest, cardiovascular diseases, rehabilitation, and stroke analysis.

2. **Portable Consumer Electronic Devices:** Portable consumer electronic devices refer to everyday electronics catering to communication, entertainment, and productivity, like smartphones, cameras, and music players. Notably, significant companies like Apple, Google, Microsoft, Nike, and Samsung are increasingly investing in wearable devices. This category includes items like wristwatches, bracelets, headbands, and rings, with glasses and smartwatches being particularly popular. Examples include Google Glass, equipped with a computer-controlled central processing unit, integrated display, camera, microphone, and wireless connectivity. Apple, Samsung, and Xiaomi watches count steps, monitor heart rate, and facilitate communication and notifications.

3. **Wearable Textile Technologies:** Wearable textile technologies are a recent trend in the textile industry, enabling wearable electro-textiles for functions such as body sensing, communication, and environmental control. This has transformed the industry through innovative properties like nano coatings and nanofibers. A significant application involves clothing that changes color based on the wearer's emotions. For instance, Philips created a dress named "Bubelle" that changes color according to the wearer's emotions, aiming to enhance social acceptance.

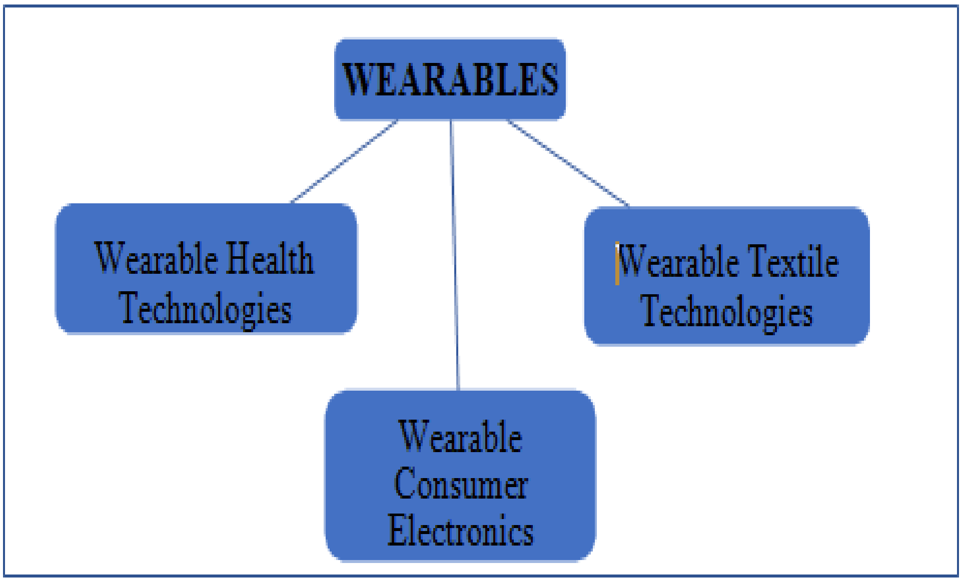

Figure 3: Types of wearables

VI. LIST OF FEW WEARABLE TECHNOLOGIES SINCE DECADES [15-20]

Year	Invention	Description
1268	Eyeglasses	Roger Bacon has made first the lenses for optical purpose. On the other-hand in China and Europe reading glasses were already used.
1665	Augmented senses	Robert Hooke has inserted artificial organs to the natural which improve our other senses of hearing, smelling, tasting, and touching."
1762	Pocket watch	John Harrison has invented first practical marine chronometer to determine longitude at the time of travel through ship
1907	First wrist watch	Alberto Santos-Dumont, who was working as pilot has given idea to famous jeweler Louis Cartier to create a time
1960	Head mounted stereophonic television display	piece so that he can keep his hands free for piloting. Heiling has presented the idea of virtual reality simulator with handle bars, binocular display, vibrating seats, stereophonic speakers, cold air blower, and a device
		chord keyboard wearable. The system was built from a modified HP 95LX palmtop computer and a Half- QWERTY one-handed keyboard. With the keyboard and display modules strapped to the operator's forearms, text could be entered by bringing the wrists together and typing.
2005	Fossil Wrist PDA	Wrist PDA which was running on palm OS was available in the market
2010	Sony Smart Watch	Sony has launched Android compatible wrist watch
2013	iWatch	Apple has launched iWatch – which is wearable computer can be wear on wrist and can work as full flagged mobile phone

VII. APPLICATIONS OF WEARABLE TECHNOLOGIES [21-23]

Wearable computers can be used in many applications in which they can be worn through user's skin, hands, voice, eyes, arms as well as motion or attention are actively engaged as the physical environment.
Various application areas are as follows:

- Augmented Reality
- Behavioural Modelling
- Health Care Monitoring Systems
- Service Management
- Smart phones
- Electronic Textiles
- Music Player through Eyeglasses
- Fashion Designing
- Military Services

VIII. LIMITATIONS OR DRAWBACKS OF WEARABLES [24, 25]

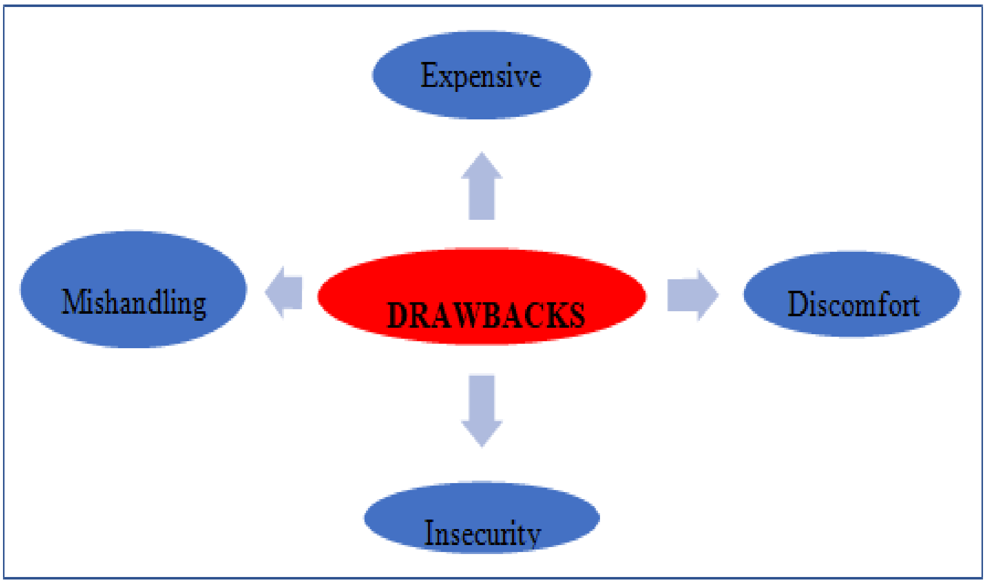

Figure 4: Drawbacks of wearable technologies

IX. CURRENT DEVELOPMENTS IN WEARABLE TECHNOLOGIES [26]

Current developments in wearable technologies emphasize rehabilitation, employing virtual reality systems, functional electrical simulations, and activity trackers. These aids are used in training programs for patients with neurological and musculoskeletal disorders. While most systems provide feedback on posture and limb movements, they are not designed for continuous usage. However, their potential increases when integrated with internet services

X. FUTURE WITH WEARABLE TECHNOLOGIES [27-30]

The future of wearable technologies is promising, with electronic companies increasingly focusing on their development. The potential flagship product is smart glass, which combines the features of traditional eyewear with a computer-controlled central processing unit, display, camera, microphone, and wireless connectivity. Though current prices are high, they are expected to decrease as the technology matures and gains social acceptance.

XI. CONCLUSION

To ensure the proliferation of wearables, user understanding must align with technological progress. Challenges like power consumption, durability, and usability are being addressed through ongoing clinical trials. Technological advancements in wearable devices offer vast rehabilitation opportunities. The review underscores how wearable technologies will significantly impact both users and manufacturers, making the future more convenient, safer, healthier, and faster.

REFERENCES

[1] Binkley. P. F, Predicting the potential of wearable technology, IEEE Engineering in
[2] Medicine and Biology Magazine, 2003; 2(6):23-27.
[3] Okwu. P.I and Onyeje I.N, Ubiquitous embedded systems revolution: Applications and emerging trends, International Journal of Engineering Research and Applications, 2013;
[4] 3(4): 610-616.
[5] Haghi, M, Thurow, K, Stoll, R. Wearable devices in medical internet of things: scientific research and commercially available devices. Healthc Inform Res 2017; 23: 4–15.
[6] Chen, KH, Chen, PC, Liu, KC Wearable sensor-based rehabilitation exercise assessment for knee osteoarthritis. Sensors 2015; 15: 4193–4211.
[7] Hartmann H, Trew T and Bosch J, The changing industry structure of software development for consumer electronics and its consequences for software architectures, Journal of systems and software, 2011; 85(11): 178-192.
[8] Liana DD, Raguse B, Gooding JJ, Chow E. Recent advances in paper-based sensors.
[9] Sensors (Basel) 2012;12(9):11505-11526.
[10] Kim D, Shin G, Kang YJ, Kim W, Ha JS. Fabrication of a stretchable solid-state micro- supercapacitor array. ACS Nano 2013 Sep 24;7(9):7975-7982.
[11] Yonezawa Y, Miyamoto Y, Maki H, Ogawa H, Ninomiya I, Sada K, et al. A new intelligent bed care system for hospital and home patients. Biomed Instrum Technol
[12] 2005;39(4):313-319.
[13] Chai Z, Zhang N, Sun P, Huang Y, Zhao C, Fan HJ, et al. Tailorable and wearable textile devices for solar energy harvesting and simultaneous storage. ACS Nano 2016 Oct
[14] 25;10(10):9201-9207.
[15] Mohammed EA, Far BH, Naugler C. Applications of the MapReduce programming framework to clinical big data analysis: current landscape and future trends. BioData Min 2014; 7:22
[16] Kumar G, Taneja A, Majumdar T, Jacobs ER, Whittle J, Nanchal R: The association of lacking insurance with outcomes of severe sepsis: retrospective analysis of an administrative database*. Crit Care Med. 2014, 42 (3): 583-591.
[17] Popat K A, Sharma P, Wearable computer applications- A future perspective, International Journal of Engineering and Innovative Technology, 2013; 3(1): 213-217.
[18] Thad Starner (n.d.) 'Wearable Computers as Intelligent Agents', Georgia Institute of
[19] Technology. Bradley Rhodes, 'A brief history of wearable computing', 2013; 16(a).
[20] Howard Rheingold (1991) Virtual reality, Rockefeller Center: Touchstone. [4] Review of the International Statistical Institute; 1969; 37:3.
[21] Wheel of Fortune gambling game in LIFE Magazine, 1964; 80-91.

[22] "Mobile Studies with a Tactile Imaging Device," C.C. Collins, L.A. Scadden, and A.B.
[23] Alden, Fourth Conference on Systems & Devices for The Disabled, 1977; 1-3.
[24] Gupta A, Stewart T, Bhulani N, et al. Feasibility of wearable physical activity monitors in patients with cancer. JCO Clin Cancer Inform. 2018;2:1-10.
[25] Mandrola J, Foy A, Naccarelli G. Screening for atrial fibrillation comes with many snags. JAMA Intern Med. 2018;178:1296-1298.
[26] Ananthanarayan S, Sheh M, Chien A, et al. Designing wearable interfaces for knee rehabilitation. In: Proceedings of the 8th international conference on pervasive computing technologies for healthcare, 2014, pp.101–108.
[27] Venkatesh, V, Morris, MG, Davis, GB User acceptance of information technology:
[28] toward a unified view. MIS Q 2003; 27: 425–478.
[29] Khalifa S, Hassan M and Seneviratne A. Step detection from power generation pattern in energy-harvesting wearable devices. In: 2015 IEEE international conference on data science and data intensive systems, Sydney, Australia, 11–13 December 2015, pp.604–
[30] 610.
[31] Banaee, H, Ahmed, MU, Loutfi, A. Data mining for wearable sensors in health monitoring systems: a review of recent trends and challenges. Sensors 2013; 13: 17472–
[32] 17500.
[33] Iqbal, MH, Aydin, A, Brunckhorst, O A review of wearable technology in medicine. J R Soc Med 2016; 109: 372–380.
[34] Lucero, A, Jones, M, Jokela, T Mobile collocated interactions: taking an offline break together. Interactions 2013; 20: 26–32.
[35] Cancela, J, Pastorino, M, Tzallas, AT Wearability assessment of a wearable system for Parkinson's disease remote monitoring based on a body area network of sensors. Sensors 2014; 14: 17235–17255.
[36] Shastry B.S. Parkinson disease: Etiology, pathogenesis and future of gene therapy. Neurosci. Res. 2001;41:5–12.
[37] 27. Knight J.F., Williams D.D., Arvanitis T.N., Chris B., Wichmann A., Wittkaemper M., Herbst I., Sotiriou S. Wearability assessment of a mobile augmented reality system. Proceedings of the 11th International Conference on Virtual Systems and MultiMedia (VSMM); Ghent, Flanders. 3–7 October 2005;pp.1–10.
[38] Tharion W.J., Buller M.J., Potter A.W., Karis A.J., Goetz V., Hoyt R.W. Acceptability and usability of an ambulatory health monitoring system for use by military
[39] personnel. IIE Trans. Occup. Ergon. Hum. Factors. 2013;1:203–214.
[40] L. Nummenmaa, E. Glerean, R. Hari, and J. K. Hietanen, "Bodily maps of
[41] emotions," Proceedings of the National Academy of Sciences, vol. 111, no. 2, pp. 646–651, 2014.
[42] K. Schindler, L. Van Gool, and B. de Gelder, "Recognizing emotions expressed by body pose: a biologically inspired neural model," Neural Networks, vol. 21, no. 9, pp. 1238–1246, 2008.

