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ARE SMARTWATCH-BASED BLOOD PRESSURE MEASUREMENTS CLINICALLY RELIABLE? A NARRATIVE REVIEW OF CUFF-BASED AND CUFFLESS TECHNOLOGIES (2020-2026)

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ABSTRACT

Aim: this narrative review evaluates the current evidence regarding the reliability of blood pressure measurements obtained using both cuff-based and cuffless smartwatches.
Methods: narrative review included evidence from prospective cohort studies, observational studies, controlled trials, validation studies, narrative reviews, and randomized controlled trials, identified through searches of PubMed/MEDLINE, Embase, Web of Science, and Google Scholar.
Results: available studies suggests a relative advantage of cuff-based smartwatches over cuffless devices in terms of measurement accuracy. However, the findings remain inconsistent, with studies providing conflicting results for both technologies, highlighting the need for further high-quality validation.
Conclusion: both cuff-based and cuffless smartwatches are promising tools for continuous blood pressure monitoring, but they are still not recommended as a primary method of blood pressure assessment. Their clinical use requires further standardization, validation, and confirmation of real diagnostic value.

KEYWORDS

Hypertension, Smartwatch, Blood Pressure Monitoring, Cuff-Based Devices, Cuffless Devices

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Introduction

Hypertension (HT) is diagnosed when systolic blood pressure (SBP) is ≥ 140 mmHg and/or diastolic blood pressure (DBP) is ≥ 90 mmHg, or when a patient is receiving antihypertensive treatment. (Nambiema et al, 2025) HT is currently the leading risk factor for cardiovascular disease and ranks first among the causes of global disability-adjusted life years (DALYs). (Carey, Muntner, Bosworth, and Whelton, 2018) It is estimated to account for approximately 8.5 million deaths annually due to stroke, ischemic heart disease, kidney disease, and other vascular conditions. The number of individuals aged 30–79 years with hypertension has approximately doubled between 1990 and 2019, largely driven by population growth and aging. Despite the availability of low-cost diagnostic methods, global rates of blood pressure control remain suboptimal. In 2019, approximately 41% of women and as many as 51% of men with hypertension were undiagnosed. (NCD Risk Factor Collaboration (NCD-RisC), 2021)

Although office-based measurements remain widely used, they are not the most accurate method for confirming the diagnosis. (Viera et al, 2021) The presence of medical personnel during measurement may induce stress in patients, leading to significantly higher readings compared to those obtained under usual conditions. (Muntner et al, 2019) This phenomenon, known as white-coat hypertension, affects approximately 15–30% of patients with elevated office blood pressure. Another important issue is masked hypertension, defined as normal blood pressure in the clinical setting but elevated values outside of it. This condition is associated with a twofold increase in the risk of cardiovascular events and similarly affects approximately 15–30% of the population. (Shimbo et al, 2020) Another limitation is time pressure in clinical settings, which often prevents averaging measurements across multiple visits, a practice necessary for reliable assessment of a patient's condition. (Muntner et al, 2019)

In recent years, the diagnosis of hypertension has evolved, placing increasing emphasis on out-of-office measurements, which allow for a more accurate assessment of the true blood pressure burden. (Viera et al,, 2021; Shimbo et al, 2020) A novel out-of-office solution currently available on the market is the use of smartwatch devices equipped with blood pressure monitoring capabilities.

Blood Pressure Measurement Technologies in Smartwatches

Cuff-based and cuffless devices constitute the main categories of smartwatches equipped with blood pressure measurement functionality.

The market for cuffless blood pressure (BP) monitoring devices is rapidly expanding. These devices typically utilize optical sensors—photoplethysmography (PPG)—and electrical sensors, such as electrocardiography (ECG), to estimate blood pressure. The estimation is based on parameters including pulse transit time (PTT), defined as the time required for the pulse wave to travel between two arterial sites (e.g., from the heart to the wrist), and pulse arrival time (PAT), defined as the interval between the detection of cardiac electrical activity (via ECG) and the arrival of the pulse wave at a peripheral sensor (e.g., on the finger or wrist). (Cohen et al, 2026) Another approach involves the use of bioimpedance technology. This method is based on estimating pulse wave velocity (PWV). By leveraging the strong linear correlation between PWV and blood pressure, the system converts these measurements into estimates of systolic, diastolic, and mean arterial pressure. (Namkoong et al, 2024) Smartwatches also employ machine learning (ML) algorithms, which act as a "translator" by analyzing the morphology and velocity of the pulse wave and converting these signals into blood pressure values. (Cohen et al, 2026)

There are also devices that incorporate an integrated wrist cuff for blood pressure measurement. (Petek et al, 2023) These are referred to as wrist cuff devices and operate similarly to traditional sphygmomanometers. They feature an inflatable cuff embedded within the wrist strap, which physically inflates to measure blood pressure. (Petek et al, 2023) Such smartwatches use the oscillometric method. The device rapidly inflates the cuff to occlude the radial artery at the wrist and then gradually deflates it. During deflation, the pressure sensor records two types of signals: the external pressure exerted by the cuff on the wrist and oscillations—small pressure fluctuations caused by pulsatile blood flow in the artery beneath the cuff. The device processor converts these oscillations into SBP and DBP values using advanced algorithms that compensate for measurement errors related to cuff tightness and account for inter-individual differences in pulse pressure. (Dhamotharan et al, 2025) These are devices based on oscillometric measurements, they should comply with ISO 81060-2, an international standard for the validation of automated non-invasive blood pressure measuring devices. This standard applies to automatic oscillometric blood pressure monitors intended for home, clinical, and ambulatory use, and aims to ensure that devices available on the market provide accurate blood pressure measurements across diverse patient populations. (Stergiou et al, 2018)

Methodology

This study was conducted as a narrative review based on evidence derived from prospective cohort studies, observational studies, controlled trials, validation studies, narrative reviews, and randomized controlled trials. Databases searched included PubMed/MEDLINE, Embase, Web of Science, and Google Scholar. The search strategy included combinations of the following keywords: “Hypertension,” “smartwatch,” “cuffless devices,” “cuff-based devices,” “blood pressure monitoring,” and “oscillometric method.” The analysis involved study selection, data extraction, qualitative synthesis, and interpretation of findings across the included studies.

Aim of the publication

The aim of this study was to evaluate the reliability of cuff-based and cuffless smartwatch blood pressure measurements in light of the most recent scientific evidence.

Results

Cuffless Devices

Recent studies evaluating cuffless smartwatch-based blood pressure monitoring demonstrate heterogeneous results, largely dependent on the study population, device technology, and calibration protocols.

Evidence from studies conducted in 2023 suggests that devices such as the Samsung Galaxy Watch 4, which utilize photoplethysmography, may achieve relatively high accuracy when assessed in cohorts of healthy young adults, showing good agreement with reference measurement methods. (Lins et al, 2023) However, findings from larger population studies indicate that, although such devices are promising tools for blood pressure monitoring, concerns remain regarding their long-term stability and the optimal frequency of recalibration. (Han et al, 2023)

Large-scale validation studies further highlight the variability in performance across cuffless technologies, including those based on electrocardiography, PPG, and pulse wave analysis. While acceptable accuracy has been reported for diastolic blood pressure across broader populations, and for systolic blood pressure in younger normotensive individuals—particularly when calibration is applied—performance declines significantly in older individuals and in patients with hypertension. Notably, calibration-free models currently demonstrate limited clinical utility. (Liu et al, 2023)

Moreover, some devices show markedly poor performance. For instance, an infrared-based smartwatch evaluated in 2023 demonstrated very low correlation with reference measurements and failed to reliably measure systolic blood pressure above 120 mmHg. (Vaseekaran, Kaese, Görlich, Wiemer, and Samol, 2023) Similarly, a 2024 comparative study of multiple devices, including both cuffless and cuff-based systems, reported that none met established validation standards, with cuffless smartwatches exhibiting particularly high measurement error rates. (Lunardi et al, 2024)

Cuff-Based Smartwatches

Studies evaluating cuff-based smartwatch devices generally report more consistent and clinically promising results compared to cuffless technologies, although some variability remains.

Several investigations have focused on the accuracy of the HUAWEI WATCH D and its newer version, the HUAWEI WATCH D2. These devices have demonstrated high accuracy in both resting and ambulatory

conditions, meeting the stringent requirements of the universal AAMI/ESH/ISO validation standards. (Zhou et al, 2025) Furthermore, the HUAWEI WATCH D2 has been shown to provide nighttime blood pressure measurements comparable to traditional ambulatory blood pressure monitoring (ABPM), while offering improved patient comfort, including fewer awakenings and reduced sleep disturbance. (Liu et al, 2025) Additional studies assessing the HUAWEI WATCH D reported consistent and accurate measurements across resting, ambulatory, and circadian blood pressure monitoring settings, with results closely aligned with reference clinical devices. (Yi et al, 2022) The device fulfilled all ISO accuracy criteria and has been suggested as a reliable option for home blood pressure self-monitoring. (Zhang, Zhou YN, Zhou Y, and Wang, 2022) However, not all findings are fully consistent. A more recent study from 2025 indicated that while the device performed relatively well in hypertensive patients, its accuracy was significantly lower in normotensive individuals. The authors concluded that smartwatch-based measurements may not yet be sufficiently reliable to replace assessments performed by medical professionals. (Velázquez Saornil et al, 2025)

Other studies have evaluated the Omron HeartGuide (BP8000), with mixed results. Some reports indicate that, despite accurate heart rate and sleep tracking, the device significantly underestimated both systolic (by an average of 10.4 mmHg) and diastolic blood pressure (by 3.2 mmHg), limiting its suitability as a replacement for conventional clinical devices. (Harfmann et al, 2024) These findings are supported by studies demonstrating that the device did not fully meet ISO 81060-2 validation criteria. (Lunardi et al, 2024) In contrast, other investigations have reported a high correlation between the Omron HeartGuide and professional-grade equipment, both in single measurements and during 24-hour monitoring. These results suggest potential applicability of the device in telemedicine-based patient monitoring. (Vaseekaran, Kaese, Görlich, Wiemer, and Samol, 2023)

Guidelines and Scientific Statements

One of the most recent publications analyzing cuffless blood pressure measurement technologies highlights that, despite their growing popularity among consumers, clinicians continue to receive conflicting evidence regarding their accuracy and calibration stability. Most of these systems estimate blood pressure based on surrogate signals and require periodic recalibration, making them more reliable for tracking trends rather than providing precise absolute blood pressure values. (Wehbe and Hiremath, 2026)

The official scientific statement from the American Heart Association (AHA) on cuffless technologies indicates that such devices typically measure changes in blood pressure relative to the calibration point, rather than absolute values expressed in mmHg. The report also identifies multiple sources of measurement error, including the influence of skin melanin, ambient temperature, obesity, and vascular stiffness on signal quality. (Cohen et al, 2026)

Current American guidelines clearly emphasize that cuffless devices should not be relied upon for diagnostic or therapeutic decision-making until they demonstrate improved accuracy and reproducibility. (Jones et al, 2025)

Discussion

Although cuff-based devices demonstrate substantially higher accuracy, they are not considered a replacement for clinically validated sphygmomanometers. (Harfmann et al, 2024) A major limitation is their high sensitivity to wrist positioning. For accurate measurement, the device must be positioned at heart level; (Velázquez Saornil et al, 2025) even a deviation of 10 cm may result in an error of approximately 7 mmHg. Furthermore, measurements are obtained at the radial artery, whereas clinical standards are based on brachial artery measurements. Physiological differences in blood pressure between these sites, related to arterial narrowing and hemodynamic factors, further contribute to measurement variability. (Vaseekaran, Kaese, Görlich, Wiemer, and Samol, 2023) Cuff-based smartwatches have also demonstrated lower accuracy in normotensive individuals, with some analyses suggesting an increased risk of false-positive results in this population. (Velázquez Saornil et al, 2025) Additionally, these devices require strict adherence to measurement protocols, including maintaining stillness, silence, and proper posture, making them susceptible to user-related errors. (Vaseekaran, Kaese, Görlich, Wiemer, and Samol, 2023)

External factors play a particularly important role in cuffless technologies. Unlike cuff-based devices, cuffless systems are highly sensitive to multiple sources of interference. For example, skin melanin content affects light absorption and measurement accuracy in PPG-based devices. (Cohen et al, 2026) Environmental conditions, such as low temperature, may induce vasoconstriction and alter pulse wave morphology, while factors such as obesity can reduce signal quality. (Velázquez Saornil et al, 2025; Cohen et al, 2026) Moreover, many machine learning models underlying these devices have been trained predominantly on young, healthy

populations. As a result, device accuracy declines significantly in older individuals and in patients with hypertension. (Liu et al, 2023)

Another key limitation is measurement stability. Most smartwatch-based systems do not directly measure blood pressure but instead track changes relative to a prior calibration point. Without calibration, these devices are only capable of monitoring trends rather than providing absolute blood pressure values. (Cohen et al, 2026) Their accuracy is therefore inherently dependent on the reference cuff-based device used during calibration. In addition, measurement error has been shown to increase over time following calibration. (Wehbe and Hiremath, 2026)

At present, there is no unified international validation protocol specifically designed for cuffless devices. The development of such standards will require extensive testing under both static and dynamic conditions, including during movement, changes in body position, physical activity, and sleep. (Cohen et al, 2026; Liu et al, 2023)

Conclusions

The analyzed studies indicate a general advantage of cuff-based smartwatches over cuffless technologies in terms of measurement reliability; however, the overall evidence remains inconclusive. Isolated validation successes do not translate into universal device reliability. Current guidelines continue to discourage the use of both cuff-based and cuffless smartwatches for the diagnosis and management of hypertension. (Jones et al, 2025; Cohen et al, 2026)

Importantly, there is currently no evidence that smartwatch-derived blood pressure measurements translate into improved hypertension control or a reduction in cardiovascular outcomes such as myocardial infarction or stroke. Future research should aim to link device-derived measurements with clinically meaningful endpoints. Large-scale studies are needed to determine whether treatment strategies based on smartwatch-derived trends are safe and effective compared to those based on conventional measurements. Further research is also required in more diverse populations, as data remain limited for pregnant women, children and adolescents, and patients with comorbidities such as chronic kidney disease. An emerging area of interest is the use of smartwatches for nocturnal blood pressure monitoring. In particular, cuff-based devices show considerable potential for assessing nighttime blood pressure with less sleep disturbance compared to traditional upper-arm cuffs. This may represent a valuable alternative for patients who poorly tolerate conventional ambulatory monitoring. (Liu et al, 2025) Future studies should focus on validating these technologies across different sleeping positions and in direct comparison with polysomnography.

In conclusion, smartwatches represent an important technological advancement toward continuous blood pressure monitoring; however, their implementation in clinical practice requires further standardization, validation, and evaluation of their true diagnostic and therapeutic value.

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