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Review

The transformative power of AI and wearables in the global prevention of cardiovascular disease

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Summary

The integration of Artificial Intelligence (AI) and wearable technologies in healthcare is revolutionizing preventive medicine, particularly in cardiovascular disease (CVD) prevention. With CVD being the leading cause of global mortality, these innovations offer transformative potential in addressing the disease through a multi-level prevention strategy. Capabilities of AI, supported by wearables, enhance data collection and analysis, allowing for tailored, patient-specific interventions. Primary prevention focuses on mitigating risk factors, while secondary prevention enables early detection through real-time monitoring, and tertiary prevention optimizes management of existing conditions to improve quality of life. This review explores the roles of AI and wearables in each level of prevention, highlighting advancements in predictive analytics, patient-centered care, and personalized treatment planning. Ethical considerations surrounding data privacy and security are also discussed, as well as the importance of accessible technology to reduce health disparities, particularly in low- and middle-income countries. As AI algorithms and wearable data improve, they will become increasingly effective in proactive health management, marking a shift from reactive treatment to preventive care. The successful implementation of these technologies depends on robust ethical frameworks and interdisciplinary collaboration, fostering a future in which preventive healthcare is more personalized, accessible, and impactful.

Key words: prevention, cardiovascular diseases, artificial intelligence, wearable technologies, predictive analytics

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Introduction

In medicine, prevention refers to the comprehensive range of activities and interventions aimed at reducing the risk of developing diseases, health-related complications, or injuries. Prevention is marked by the proactive approach that patients take to improve their health, often with their physician's guidance. This approach not only aims to prevent diseases before they occur, but also aims to manage and reduce the impact of any existing conditions, ultimately enhancing overall health and quality of life. Prevention can be broken down into three levels: primary, secondary, and tertiary [1].

Primary prevention is focused on preventing diseases or injuries before their occurrence. This includes vaccination, lifestyle modifications, and environmental modifications which will in turn reduce the risk of developing an adverse health outcome. Secondary prevention aims at early detection of disease, thus enabling early intervention to prevent further progression of the disease. Strategies include screening programs and early interventions. Tertiary prevention involves reducing the impact of already existing conditions by minimizing their impact on the patient's overall health and quality of life. Together, these levels of prevention combined form a comprehensive healthcare strategy to address a wide spectrum of health-related issues.

Data science is a field of study concerned with analyzing vast volumes of data and employing a wide range of advanced tools and techniques to uncover hidden patterns, derive meaningful insights, and aid in decision-making [2]. It is widely recognized as a driving force behind the evolution of artificial intelligence (AI). In recent years, data science has also made significant inroads into healthcare, facilitated by the introduction of wearable technologies and advanced AI algorithms capable of analyzing massive datasets at unprecedented speed. Moreover, the extensive information collected by wearables, thanks to their continuous monitoring capabilities, enables the continuous improvement of these algorithms. This enhancement over time makes them increasingly accurate in predicting adverse health outcomes and advising patients to seek guidance from their physicians.

In healthcare, wearables and AI have the potential to facilitate early diagnosis, identify irregularities in medical imaging that might otherwise be missed, enhance efficiency, and support decision-making processes [2]. Through their application, we can enhance patient safety, quality of care, and outcomes by leveraging AI as an additional resource within evidence-based medicine. This approach not only aids in refining decision-making but also utilizes the continuous stream of collected data to refresh guidelines and elevate patient care outcomes.

AI and Wearables in the Prevention of Cardiovascular Diseases

Globally, cardiovascular diseases (CVD) are the leading cause of death, with a significant portion taking place in low and middle-income countries [3]. In decreasing the global burden and prevalence of CVD worldwide, prevention at all three levels is the key. Notably, we can make a significant impact through education, screening, and controlling for risk factors. With the synergy of AI and wearables we can take this a step further to identify patients at risk through predictive algorithms and even use the vast amount of data collected from the wearables to be analyzed further and aid in delivering a patient-tailored approach to mitigating further risk.

Capability of AI to assimilate and interpret health data from wearables paves the way for the customization of treatment paradigms [4–7]. By evaluating patient-specific data, AI algorithms can recommend treatment plans that are tailored to the individual's health profile, enhancing the efficacy of chronic condition management, including hypertension and diabetes, which are precursors to cardiovascular

diseases. This personalized approach promises enhanced patient adherence, improved health outcomes, and an elevated standard of living. Thus, the approach of integrating wearables and AI is applicable in all three levels of prevention.

As we stand on the cusp of a new era in preventive healthcare, propelled by the integration of AI and wearables, the future holds boundless potential for transforming the ways we predict, prevent, and manage diseases, particularly CVD. The trajectory of this integration is not linear but rather an evolving journey promising to redefine the paradigms of health and wellness. As we navigate through this promising future, several key directions emerge, poised to shape the landscape of preventive medicine.

The future will see a significant leap in the predictive capabilities of AI algorithms, driven by advancements in machine learning and deep learning techniques [7]. These enhanced analytics will be capable of processing complex, multi-dimensional data from wearable devices in real-time, offering more accurate and timely predictions of health risks. The evolution of predictive analytics will enable earlier interventions, potentially before diseases manifest clinically, thereby shifting the focus firmly towards primary prevention.

Personalization will be at the heart of future preventive strategies, with AI playing a pivotal role in tailoring health interventions to the unique genetic, physiological, and lifestyle profiles of each individual. This bespoke approach will not only enhance the efficacy of preventive measures, but also could improve patient engagement and adherence.

Importantly, to decrease the global burden, we must address how such technologies could be beneficial in regions where the impact of CVD is most significant, particularly in low- and middle-income countries. In these countries, key factors include access to healthcare and cost. As we continue to witness advances in AI and wearables, costs are expected to decrease, thereby increasing accessibility and ensuring that a larger portion of the population has access. Additionally, as technology and society advance, we can further improve access to healthcare through telemedicine and other modalities, reaching a broader patient population. Above all, with increased access to healthcare and technologies, we can work to further improve algorithms since we will have more data collected, aiding us in enhancing treatments and guidelines. This will ultimately play a crucial role in reducing health disparities and achieving equitable health outcomes across various socio-economic and demographic groups.

Despite all, it is also important to consider the challenges we may face along the way as we utilize these powerful technologies and algorithms. Notably, we must address ethical considerations, particularly regarding data privacy and security. The future will necessitate the development of robust ethical frameworks and regulatory guidelines safeguarding individual privacy while ensuring the responsible use of AI in healthcare [2, 4]. Transparent and ethical AI models, coupled with secure data practices, will be essential in maintaining trust and confidence among users, which is critical for the widespread adoption of wearable technology in preventive medicine. Furthermore, it is also important to recognize that these technologies should be used as an aid to synthesize this mass information, but any decision should ultimately be made by the physician.

Discussion

Predictive analytics represents a transformative shift in the approach to healthcare, particularly in the prevention and management of CVD. This technology leverages AI, ML, and the vast arrays of health data to aid in forecasting potential health events. The core of predictive analytics lies in its ability to process and analyze historical health data,

lifestyle information, and real-time health metrics to identify patterns and risk factors associated with cardiovascular diseases; all of which wearables are able to do easily and non-invasively. At the heart of predictive analytics are advanced machine learning algorithms capable of sifting through complex and voluminous datasets to identify those at risk of developing CVD. Notably, deep learning can uncover subtle patterns in the data that may not be immediately apparent to human analysts. These patterns can include correlations between lifestyle choices, genetic predispositions, and the likelihood of developing heart disease. As more data becomes available, these algorithms self-improve, increasing their predictive accuracy over time.

The efficacy of predictive analytics in CVD prevention can be significantly enhanced through the integration of any additional data sources. Electronic Health Records, for example, can provide a comprehensive history of a patient's health, including past illnesses, treatments, and outcomes. When combined with real-time data from wearable devices, such as heart rate and activity levels, predictive models gain a nuanced understanding of a patient's health status and risk factors. This integration allows for the early identification of individuals at risk, facilitating timely interventions. The generated predictive insights can transform the landscape of CVD prevention. For high-risk individuals, personalized intervention plans can be developed, combining lifestyle modifications, medication, and monitoring to mitigate the risk. Predictive analytics also plays a crucial role in identifying asymptomatic individuals who may benefit from early treatment interventions, effectively shifting the healthcare model from reactive to proactive.

While predictive analytics may offer several significant benefits, several challenges must be addressed. The accuracy of predictions heavily depends on the quality and completeness of the data. Inaccuracies in data or biases within algorithms can lead to false positives or negatives, potentially impacting patient care. Ethical considerations around privacy and consent are paramount, as predictive analytics involves handling sensitive personal health information. Patients must be assured of the security of their data and the ethical use of predictive models. Thus, the further evolution of AI and wearables in medicine calls for updates in policy regarding patient data and handling of such information.

Additionally, it is crucial to consider the advantages and disadvantages associated with different types of databases: open, shared, or closed. Each type presents unique implications for patient privacy and data security. An open database is publicly accessible and may foster greater innovation and collaboration yet poses significant risks to patient confidentiality. A shared database restricts access to a group of authorized users, offering a balance between collaboration and privacy, but still requires stringent data protection measures. A closed database, with its strict access controls, provides the highest level of privacy and security, though it may limit the potential for external insights and improvements. The challenge lies in finding an optimal balance that safeguards patient data while still leveraging these databases effectively to advance CVD prevention efforts. This calls for extensive decision making with regard to the most appropriate database model that will maximize patients' benefits without compromising their privacy and security.

The future of predictive analytics in CVD prevention is poised for growth, driven by technological advancements and increased data availability. Next-generation wearables will provide more detailed health metrics, enhancing the data pool for predictive analysis. Furthermore, the integration of genomics into predictive models could offer even more personalized risk assessments and treatment plans. To take advantage of the full potential of predictive analytics, we must promote collaboration across discipline to combine expertise, data science, and ethical considerations.

Overall, predictive analytics is promising avenue in transforming the prevention and management of cardiovascular diseases. By harnessing the power of data and AI, healthcare can move towards more personalized, proactive, and preventative care models. However, the successful implementation of this technology requires careful consideration of ethical standards, data privacy, and the continuous improvement of predictive algorithms to ensure they serve the best interest of patients.

Conclusion

As we venture into this future, the integration of AI and wearable technology in preventive medicine offers a beacon of hope for a healthier, more proactive society. The path ahead is paved with challenges, but the potential rewards–a world where preventive healthcare is personalized, accessible, and effective–make this journey not only worthwhile, but imperative.

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References:

1. Gordon Jr RS. An operational classification of disease prevention. Public Health Rep 1983;98(2):107–9.
2. Babic S, Petrovic M, Lozuk B, Bojic M. Data Science in Modern Healthcare. HealthManagement.org The Journal 2022;22(4):200–2.
3. World Health Organization. Cardiovascular diseases (CVDs) [Internet]. [cited 2024 April 3]. Available from: https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds)
4. Huang JD, Wang J, Ramsey E, Leavey G, Chico TJA, Condell J. Applying Artificial Intelligence to Wearable Sensor Data to Diagnose and Predict Cardiovascular Disease: A Review. Sensors (Basel) 2022;22(20):8002.
5. Raj MM, Riyaz NUS, Reddy M, Yalcin HC, Ouakad HM, Bahadur I, et al. A review of smart sensors coupled with Internet of Things and Artificial Intelligence approach for heart failure monitoring. Med Biol Eng Comput 2021;59(11-12):2185–203.
6. Pevnick MJ, Birkeland K, Zimmer R, Elad Y, Kedan I. Wearable technology for cardiology: An update and framework for the future. Trends Cardiovasc Med 2018;28(2):144–50.
7. Phillips SP, Spithoff S, Simpson A. Artificial intelligence and predictive algorithms in medicine: Promise and problems. Can Fam Physician 2022;68(8):570–2.
8. Leclercq C, Witt H, Hindricks G, Katra RP, Albert D, Belliger A, et al. Wearables, telemedicine, and artificial intelligence in arrhythmias and heart failure: Proceedings of the European Society of Cardiology Cardiovascular Round Table. Europace 2022;24(9):1372–83.

Transformaciona moć veštačke inteligencije i nosivih uređaja u globalnoj prevenciji kardiovaskularnih bolesti

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Sjedinjavanje veštačke inteligencije (AI) i nosivih tehnologija u zdravstvenoj zaštiti unapređuje preventivnu medicinu, posebno u prevenciji kardiovaskularnih bolesti (KVB). Sa KVB kao vodećim uzrokom globalnog mortaliteta, ove inovacije pružaju transformativni potencijal u rešavanju problema bolesti kroz višeslojnu strategiju prevencije. AI, uz podršku nosivih uređaja, unapređuje prikupljanje i analizu podataka, omogućavajući prilagođene, specifične intervencije za svakog pacijenta. Primarna prevencija usmerena je na smanjenje faktora rizika, dok sekundarna prevencija omogućava rano otkrivanje putem praćenja u realnom vremenu, a tercijarna prevencija optimizuje upravljanje postojećim stanjima kako bi se poboljšao kvalitet života. Ovaj pregled istražuje uloge AI i nosivih uređaja na svakom nivou prevencije, ističući napredak u prediktivnoj analitici, nezi usmerenoj na pacijenta i planiranju personalizovanog tretmana. Diskutuju se i etički aspekti koji se odnose na privatnost i bezbednost podataka, kao i važnost pristupačne tehnologije u smanjenju zdravstvenih nejednakosti, naročito u zemljama sa niskim i srednjim prihodima. Kako AI algoritmi i podaci iz nosivih uređaja napreduju, oni će postajati sve efikasniji u proaktivnom upravljanju zdravljem, označavajući prelaz sa reaktivnog lečenja na preventivnu negu. Uspešna implementacija ovih tehnologija zavisi od snažnih etičkih okvira i interdisciplinarne saradnje, čime se podstiče budućnost u kojoj je preventivna zdravstvena zaštita personalizovanija, pristupačnija i efikasnija.

Ključne reči: prevencija, kardiovaskularne bolesti, veštačka inteligencija, nosive tehnologije, prediktivna analitika