Fuzzy Systems and Soft Computing
ISSN : 1819-4362

EVALUATING THE IMPACT OF WEARABLE DEVICES ON HEALTH AND FITNESS

SUPRIYA SAPA, MCA Department, IMSCDR (Pune University), Ahmednagar, Maharashtra
Dr. SHARVARI TAMANE, UDICT Department, MGM University, Ch. Sambhajinagar, Maharashtra
Dr. MADHURI GODBOLE, MCA Department, IMSCDR (Pune University), Ahmednagar, Maharashtra
Dr. SANGITA PHUNDE, MCA Department, MITCOM, MITADT University, Lonikalbhor, Pune, Maharashtra

Abstract

Wearable devices are smart accessories that can be worn externally, such as smart watches, wristbands, rings, and can also be embedded in clothing. These are electronic gadgets that utilize various technologies, including software, sensors, and network connections. Wearable devices like smart watches and wristbands have gained increased popularity during the pandemic period when people have become more health-conscious. In today's fast-paced life, it's not feasible for individuals to visit the doctor daily for health checkups. In such situations, wearable devices come into play, providing assistance in monitoring and tracking a person's health. In such scenarios, wearable devices are employed to assist individuals with health monitoring and tracking. These devices help track individuals' daily physical activities, including the number of steps taken, distance covered, calories burned, as well as monitor vital signs such as heart rate, blood pressure, and blood oxygen levels. These devices continuously monitor the above parameters, which is particularly valuable for patients and senior citizens dealing with chronic and cardiovascular diseases. This continuous monitoring is crucial for assessing their health. This research paper concludes that the prime objective to buy wearable device is Heath tracking. The features most preferred are Steps: Walk & Run, Calories burnt feature and Heart Beat Rate feature and the least preferred features are Multi sport like Swim, Cycle, Exercise, Sleep Tracking & Analysis and Blood oxygen level. The majority of respondents monitor their data and agree that it enhances their understanding of their health and fitness.

Keywords:
Wearable device, smart watch, health, track, monitor.

Introduction

Wearable devices are smart accessories that can be worn externally, such as smart watches, wristbands, rings, and can also be embedded in clothing. These are electronic gadgets that utilize various technologies, including software, sensors, and network connections. The adoption of wearable products, such as activity trackers and body monitors, provides real-time information on the user’s overall well-being. These wearable devices also provide information related to day-to-day events and physiological data, including sleep quality, heart rate, blood oxygen level, blood pressure, cholesterol level, and calories burned. The pandemic has heightened the importance of wearable technologies and devices. Fitness wristwatches can synchronize with mobile applications to deliver essential fitness information and statistics to users. The study highlights the potential of regularly used wearable devices and their functionalities. It assesses the influence of wearable devices on health and fitness, taking into account factors such as users' engagement in downloading and monitoring their health data and the extent to which it helps them address health issues and enhance their fitness. The study concludes that the primary objective of using wearable devices is health tracking and fitness.

Literature Review

Using Wearable and Machine Learning to Enable Personalized Lifestyle Recommendations to Improve Blood Pressure- PO-HAN CHIANG 1, (Member, IEEE), MELISSA WONG 2,3, AND SUJIT DEY1, (Fellow, IEEE) – July 2021. The proposed system consists of automated data collection using home BP monitors and wearable activity trackers and feature engineering techniques to address time-

series data and enhance interpretability. The system proposes Random Forest with Shapley-Value-based Feature Selection to offer personalized BP modelling and top lifestyle factor identification, and subsequent generation of precise recommendations based on the top factors. The results validate system's ability to provide accurate personalized BP models and identify the top features which can vary greatly between individuals. It validates the effectiveness of personalized recommendations in a randomized controlled experiment. After receiving recommendations, the subjects in the experimental group decreased their BPs by 3.8 and 2.3 for systolic and diastolic BP, compared to the decrease of 0.3 and 0.9 for the subjects without recommendations. The study demonstrates the potential of using wearables and machine learning to develop personalized models and precise lifestyle recommendations to improve BP.

Cognitive Training and Stress Detection in MCI Frail Older People through Wearable Sensors and Machine Learning - FRANCA DELMASTRO 1, FLAVIO DI MARTINO1, AND CRISTINA DOLCIOTTI2 – April 2020. This paper presents a pilot study involving a group of frail older adults suffering from Mild Cognitive Impairment (MCI) who actively participated in cognitive and motor rehabilitation sessions equipped with wearable physiological sensors and a mobile application for physiological monitoring. The collected data is analyzed to investigate the stress response of frail older subjects during the therapy, and how the cognitive training is positively affected by physical exercise. Then, it evaluated a stress detection system based on several machine learning algorithms in order to highlight their performances on the real dataset collected. The system proposed a mobile system architecture for online stress monitoring able to infer the stress level during a session. The obtained result is then used as input for a Decision Support System (DSS) in order to support the medical user in the definition of a personalized therapy for frail older adults.

Machine Learning for Healthcare Wearable Devices: The Big Picture Farida Sabry,1TamerEltaras , WadhaLabda ,1 KhawlaAlzoubi, and Qutaibah Malluhi 1 – April 2022. The wearable devices are used for remote patient monitoring and detection of any irregularities with the human body. In this review, they presented ML tasks that have been researched in the healthcare wearable devices field, the machine learning techniques used, the different modalities used, and the available datasets in the field. The different challenges facing machine learning applications on wearable devices (deployment alternatives, power consumption, storage and memory, utility and user acceptance, data availability and reliability, communication, security and privacy) were discussed while identifying possible solutions found in the literature. Finally, the study highlights issues that require further research concerning data availability, reliability, and privacy to enable effective and efficient learning from data generated by wearable devices.

Wearable Activity Trackers, Accuracy, Adoption, Acceptance and HealthImpact: A Systematic Literature Review - Shin, Grace, Mohammad HosseinJarrahi, Yu Fei, Amir Karami, NicciGafinowitz, AhjungByun, and Xiaopeng Lu - Journal of Biomedical Informatics (May 1, 2019). In this paper six key themes of Wearable Activity Trackers research are identified: (1) Technology Focus (2) Patient Treatment and Medical Settings(3) Behaviour Change(4) Acceptance and Adoption (Abandonment)(5) Self-monitoring Data Centred and (6) Privacy. The most important research gap identified is the attempt to understand the rich human-information interaction that is enabled by WAT adoption. This paper highlighted the evolution of above six research themes from 2013 to 2017. This paper summarizes evidence from 463 studies of wearable activity tracking (WAT) devices. The primary contribution of this paper is the accumulation of highly dispersed research on WAT and the secondary contribution is the analysis of a diverse set of disciplinary interests in WAT that has implications for personal health and fitness data management.

Wearable data analysis, visualization and recommendations on the go using android middleware – Marios C. Angelides1 •LissetteAndreaCabelloWilson1•PaolaLilianaBurneoEcheverría1, Department of Electronic and Computer Engineering, College of Engineering Design and Physical Sciences, Brunel University London, Uxbridge UB8 3PH, UK Springer Journal-2018. The paper highlights the use of wearable device, the analysis and visualization of the wearer activity data it records. The paper showed the range of issues with wearable’s and grouped these issues under four categories, namely ethical/legal, economic, social and technological. It concluded with the recommendations generated using a machine

learning technique to support the wearer with their monitoring of their daily goals and activities. The author did this in 9 steps and the steps are as follows:

- The wearer configures their wearable and sets initial goals.
- The wearable sensors track the wearer's daily activities and record data.
- The wearable synchronizes with a smart device to transfer the wearable data recorded.
- The raw data is forwarded by the smart phone to the wearable data server.
- From the server it is retrieved and analysed in comparison to community data to generate personal recommendations.
- The results of the analysis and the recommendations are forwarded to the smart device.
- Then they are visualized and offered to the wearer.
- This assist the wearer with monitoring their daily goals and activities.
- The smart phone synchronizes with the wearable to auto-update any revised goals

Objectives

Primary Objective

1. The study aims to assess awareness of wearable devices for health tracking
2. The study intends to examine the various features of wearable devices used for health tracking.
3. The study will investigate the tracking of data downloaded from wearable devices for health and fitness.
4. The study aims to investigate the trustworthiness, accuracy, and privacy of the downloaded data

Research Methodology

Research Design: The research design is Descriptive research design.

Data Collection

Primary data: A structured questionnaire was created using Google Forms and distributed to wearable device users via WhatsApp. Data were collected from 73 users in Ahmednagar, Pune, and Solapur using a convenience sampling method.

Secondary data: Website, Internet, Research Magazines, etc.

Research Instrument

The structured questionnaire was designed and it contains 36 close end questions with 1 open end questions. Questionnaire was containing separate questions on usage of health tracking features of wearable device, their impact on improving one's health, problem faced while downloading the data and trustfulness, accuracy and privacy of the data.

Statistical tools for analysis

The researcher employed the chi-square test for statistical analysis. Descriptive statistics, including frequency, relative frequency, mean, mode, proportions, percentages, bar graphs, and pie charts, were used as needed.

Limitations

- The paper does not include the SOS emergency service feature for detecting and calling for help in cases of danger or heart attacks.
- This paper does not cover health tracking through mobile apps

Data Analysis and Findings - Testing of hypothesis

Null Hypothesis (H_0): "There is no significant association between age and health tracking objectives."

Alternate Hypothesis (H_1): "There is a significant association between age and health tracking objectives."

TABLE I: TO FIND THE RELATION BETWEEN AGE AND HEALTH TRACKING OBJECTIVE

Age	**Is Heath-tracking prime objective**		
	yes	**no**	***Row Totals***

16-21	6 (9.14) [1.08]	8 (4.86) [2.03]	14
22-25	23 (22.19) [0.03]	11 (11.81) [0.05]	34
26-40	12 (11.10) [0.07]	5 (5.90) [0.14]	17
41-60	6 (4.57) [0.45]	1 (2.43) [0.84]	7
Column Totals	47	25	**72 (Grand Total)**

()-expected frequency and []-chi-square values

The chi-square statistic is 4.6905, and the p-value is 0.195915. Since the p-value is greater than the significance level of 0.05 ($p < 0.05$), the result is not significant. Therefore, we do not reject the null hypothesis, suggesting that age and health tracking objectives are independent.

Null Hypothesis (H0): "Sex and health tracking objective are independent."

Alternative Hypothesis (H1): "Sex and health tracking objective are dependent."

TABLE II: TO FIND THE RELATION BETWEEN SEX AND HEALTH TRACKING OBJECTIVE

Sex	**Is Heath-tracking prime objective**		
	yes	**no**	***Row Totals***
Female	23 (24.81) [0.13]	15 (13.19) [0.25]	38
Male	24 (22.19) [0.15]	10 (11.81) [0.28]	34
Column Totals	47	25	**72 (Grand Total)**

The chi-square statistic is 0.8015, and the p-value is 0.370637. Since the p-value is greater than the significance level of 0.05 ($p < 0.05$), the result is not significant. Therefore, we do not reject the null hypothesis, suggesting that sex and health tracking objectives are independent.

Null Hypothesis (H_0): "Educational status and health tracking objectives are independent."

Alternative Hypothesis (H_1): "Educational status and health tracking objectives are not independent."

TABLE III: TO FIND THE RELATION BETWEEN EDUCATIONAL STATUS AND HEALTH TRACKING OBJECTIVE

Education	**Is Heath-tracking prime objective**		
	yes	**no**	***Row Totals***
Graduate	14 (13.71) [0.01]	7 (7.29) [0.01]	21
PG	33 (33.29) [0.00]	18 (17.71) [0.00]	51
Column Totals	47	25	**72 (Grand Total)**

()-expected frequency and []-chi-square values

The chi-square statistic is 0.0252, and the p-value is 0.873791. Since the p-value is greater than the significance level of 0.05 ($p < 0.05$), the result is not significant. Therefore, we do not reject the null hypothesis, suggesting that educational status and health tracking objectives are independent

Null Hypothesis (H_0): "Sex and the usefulness of the device for health tracking are independent."

Alternative Hypothesis (H_1): "Sex and the usefulness of the device for health tracking are not independent."

TABLE IV: TO FIND THE RELATION BETWEEN SEX AND USEFULNESS OF THE DEVICE FOR HEALTH TRACKING

Sex	**Usefulness of the device for health tracking**					
	not useful	**somewhat**	**can't say**	**useful**	**Very useful**	***Row Totals***

Female	2 (2.11) [0.01]	11 (12.67) [0.22]	3 (2.11) [0.37]	17 (14.78) [0.33]	5 (6.33) [0.28]	38
Male	2 (1.89) [0.01]	13 (11.33) [0.25]	1 (1.89) [0.42]	11 (13.22) [0.37]	7 (5.67) [0.31]	34
Column Total	4	24	4	28	12	**72 (Grand Total)**

()-expected frequency and []-chi-square values

The chi-square statistic is 2.5714, and the p-value is 0.631893. Since the p-value is greater than the significance level of 0.05 ($p < 0.05$), the result is not significant. Therefore, we do not reject the null hypothesis, suggesting that sex and the perceived usefulness of the device for health tracking are independent.

Null Hypothesis (H_0): Age and the usefulness of the device for health tracking are independent.

Alternative Hypothesis (H_1): Age and the usefulness of the device for health tracking are dependent.

TABLE V: TO FIND THE RELATION BETWEEN AGE AND USEFULNESS OF THE DEVICE FOR HEALTH TRACKING

Age	**Usefulness of the device for health tracking**					
	Not useful	**somewhat**	**can't say**	**useful**	**Very useful**	***Row Totals***
22-25	3 (2.67) [0.04]	11 (9.33) [0.30]	2 (2.00) [0.00]	12 (14.00) [0.29]	6 (6.00) [0.00]	34
26-40	1 (1.33) [0.08]	3 (4.67) [0.60]	1 (1.00) [0.00]	9 (7.00) [0.57]	3 (3.00) [0.00]	17
Column Total	4	14	3	21	9	**51 (Grand Total)**

()-expected frequency and []-chi-square values

The chi-square statistic is 1.875, and the p-value is 0.758736. Since the p-value is greater than the significance level of 0.05 ($p < 0.05$), the result is not significant. Therefore, we do not reject the null hypothesis, suggesting that age and the perceived usefulness of the device for health tracking are independent.

Null Hypothesis (H0): Educational status and the usefulness of the device for health tracking are independent.

Alternative Hypothesis (H1): Educational status and the usefulness of the device for health tracking are not independent.

TABLE VI: TO FIND THE RELATION BETWEEN EDUCATIONAL STATUS AND USEFULNESS OF THE DEVICE FOR HEALTH TRACKING

Education	**Usefulness of the device for health tracking**					
	not useful	**somewhat**	**can't say**	**useful**	**Very useful**	***Row Totals***
Grad	1 (1.51) [0.17]	7 (7.23) [0.01]	1 (1.21) [0.04]	9 (8.44) [0.04]	4 (3.62) [0.04]	22
PG	4 (3.49) [0.07]	17 (16.77) [0.00]	3 (2.79) [0.02]	19 (19.56) [0.02]	8 (8.38) [0.02]	51
Column Totals	5	24	4	28	12	**73 (Grand Total)**

()-expected frequency and []-chi-square values

The chi-square statistic is 0.4166, and the p-value is 0.981093. Since the p-value is greater than the significance level of 0.05 ($p < 0.05$), the result is not significant. Therefore, we do not reject the

null hypothesis, suggesting that educational status and the perceived usefulness of the device for health tracking are independent.

Null Hypothesis (H0): Being IT friendly and facing obstacles in downloading data are independent.

Alternative Hypothesis (H1): Being IT friendly and facing obstacles in downloading data are not independent.

TABLE VII: TO FIND THE RELATION BETWEEN BEING IT FRIENDLY AND FACING OBSTACLES IN DOWNLOADING DATA

IT friendly	**Facing obstacles in downloading data**		
	yes	**No**	***Row Totals***
yes	21 (23.26) [0.22]	46 (43.74) [0.12]	67
no	4 (1.74) [2.95]	1 (3.26) [1.57]	5
Column Totals	25	47	**72 (Grand Total)**

()-expected frequency and []-chi-square values

The chi-square statistic is 4.8599, and the p-value is 0.027488. Since the p-value is less than the significance level of 0.05 ($p < 0.05$), the result is significant. Therefore, we reject the null hypothesis, indicating that being IT friendly and facing obstacles in downloading data are dependent.

Null Hypothesis (H0): "Educational status and the usefulness of the device to improve health are independent."

Alternative Hypothesis (H1): "Educational status and the usefulness of the device to improve health are not independent."

TABLE VIII: TO FIND THE RELATION BETWEEN EDUCATIONAL STATUS AND THE USEFULNESS OF THE DEVICE TO IMPROVE HEALTH

Education	**Usefulness of the device to improve health**			
	agree	**can't say**	**disagree**	***Row Totals***
Grad	11 (8.49) [0.74]	3 (3.96) [0.23]	1 (2.55) [0.94]	15
PG	19 (21.51) [0.29]	11 (10.04) [0.09]	8 (6.45) [0.37]	38
Column Totals	30	14	9	**53 (Grand Total)**

()-expected frequency and []-chi-square values

The chi-square statistic is 2.6711, and the p-value is 0.263013. Since the p-value is greater than the significance level of 0.05 ($p < 0.05$), the result is not significant. Therefore, we do not reject the null hypothesis, suggesting that educational status and the perceived usefulness of the device to improve health are independent.

Findings

The major objective for all age groups, sexes, and educational statuses is health tracking.

1. All age groups, sex and educational status feel that device is useful for health tracking.
2. Respondents who are not IT friendly face more obstacles while downloading the data.
3. Respondents of all educational statuses, sexes, and ages feel that the device is useful for improving health.
4. Preferred features of wearable devices include Steps (Walk & Run), Calories Burnt, and Heartbeat Rate. Least preferred features are Multi-sport (Swim, Cycle, and Exercise), Sleep Tracking & Analysis, and Blood Oxygen Level.
5. Majority of the respondents monitor their data and agree that it helps them to understand health fitness.
6. Majority of the respondents do not download their data because they are not aware of downloading the data.

7. -Majority of the respondents who download their data do not track the data for checking their health fitness.
8. 50% of the respondents say that tracking the data helps them to improve their health fitness, trust the recorded data and feel that the recorded data is secure and private.
9. Majority of the respondents feel that the recorded data is accurate.
10. 50% of the respondents are satisfied with the work fineness of the device.

Recommendation

Based on the findings, here are some potential recommendations:

- **Education and Awareness**: To address the lack of awareness about downloading data, it is recommended to provide educational resources and support for users, especially those who are not IT-friendly. This can help users make the most of their wearable devices.
- **User-Friendly Interfaces**: Design wearable device interfaces that are user-friendly and intuitive, making it easier for all users, including those who may not be tech-savvy, to download and use their data effectively.
- **Emphasize Valuable Features**: Since Steps: Walk & Run, Calories burnt, and Heart Beat Rate are the most preferred features, wearable device manufacturers and developers should continue to focus on improving and enhancing these aspects.
- **Enhance Privacy and Security**: Given that users trust the recorded data and value its security and privacy, it is crucial for manufacturers to prioritize data security and privacy in the design and functionality of their devices and accompanying apps.
- **Encourage Data Monitoring**: To maximize the health benefits of wearable devices, users should be encouraged and educated on the importance of actively monitoring their data for health and fitness improvements.
- **Customizable Features**: Consider allowing users to customize their devices to enable or disable certain features, tailoring the device to their specific needs and preferences.
- **Feedback and Support**: Establish a feedback mechanism for users to provide insights and request assistance, which can help improve the overall user experience. These recommendations aim to enhance the usability, effectiveness, and satisfaction of users with wearable devices for health tracking.

Conclusion

All respondents feel that wearable device is useful for health tracking and it is useful to improve health. Majority of the features used are Steps: Walk &Run, Calories burnt and Heart Beat Rate and the least preferred features are Multi sport like Swim, Cycle, Exercise, Sleep Tracking & Analysis and Blood oxygen level. Majority of the respondents monitor their data. 50% of the respondents say that tracking the data helps them to improve their health fitness and they trust the recorded data and feel the data is secure and private. Respondents who are not IT friendly face more obstacles while downloading the data. Majority of the respondents do not download their data because they are not aware of downloading the data. The respondents who download their data, majority of them do not track the data for checking their health fitness.

Acknowledgment

We would like to express our gratitude to the respondents who use wearable devices that made this research possible. We also want to thank our guide Dr.Sharvari Tamane for her valuable insights and collaborative efforts throughout this project. Finally, we are deeply thankful for the unwavering support of our families and friends.

References

1. Chiang, Po-Han, Melissa Wong, and SujitDey. “Using Wearables and Machine Learning to Enable Personalized Lifestyle Recommendations to Improve Blood Pressure.”*IEEE Journal of Translational Engineering in Health and Medicine* 9 (2021): 1–13.

2. Delmastro, Franca, Flavio Di Martino, and Cristina Dolciotti. “Cognitive Training and Stress Detection in MCI Frail Older People Through Wearable Sensors and Machine Learning.” *IEEE Access* 8 (2020): 65573–90.
3. Sabry, Farida, Tamer Eltaras, WadhaLabda, KhawlaAlzoubi, and QutaibahMalluhi. “Machine Learning for Healthcare Wearable Devices: The Big Picture.” *Journal of Healthcare Engineering* 2022 (April 18, 2022): e4653923.
4. A Survey of Wearable Devices and Challenges- SurangaSeneviratneThe University of Sydney, Tham Nguyen- University of Technology Sydney GuohaoLan- Delft University of Technology,Article in IEEE Communications Surveys and Tutorials -July 2017
5. Shin, Grace, Mohammad HosseinJarrahi, Yu Fei, Amir Karami, NicciGafinowitz, AhjungByun, and Xiaopeng Lu. “Wearable Activity Trackers, Accuracy, Adoption, Acceptance and Health Impact: A Systematic Literature Review.” *Journal of Biomedical Informatics* 93 (May 1, 2019): 103153.
6. Wearable data analysis, visualization and recommendations on the go using android middleware - MariosC.Angelides1•LissetteAndreaCabelloWilson1•PaolaLilianaBurneoEcheverría1, Department of Electronic and Computer Engineering, College of Engineering Design and Physical Sciences, Brunel University London, Uxbridge UB8 3PH, UK - Springer Journal-2018
7. Survey on: Applications of Smart Wearable Technology in Health InsuranceApeksha Shah1, Dr. Swati Ahirrao2, Dr. Shraddha Phansalkar2, Dr. Ketan Kotecha3Symbiosis Institute of Technology, Symbiosis International (Deemed University)-Pune-2021IOP Conference Series: Materials Science and Engineering