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INSIGHTS FROM COMBINED STUDIES

Tracking Blood Pressure Changes with Cuffless Monitoring

Unlocking Unmatched Precision for Nocturnal Trends, Medication Titration and Intervention

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ABSTRACT

Accurate tracking of blood pressure (BP) changes is essential for effective monitoring and hypertension management. It enables the assessment of nocturnal BP dipping, evaluation of medication titration, and monitoring of outcomes from medical interventions like renal denervation, a treatment for resistant hypertension. Cuffless BP monitors offer a groundbreaking solution by overcoming the episodic limitations of traditional cuff-based methods, facilitating continual BP assessment and more precise tracking of BP changes. This review explores the latest advancements in cuffless BP technology, with a focus on tracking nocturnal BP trends, medication-induced BP changes, and post-renal denervation outcomes. We demonstrate that the cuffless BP technology developed by Aktiia SA serves as an ideal platform for effective BP tracking across diverse clinical conditions.

INTRODUCTION

High blood pressure (BP) is the most important modifiable risk factor for cardiovascular disease, stroke and premature death [1]. Despite decades of clinical engagement, global hypertension control rates remain at just 20% [2]. Hypertension diagnosis and management relies heavily on BP measurements performed by cuff-based sphygmomanometers, which are uncomfortable and episodic by nature. For instance, clinic BP assessments are limited to occasional daytime readings and are vulnerable to white-coat effects. Home BP monitoring (HBPM) extends monitoring to long-term use at home, but limited to daytime readings only. Ambulatory BP monitoring (ABPM) is performed over more comprehensive 24–48-hour snapshots, but it is seldom performed once a year. As a result, traditional cuff-based methods provide sparse data that fail to capture key aspects of BP variability.

BP is inherently dynamic, influenced by natural rhythms and medical interventions. One key factor is night-time dipping, a normal decrease in BP during sleep. The absence of this dipping is linked to an increased risk of cardiovascular events [3]. Anti-hypertensive medications are another factor, as they aim to control high BP. Improper dosing, however, can result in overcorrection or insufficient control [1]. Lastly, surgical procedures such as renal denervation offer potential solutions for patients with resistant hypertension [4]. Effective management in all these cases demands continual, long-term BP monitoring – something traditional cuff-based devices cannot provide.

Advances in photoplethysmographic (PPG) technology – optical signals that contain the pulsatility components of the blood – now enable new cuffless BP monitoring solutions that address the fundamental limitations of cuff-based monitors [5]. This review highlights how a cuffless BP monitor, the Aktiia monitor (Aktiia SA, Neuchâtel, Switzerland), can serve as an ideal platform for effective BP tracking across diverse clinical scenarios, including nocturnal BP dipping, as well as BP changes induced by anti-hypertensive medications and renal denervation.

METHODS

The cuffless BP monitor

Aktiia SA has developed a CE-marked, non-invasive, cuffless BP monitor that offers a convenient solution for long-term BP monitoring [5,6]. The device uses optical sensors embedded in a wrist-worn bracelet to collect PPG signals (Figure 1), which are analysed to estimate BP following an initial calibration with a traditional cuff-based BP device. The measurements are automatically displayed in a smartphone application, eliminating the discomfort and inconvenience often associated with traditional BP monitoring. This makes the Aktiia monitor ideal for continual BP tracking in real-world daily conditions.

While some recent research has questioned the ability of the Aktiia monitor to accurately track night-time BP dipping and medication-induced BP changes [7], we at Aktiia remain deeply committed to rigorous scientific validation. We continually advance our technology to ensure reliable, real-world BP monitoring across diverse conditions. In this review, we present findings from three studies that evaluated the performance of the Aktiia monitor in tracking BP changes under various conditions. The methods and key results are outlined below.

Figure 1. Aktiia's CE-marked device is currently available in seven European markets and approved as a medical device in 44 countries worldwide. Built on 20+ years of research, Aktiia's technology provides unparalleled innovation and ease in BP data collection and machine learning modelling, offering personalized, continual, and medical-grade BP and heart rate data. Aktiia empowers people, researchers, and clinicians with unique BP data paving the way for novel understanding and personalized patient care of hypertension. With over 11 billion data points from across the globe, Aktiia's continual BP dataset is growing exponentially, creating countless opportunities for deep learning on public health trends and patterns to advance our understanding of BP, to provide predictive insights on a global scale.

Study 1 – Tracking nocturnal BP dipping

This study, presented at the 2024 European Society of Hypertension Annual Meeting [8] and recently accepted for publication in the Journal of Hypertension [9], evaluated the ability of the Aktiia cuffless monitor to detect night-time BP dipping. A total of 63 participants enrolled in a 12-week cardiac rehabilitation program at the Réseau Hospitalier Neuchâtelois (RHNE, Switzerland) wore both the Aktiia monitor and a traditional ABPM device (Dyasis 3, Novacor, France). Night-time dipping was assessed by comparing daytime (9am–9pm) and night-time (11pm–7am) BP averages recorded by both devices during two sessions:

- Session 1: Data from the first day of monitoring.
- Session 2: Data from the final day of the program.

Only sessions with sufficient valid measurements from both devices were included in the analysis. The performance of the Aktiia monitor in identifying night-time dipping was compared against the ABPM as the reference standard.

Study 2 – Tracking BP changes induced by medication titration

This study, part of the COntinual vs OccasionaL (COOL-BP) study, has been published in the American Journal of Hypertension [10]. Twenty subjects undergoing medication titration in a remote hypertension management program were instructed to perform HBPM and wear the Aktiia monitor. BP changes detected by both devices were analysed during predefined windows of interest:

- Pre-Titration Period: The nearest week before medication adjustment, with ≥12 valid daytime readings over ≥3 days recorded by HBPM.
- Post-Titration Period: The nearest week following a mandatory seven-day stabilization period after medication adjustment, also requiring ≥12 valid readings by the Aktiia device.

Windows of interest were included only if sufficient data were available from both devices.

Study 3 – Tracking BP changes induced by radiofrequency renal denervation

This case report, submitted to the 2025 European Society of Hypertension Annual Meeting, highlights a 62-year-old woman with long-standing, untreated stage 2-3 hypertension and multiple medication intolerances or inefficacies (e.g., nightmares with angiotensin receptor blockers, oedema with calcium channel blockers, and hypokalemia with thiazide diuretics). After excluding secondary hypertension, the patient was treated with spironolactone and eplerenone, which caused arthralgia and muscle pain. Her medical history included preeclampsia, one episode of multiple sclerosis, paroxysmal atrial fibrillation treated with ablation, and sleep apnoea managed with continuous positive airway pressure.

After five years of intermittent treatment with candesartan (8 mg), the patient developed albuminuria and left ventricular hypertrophy. Endovascular renal denervation (Symplicity Spyral™, Medtronic) was performed under sedation, delivering 19 lesions to the left and 16 to the right renal arteries. The patient wore the Aktiia monitor for continual BP tracking before and after the procedure. Systolic BP, diastolic BP, and heart rate were analysed over one year before and one year after renal denervation. The patient discontinued candesartan approximately one-month following the intervention.

RESULTS

Study 1 – Tracking nocturnal BP dipping

Of the 63 participants, 30 fulfilled the data requirements for inclusion (26 in Session 1 and 12 in Session 2). Night-time dipping detection by the Aktiia monitor was evaluated using two key metrics:

- The area under the curve: A measure of the monitor's ability to distinguish between night-time dipping and non-dipping. The area under the curve of the receiver operating characteristic curve was 0.72 (Figure 2A), with the optimal night-dip threshold for Aktiia determined at -2.96% (red dot on the receiver operating characteristic curve), achieving 91% sensitivity and 63% specificity. These results align with previous data, showing that Aktiia effectively tracks nocturnal dipping when a factor of 3 is applied to match the 10% ABPM dipping threshold. [5].
- The concordance rate: A measure of agreement between the night-dip percentages recorded by Aktiia and ABPM. The four-quadrant plot indicated a concordance rate (accuracy) of 78.9%, with a precision of 83.3% (Figure 2B).

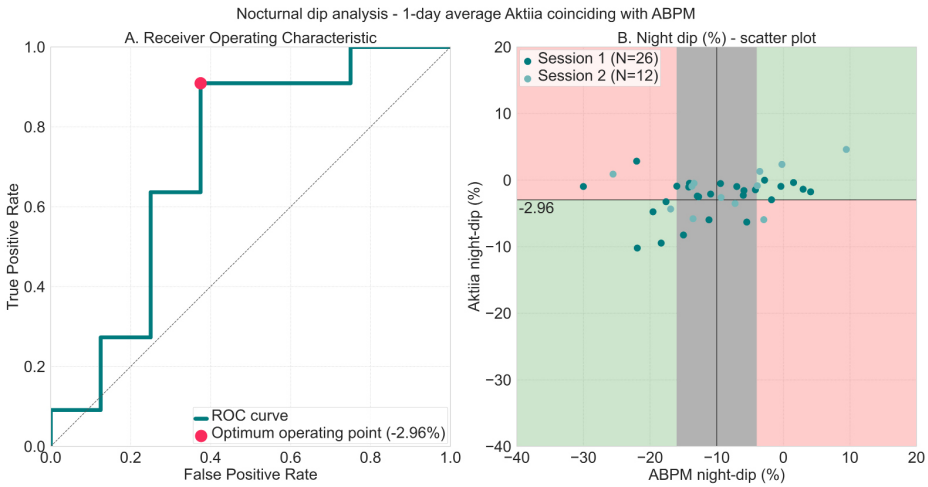

Figure 2. A. Receiver operating characteristic curve evaluating Aktiia's detection of night-time BP dipping compared to ABPM (reference: -10% night-dip). The area under the curve is 0.72, with the optimal threshold at -2.96% (91% sensitivity, 63% specificity). (B) Four-quadrant plot showing concordance between night-dips recorded by ABPM and Aktiia, with a concordance rate of 78.9% and precision of 83.3%. Of the original 38 sessions from 30 subjects, 19 sessions from 16 unique subjects were included in the analysis (excluding data within the ±6% zone). ROC - Receiver operating characteristic.

These results demonstrate that the Aktiia monitor accurately detects night-time BP dipping, supporting its potential for long-term BP monitoring. Interestingly, while the amount of the dipping is found to be smaller for the Aktiia monitor than for cuff-based device, recent independent research has raised concerns about the accuracy of cuff-based devices in tracking nocturnal BP changes [11]. The findings indicate that these devices are highly sensitive to hydrostatic forces caused by changes in body position, such as lying down during sleep. The study showed that a significant portion of the nocturnal BP dipping observed with these devices may reflect hydrostatic effects rather than a true physiological reduction during sleep. This raises the possibility that traditional BP monitoring devices, relied upon for decades, may have inadvertently generated misleading data – potentially influencing hypertension management strategies. Conversely, the Aktiia monitor has been shown to reliably capture BP measurements in different body positions as opposed to traditional cuffed BP devices [12]. Further studies are needed to distinguish true physiological BP reductions during sleep from external influences. Cuffless BP monitors present an ideal solution, offering the ability to passively and comfortably measure BP throughout the night.

Study 2 – Tracking BP changes induced by medication titration

Five patients provided overlapping qualifying BP measurements across 8 medication titration events. The analysis revealed a strong concordance rate of 87.5% between systolic BP changes detected by HBPM and the Aktiia monitor (Figure 3).

The ability of cuffless devices to accurately track BP changes following medication titration has significant implications for hypertension management. These devices provide an optimal platform for remote BP monitoring, enabling rapid follow-up on medication efficacy by continually tracking BP trends. This helps to mitigate the risks associated with under- or over-correction of dosage.

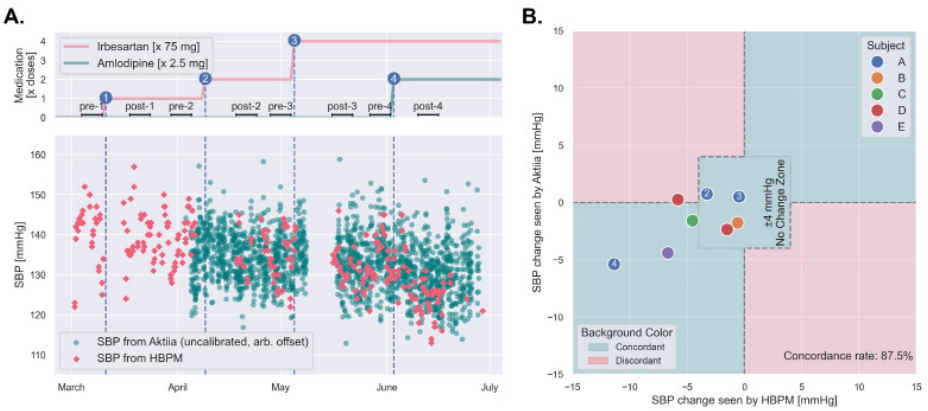

Figure 3. (A) Time series of systolic BP measurements captured by HBPM and the Aktiia monitor during medication titration. Each medication adjustment was followed by a minimum seven-day stabilization period, with no recalibration of the cuffless device during this time. (B) Concordance plot comparing systolic BP changes detected by HBPM and the Aktiia cuffless monitor over 8 medication titration events for 5 patients. Each dot represents one event; Subject A is represented by 3 dots (one per titration). A ±4 mmHg no-change zone was applied to reflect less than half the tolerable error of the cuff. Data points within green areas indicate concordance, while those in red indicate discordance. Numbered blue dots correspond to Subject A's titrations shown in panel A. SBP – systolic BP.

Study 3 – Tracking BP changes induced by radiofrequency renal denervation

Significant reductions in BP were observed following renal denervation:

- Systolic BP: Decreased from 153.82±8.30 mmHg to 148.01±9.04 mmHg (difference: -5.81±0.17 mmHg, P<0.0001; Figures 4A-4B).
- Diastolic BP: Decreased from 100.80±6.60 mmHg to 96.30±6.47 mmHg (difference: -4.50±0.13 mmHg, P<0.0001; Figures 4C-4D).
- No significant differences were observed for heart rate: 76.18±11.54 bpm to 76.40±12.05 bpm (difference: 0.22±0.23 bpm, P=0.3217; Figures 4E-4F).

This single-case study highlights the potential of cuffless devices for BP monitoring and hypertension management. It represents the first demonstration of how continual cuffless monitoring can assist patients and providers in assessing the effectiveness of medical interventions. In this case, continual use of the Aktiia monitor revealed that discontinuing antihypertensive treatment one month following the medical intervention appeared to influence the short-term BP response, underscoring the critical importance of medication adherence. This level of insight was made possible by the unparalleled granularity of measurement provided by the Aktiia monitor – something traditional cuff-based methods simply cannot achieve.

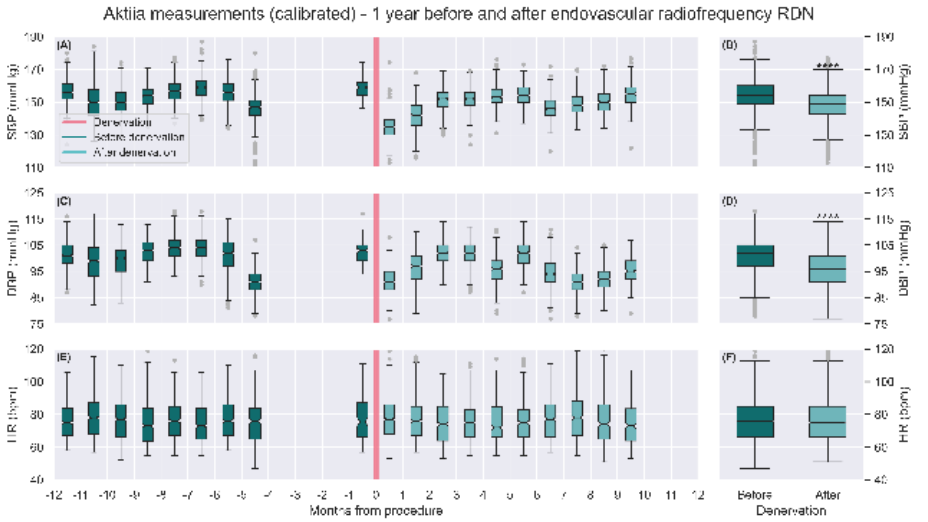

Figure 4. Systolic BP (A, B), diastolic BP (C, D), and heart rate (E, F) measured by the Aktiia monitor during the one year before and one year after renal denervation in a patient with long-standing hypertension untreated due to medication intolerance or inefficacy. Significant reductions were observed for systolic BP and diastolic BP following renal denervation, while heart rate remained unchanged. A total of 5,107 readings were collected before renal denervation and 5,876 readings after the procedure. RDN - renal denervation, SBP – systolic BP, DBP – diastolic BP, HR – heart rate. **** P<0.0001.

Conclusion

The three studies summarized here demonstrate that the Aktiia monitor delivers unmatched precision in tracking BP changes across diverse clinical scenarios, including nocturnal BP dipping, medication titration, and post-procedural outcomes such as radiofrequency RDN. Cuffless, continual BP monitoring overcomes the limitations of traditional cuff-based devices, offering a non-invasive, user-friendly solution for long-term BP assessment. By unlocking unprecedented granular insights into BP trends, the Aktiia monitor stands out as an innovative tool with the potential to transform hypertension management, optimize treatment strategies, and advance personalized patient care.

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