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SHORT COMMUNICATION

Wearable devices as a valid support for diagnostic excellence: lessons from a pandemic going forward

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Abstract

Today, the use of wearable devices is continuously increasing with many different application fields. Their low-cost and wide availability make these devices proper instruments for long-term monitoring, potentially useful to detect physiological changes related to influenza or other viruses. The relevance of this aspect and the impact of such technology have become evident particularly in the last year, during COVID-19 emergency; (big) data from wearable devices (already worn by many citizens) together with artificial intelligence techniques gave birth to specific studies dedicated to quickly identify patterns discriminating between healthy and infected people. These evaluations are made on the basis of parameters measured by these devices, among which heart rate, physical activity, and sleep seem to play a dominant role. This could be extremely significant in terms of early detection and limit of contagion risk. However, there is still a lot of research to be conducted in terms of measurement accuracy, data management (privacy and security issues), and results exploitation, in order to reach an accurate and reliable solution helping the whole healthcare system particularly in epidemic events, such as the SARS-CoV-2 pandemic.

Keywords Wearable devices · Remote health monitoring · COVID-19 · Artificial intelligence · Measurement uncertainty

1 Introduction

Wearable devices are more and more popular worldwide. Their easiness of use, joined with a relatively low-cost and wide market availability, plus an increasing capability of non-invasive and long-term continuous data collection enabled by the advances in sensor electronics integration are the keys of this success. From a medical point of view, wearable devices along with smart sensors have been developed to support a large number of healthcare services. As a result, the interest in assessing their potential to early and quickly detect symptoms of a viral pathology, as for the case of COVID-19, is extremely high, and the urgent need of remote monitoring tools has become glaring in the last months [1], given the heavy impact of the pandemic in sanitary, social, and economic terms [2]. Telemedicine and eHealth undoubtedly play a pivotal role in the healthcare systems, proving themselves safe and effective also during a pandemic emergency [3]. However, it is important to take into account the measurement accuracy and the reliability of wearable devices, which are two metrological aspects little investigated in literature. Collaboration among interdisciplinary researchers and wearable vendors can undoubtedly lead to more effective solutions for testing, tracking, and tracing [4] (TTT) strategies, as demonstrated by ongoing projects and published research [5], but, alongside, it would be fundamental to characterize and validate these wearable products from a metrological point of view.

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2 Methodology

The authors of this contribution have analyzed the literature and used their knowledge on the topic to derive a commentary on the potentiality of wearable devices in a pandemic context, with a particular focus on metrological aspects to evaluate them for efficiently and reliably measuring the health status of a person. The aim is to provide the reader with several insights for future research, also in a perspective of collaborative studies involving multiple disciplines.

3 Results and discussion

Among the studies performed on these topics, an interesting example is the DETECT study, seeking for volunteers' wearables data, self-reported symptoms, and diagnoses [6]. It shows that a combination of increased resting heart rate (HR), decreased physical activity, and increased amount of sleep hours (so, both physiological and behavioral data) may be a crisp sign of the onset of a viral illness, like (in particular) COVID-19 but also other infections. A project like this (which may be considered a sort of digital clinical trial [7]) – also together with other studies collecting physiological data from thousands of citizens [8, 9] – allows scientists to merge data from worldwide populations, thus properly feeding artificial intelligence (AI) algorithms [10] to identify possible patterns able to discriminate between healthy and sick people. The project potential impact could be significant in terms of the early detection of possible risk, hence limiting the number of contacts and hindering the virus diffusion. In fact, there seem to be fluctuations in the key metrics days before symptoms become evident [11], when the contagion probability appears even higher, and the improved very short-term forecasting has already been demonstrated for influenza-like illness [12].

In this perspective, wearable devices have been widely involved in both activity recognition and physiological parameters monitoring systems, also reaching high performances [13]. Therefore, they seem to be able to help an anticipation and early detection of viral symptoms, hence to hinder the spread of contagion between individuals; moreover, they could also provide the users with hints on how to fight against possible infections, thus improving lifestyles and the general population health at a global scale, without upsetting daily habits. Since wearables are already very diffused (hence providing big data to track and predict the virus trend [14]), such devices can help to remotely monitor more and more citizens, who may require clinical attention, during their daily life. This means to reduce as much as possible the frequency and number of health check-ups at the hospitals and to limit the contacts with healthcare professionals, who are among the most exposed workers. In particular, the appearance of a certain virus, whether it is or not SARS-CoV-2, could be identified through the analysis of the trend of specific biomarkers (e.g. HR, skin temperature, etc.) as a first clinical screening. Not only classical wearable devices like smartwatches can be used, but also more innovative ones, such as headsets for breathing signals [15]. It is important to observe that, even if absolute measured values could be not extremely precise (most wearables are not medical devices), and a baseline reference value for the specific parameter measured from a specific subject could not be available, the analysis of the values trend over time and over population groups in a certain geographic area can be used to early identify deviations, possibly linked to the disease onset. In fact, the extended periods allow monitoring biometric data during several daily activities, thus ensuring and helping the definition of a personal trend. Besides, absolute thresholds have a reduced value, since what is "normal" depends on the subject status. Furthermore, wearable devices allow to easily collect data streams on a long term, which would be inconceivable to do through laboratory experiments or dedicated acquisitions: these devices are usually worn 7 days a week, almost along the day (e.g. smartwatches), without the user feeling "observed" and, therefore, conditioned by the ongoing measurement.

Despite their incrementally popular use, the accuracy, uncertainty, and stability of measures made by wearable devices are often difficult to retrieve and also the evaluation procedures are unclear and at present there are neither agreed nor standard procedures available [16]. However, the onboard sensors uncertainty should be somehow quantified (also to allow users to take informed decisions), so as to assign a weight (importance) to each sensor data in the framework of analytics and AI-based classification, hence limiting the rate of false positive/false negative outcomes from the processing of wearables data. In terms of device efficiency and signal quality, a valuable contribution to diagnostic excellence (implying a timely, accurate, and convenient diagnosis), while reducing the risk of diagnostic errors [17], can be achieved.

The analysis of both physiological and behavioral data collected by means of wearables may be exploited with different purposes: i) to help the early identification/selection of those subjects who should deserve further investigation (by lab tests with higher specificity), ii) to anticipate treatment (possibly at home) in order to avoid accessing intensive care units (ICUs), and iii) to prevent the rapid spread of the virus. Furthermore, wearable devices could also help in the monitoring of people during lockdown, where telemedicine can allow both tracking and communicating with patients. The same is valid for patients in quarantine and isolation, timely detecting behavioral changes that could influence the person's health status [18], resulting in critical conditions.

A still open aspect in the large use of wearables in diagnosis is the management of such big amounts of individual data and the related privacy and security issues, resulting in ethical problems [19]. Moreover, the final message to the user should be carefully mediated, in order to better manage possible risks related to her/his health conditions.

Hence, the potentiality of wearables in the management of infectious diseases seems very high, but many challenges have still to be faced and need the collaboration of worldwide scientists and researchers from several fields (e.g. medical, engineering, and science areas, hence to sustain the healthcare delivery with innovative technologies like robotic, autonomous, and smart wearable systems [20]), to reach an accurate, reliable, and valuable solution, putting this topic as a very relevant one in the present scenario.

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Declarations

Conflicts of interest The authors declare that they have no conflicts of interest.

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