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WEARABLE SENSORS IN HEALTHCARE: RELIABLE ENOUGH?

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Abstract

Wearable biosensors in healthcare have made a dynamic transformation in the way technology and healthcare are integrated at the consumer level. Their non-invasive, continuous, and dynamic methodology of measuring parameters has piqued the interest of researchers and the community equivocally. Biochemical markers such as sweat, tears, saliva, and intestinal fluid are measured to derive health statistics and status. Their use in diabetes, cardiac disorders, strokes, and menstrual disorders to myriad fitness aspects has been witnessed in the past decade. This research paper aims towards identifying the reliability of sensors in healthcare as mentioned earlier in monitoring scenarios and to find feasible solutions to improve the standard of healthcare facilities using remote health monitoring(RHM) and the Internet of medical things(IoMT).

Keywords:- Activity tracker Smartwatches Diabetes Stroke Cardiac issues Asthma Fitness Internet of Medical things Remote health monitoring Sensors

1. Introduction

As the world is moving into the digital age, the Internet of things is becoming increasingly used and valuable. In parallel, the general population is augmenting their focus on health, fitness, and wellness. Fitness trackers such as FitBits, Apple Watches, Samsung sensors,and many more have skyrocketed their sales in the last few years as users gush over the fancy new features being added. The charts below illustrate the expanding market fuelled by increasing user base due to health awareness and multiple beneficial features being included in the trackers.The global wearable technology market size is expected to reach USD 118.16 billion by2028, registering a CAGR of 13.8% from 2021 to 2028 as shown in figure 1b.

The advent of the pandemic catapulted the adoption of remote healthcare and technology. Research by agencies such as IQVIA, McKinsey, and a few others indicates that the adoption curve has been accelerated by at least a decade. This has impacted not only the practice methodology of Health care professionals(HCPs) but also the consulting-seeking behaviour of the general populace. Nearly 77% of the HCPs use remote / tech-enabled tools for patient consulting. Focus on health and wellness has been paramount pre, peri, and post-pandemic and has brought focus on the critical health parameters.

The other major aspect is data centricity with both collection and management facilitated by IoMT. The IoMT is mainly used to collect the remote data for patient through wearable sensors/devices and store them in the cloud databases. There are three main stages in this data management: device layer (body sensor network (BSN)) Fog layer and cloud service as shown in

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The main challenge for widespread usage of all types of sensors in the healthcare industry is the reliability and accuracy of the data collected by them. Errors in this data can impact the remote management of patients and can prove fatal. This research paper hence measures the reliability of some of the most prevalent sensors in the healthcare industry and also understand if some of these devices are capable of foreshadowing certain illnesses.

Theory and Experimentation

Wearable sensors do not only have the sole purpose of monitoring activity for the user. The public health relevance of such wearable devices is increasing and may impact areas, such as physical activity, well-being, cardiovascular health, mortality risk, dietary habits, among others. For example, higher volumes of physical activity energy expenditure measured by wearable devices was recently shown to be associated with reduced mortality rates, and that higher-intensity activity reduced mortality rates to a larger extent than lower-intensity activity (Strain et al. 2020). Recent advances in technology have resulted in a myriad of wrist-based sensors being built into the current generation of fitness watches. These include digital 3-axis accelerometers, pulse oximeters, optical heart rate sensors, thermometers, barometers, and magnetometers, among others. These sensors, in combination with ever- improving algorithms—most of them proprietary—have led to fitness companies marketing these devices as being capable of estimating and monitoring such physiological parameters as step count, heart rate (HR), sleep quality, sleep rhythm, energy expenditure (EE), maximal oxygen consumption (V˙O2maxV˙O2max), peripheral oxygen saturation, and the "training effect" of both individual and cumulative exercise bouts.

The data from these devices also enable doctors to carry out quicker diagnostics, so in order for them to make an informed decision, they need the data to be reliable and accurate. Various trials have been conducted for different disorders using patients to assess the reliability and dependability of data from wearable tech. Research-grade wearable technologies include the Actigraph GT3X + and ActivPAL

This is not only necessary for certain terminal or immediate response treatments but also for the general improvement of physical and mental well-being of patients. All of these possibilities are only available when the data can be trusted. Even people susceptible to cardiac illnesses, or diabetes or strokes will also benefit as certain discourse markers in levels of biological markers can help foreshadow the aforementioned diseases.

Post Stroke : A review published in *Journal of NeuroEngineering and Rehabilitation by Denise M Peters et al*, emphasised that emerging wearable technologies can provide new opportunities to enhance assessment and rehabilitation post-stroke. Wearable devices allow the capturing of mobility and physical activity performance in different free-living settings, and clinical access to this data can potentially assist with earlier identification of functional decline and improve the timeliness of referrals, reassessment, and treatment. 13 articles were published in peer-reviewed journals; 6 were randomized control trials (RCTs)

,5 were cross-sectional studies 1 was a non-randomized control trial and 1 was a longitudinal pilot study. The mean sample size of the study was 23 participants. As anticipated, there is little consistency in the choice of device used to collect and analyze people's gait and mobility post-stroke. The most commonly used wearable technologies were triaxial accelerometers of varied brands with fewer studies using pressure sensors for gait assessment These studies conducted

reliability and validity analysis of one or more of the following outcome measures: gait speed, step counts, and/or swing symmetry, which were compared against a criterion standard that included one of the following: 3D gait analysis, clinical outcome measures of gait and mobility, or video-based counts. Stroke/ Post trauma : Devices like SpineX fall in between the werable tech and medical devices paradigm by helping post trauma paraplegic patients to walk again. These are wearable tech / sensors that build the new realm of possibilities in science.

Cardiac: Experiment by Priyanka Kakria, N.K. Tripathi, Peenapong Kitipawang reports that

- "A real-time health monitoring system for remote cardiac patients using smartphone and wearable sensors", was designed to find out which sensors measure cardiac activity the best and also a questionnaire was designed to check the pulse and oxygen levels of 40participants using wearable sensors and handheld android device.

Additionally, a trial by Giles et al (2016) measured heart rate and heart rate variability in thetrial participants. Heart rate with wearable sensors depends on multiple confounding factors such as stress, hormones, sleep, body temperature, skin pigmentation, sweat, metabolism, etc. These impact the PPG-based sensors and can produce different readings of Heart ratevariability. As per Shaffer and Ginsberg (2017), the heart rate can also change with age, sex, health, and baseline heart rate itself. Hence baseline monitoring and algorithms to predict the outcomes are essential for accuracy. A study by Graham et al, studied 77 participants in an ongoing study with wearable devices and found that the devices were useful in the early detection of physical decline

Diabetes: A publication by Rodrigez et al (2021), reviewed 26 publications that focused on the use of wearable sensors in monitoring diabetes and related parameters. A total of 30 different sensors were used across these studies, with a maximum sample size of 100 participants per study. Their recommendations find potential in the use of wearable tech fordiabetes management.

Fitness/ step tracking /distance covered and energy expended: Wearable tech is routinely used by fitness enthusiasts and athletes to measure parameters related to fitness and health. There are multitudes of studies measuring these parameters and have been the focus of wearable tech companies to associate the correlation between fitness and health. A study by Fuller (2020) examined 158 publications, 9 different wearable brands, and 45 devices for measuring step count and found that certain measures had reliability and validity. Many other researchers also found that some earlier shortcomings of the measurement of steps were mitigated by the manufacturers.

Ongoing studies

Asthma: Apple and Anthem, along with the University of California, Irvine, and software company CareEvolution, are launching a two-year, 900-participant study. The study is investigating how devices like Apple watch and IPhone can support patients to control their asthma and hospitalization

Results and Discussion

Various trials have clearly demonstrated that wearable tech has a definite place in health care management and monitoring. Trials quoted above have shown that wearable technology has impacted the prevention, improved predictability, and become a strong input in the assessment of patients. Some parameters and measurements are more reliable and validated particularly in

more controlled environments. However, with dynamic environments, and variety in manufacturer models and algorithms, the validity and reliability is dynamic.

In heart rate variability, cardiac conditions, step count, and fall prediction once the baseline has been established, data from the wearable sensors have been found to be useful and helpful in the prevention of the unfavourable impact of the health abnormality. The impact of the environment on the variability and reliability of sensors is known. As well as inter-individual variation makes the performance of the devices challenging.

The algorithms used for the wearable sensors are proprietary and therefore the measurements, their interpretation of metrics also impact the validity. Systematic reviews have shown that some algorithms perform well at the population level, however estimation at individual level is still large

Discussion

Wearable technology and sensors are here to stay and be an integral part of healthcare management. They have advanced rapidly over the past decade or so. The validity and reliability of the sensors has been of interest to manufacturers and end users.

The validity and reliability of wearable technology is still not an established concept. Inter brand variability and reliability differences in conditions elucidated above mandates the standardisation of measurements and interpretation of the data obtained from the wearablesensors.

Conclusion

Even though, the devices have relatively high accuracy (98%), they still need improvement to successfully predict illnesses such as diabetes, stroke and cardiac illnesses. In the IoMT era, remote healthcare monitoring represents the future of the healthcare industry. Importantly, in order to improve people's quality of life, vital signs of humans' body such as glucose level can be monitored. Global cases of certain illnesses are certainly increasing and wearable sensors posts to be the future of the industry. Not only it helps patients to identify and improve certain aspects of their lives but also helps doctors to make more informed and healthier diagnoses for both the doctor and the patient. Recommendation to conduct a phase 3 trial validating the efficacy of wearable devices will probably bring some standardisation and improve the reliability and validity. Wearable technology is going to be an integral part of our life and is going to be the tool to measure variety of metrics. Individuals will need assistance in interpreting this data, sharing it with their physicians, finding its use in prevention and meaningful prevention of serious diseases. Hence standards for wearable devices akin to medical devices need to be introduced. Validity and reliability can also improve if the data is collected over a longitudinal period of time rather than a point in time thereby indicating trends and variances in the same. Additionally, if devices are capable of more individualised capabilities their usage, reliability and validity will be further well accepted. It's time for science and technology to work towards ushering in the new era in wearable technology.

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